Teaching Through Inquiry
OSLN PD Webinar Series

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Checklist—before we start

- Use the Zoom chat to communicate with Mackenzie (moderator)
- Interactive Polling
- You may ask questions via the Q&A box or raise your hand if you would like to ask your questions out loud
- The slide deck will be emailed to you
- This webinar is being recorded

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Objectives

- *Strengthen understanding of science inquiry*
- *Enhance pedagogical knowledge of science teaching*

Session 1: *Teaching Science Through Inquiry*

Session 2: *Examples of Subtle Shifts for Promoting Student Inquiry*

Session 3: *Incorporate More Student Inquiry in Your Science Lesson*

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Today's Agenda

- Review of scientific inquiry (session 1)
- Consider examples of subtle shifts in lesson plans intended to promote student inquiry
- Share reflection tool for gauging student inquiry in science lessons
- Q&A

What is Scientific Inquiry?

The process skills of science

- asking questions
- planning and conducting experiments
- analyzing data to draw conclusions
- communicating results to others

The guiding principles for *Ohio's Learning Standards and Model Curriculum for Science* include:

Scientific and Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Ohio | Department of Education

National Research Council. 2012. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press.

The guiding principles for *Ohio's Learning Standards and Model Curriculum for Science* include:

Table 1: Nature of Science

Nature of Science One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.	
Categories	**K-2**
Scientific Inquiry, Practice and Applications All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.	• Apply knowledge of science content to real-world challenges. • Plan and conduct simple scientific investigations using appropriate safety techniques based on explorations, observations and questions. • Employ simple equipment and tools to gather data and extend the senses. • Use data and mathematical thinking to construct reasonable explanations. • Communicate with others about investigations and data.
Science is a Way of Knowing Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past, and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.	• The world is discovered through exploration. • Exploration leads to observation. Observation leads to questions. • Natural events happen today as they happened in the past. • Events happen in regular patterns and cycles in the natural world.
Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• Everyone explores the world which generates questions. • The answer is not always as important as the process. • Questions often lead to other questions. • Discoveries are communicated and discussed with others. • People address questions through collaboration with peers and continued exploration. • Everyone can see themselves as scientists.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• It is essential to learn how to identify credible scientific evidence. • Ideas are revised based on new, credible scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

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What is Teaching Through Inquiry?

Teaching strategies that give students responsibility for applying the process skills of science

- asking questions
- planning and conducting experiments
- analyzing data to draw conclusions
- communicating results to others

Are my science lessons inquiry-based?

Pedagogy of Science Teaching

Mallinson Institute for Science Education

https://wmich.edu/science/inquiry-items

Theoretical framework for understanding inquiry-based teaching

- **Inquiry-based instruction is <u>NOT</u> dichotomous!!!**
- **For any given science lesson, the degree of student inquiry should be considered as existing across a continuum:**

No Student Inquiry ⟷ ***Everything In-Between!!!*** ⟷ **Full Student Inquiry**

Inquiry Spectrum

less student inquiry ⟷ more student inquiry

Didactic Direct

Teacher presents and explains science content directly, illustrates with example or demo

No student activities

Active Direct

Teacher presents and explains science content directly, illustrates with example or demo

Students actively follow instructions

Guided Inquiry

Students actively explore phenomenon or idea with teacher guidance toward desired science content

Open Inquiry

Students actively explore phenomenon or idea as they choose

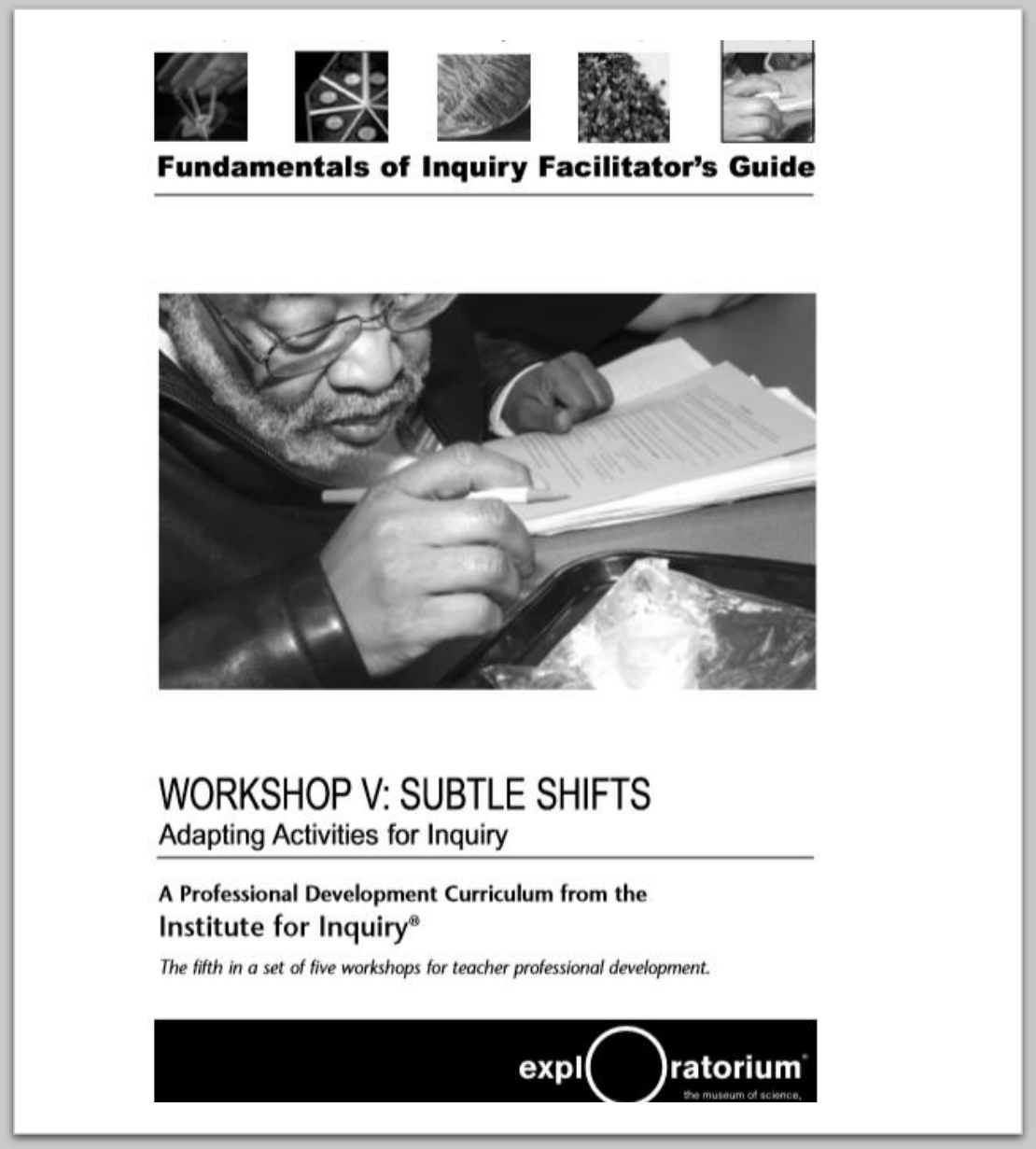
Teacher facilitates process but does not prescribe

Significant Portion of Science Curriculum

Subtle Shifts:
Adapting Activities for Inquiry

Take Home Messages

- To help learners develop the abilities to do scientific inquiry, teachers need to give students responsibility for using the process skills of science
- Teachers can make small shifts in existing activities to help learners strengthen the process skills needed for scientific inquiry
- Lessons can be modified in specific ways to achieve particular purposes



Fundamentals of Inquiry Facilitator's Guide

WORKSHOP V: SUBTLE SHIFTS

Adapting Activities for Inquiry

A Professional Development Curriculum from the Institute for Inquiry®

The fifth in a set of five workshops for teacher professional development.

exploratorium

the museum of science,

https://www.exploratorium.edu/sites/default/files/pdfs/ifi/Subtle_Shifts.pdf

Changes Activity (Shifted)

Evidence of Chemical Change

In this activity, you'll try to determine whether or not a chemical change has taken place by investigating the question, "What indicates the occurrence of a chemical change?" Careful observations will help you gather evidence.

Exploration: Part I

Read all of Part I. Then design a data-collection sheet on which you can record what you do and what you observe. Be sure that it is in a format that is easy to follow and can be shared with others. Then do the activity.

- Put on your safety equipment.
- Place ¼ teaspoon of sodium bicarbonate ($NaHCO_3$) and ½ teaspoon of calcium chloride ($CaCl_2$) into a ziplock bag.
- Fill a medicine cup with 5 mL of phenol red solution. Carefully place the cup in the bag, keeping it upright until after you zip the bag closed.
- Squeeze out as much air as possible and seal the bag.
- Keeping the bag sealed, tip the cup over, mix the chemicals together, and observe the result.
- Record what you did and what you observed on your data-collection sheet. Record the evidence you think indicates a chemical change.

Exploration: Part II

Choose Option A or Option B (below) to continue your investigation. Design a new data-collection sheet for that option. Complete the second option if time permits, using another data collection sheet.

OPTION A

- Predict what would happen if you tried the experiment again but left out one of the chemicals.
- Test your prediction. Record what you did and what you observed.
- Repeat this experiment, leaving out a different chemical.

OPTION B

- Predict what would happen if you varied the amount of one of the chemicals.
- Test your prediction. Record what you did and what you observed.
- Repeat this experiment several times, each time varying a different chemical.

Summary

1. Analyze and summarize the results of your experiments on your data-collection sheets.
2. List any questions you still have on your data-collection sheets.
3. Describe what you have discovered about chemistry from this activity.

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OPTION A

- Predict what would happen if you tried the experiment again but left out one of the chemicals.
- Test your prediction. Record what you did and what you observed.
- Repeat this experiment, leaving out a different chemical.

OPTION B

- Predict what would happen if you varied the amount of one of the chemicals.
- Test your prediction. Record what you did and what you observed.
- Repeat this experiment several times, each time varying a different chemical.

Summary

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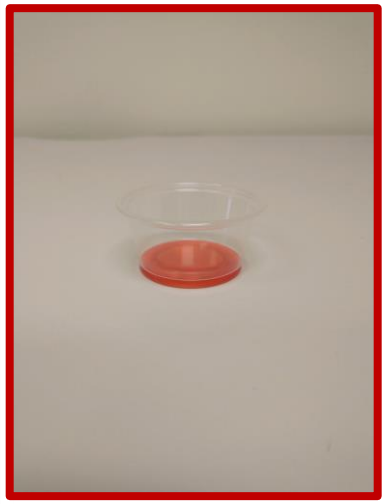

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- Keeping the bag sealed, tip the cup over, mix the chemicals together, and observe the result.
- Record what you did and what you observed on your data-collection sheet. Record the evidence you think indicates a chemical change.

Exploration: Part II

Choose Option A or Option B (below) to continue your investigation. Design a new data-collection sheet for that option. Complete the second option if time permits, using another data collection sheet.

OPTION A

- Predict what would happen if you tried the experiment again but left out one of the chemicals.
- Test your prediction. Record what you did and what you observed.
- Repeat this experiment, leaving out a different chemical.

OPTION B

- Predict what would happen if you varied the amount of one of the chemicals.
- Test your prediction. Record what you did and what you observed.
- Repeat this experiment several times, each time varying a different chemical.

Summary

1. Analyze and summarize the results of your experiments on your data-collection sheets.
2. List any questions you still have on your data-collection sheets.
3. Describe what you have discovered about chemistry from this activity.

Observations (Part I)

- Color change, turned yellow
- Foaming/bubbling, bag expanded
- Feels hot

Changes Activity (Shifted)

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Exploration: Part I

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- Record what you did and what you observed on your data-collection sheet. Record the evidence you think indicates a chemical change.

Exploration: Part II

Choose Option A or Option B (below) to continue your investigation. Design a new data-collection sheet for that option. Complete the second option if time permits, using another data collection sheet.

OPTION A

- Predict what would happen if you tried the experiment again but left out one of the chemicals.
- Test your prediction. Record what you did and what you observed.
- Repeat this experiment, leaving out a different chemical.

OPTION B

- Predict what would happen if you varied the amount of one of the chemicals.
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- Repeat this experiment several times, each time varying a different chemical.

Summary

1. Analyze and summarize the results of your experiments on your data-collection sheets.
2. List any questions you still have on your data-collection sheets.
3. Describe what you have discovered about chemistry from this activity.

Part II (Option A)

Repeated Part I without $CaCl_2$

- No change observed when mixed together

Repeated Part I without $NaHCO_3$

- Color change, turned purple
- Feels hot
- No foaming/bubbling

Changes Activity (Shifted)

In this activity, you'll try to determine whether or not a chemical change has taken place by investigating the question, "What indicates the occurrence of a chemical change?" Careful observations will help you gather evidence.

Exploration: Part I

Read all of Part I. Then design a data-collection sheet on which you can record what you do and what you observe. Be sure that it is in a format that is easy to follow and can be shared with others. Then do the activity.

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Exploration: Part II

Choose Option A or Option B (below) to continue your investigation. Design a new data-collection sheet for that option. Complete the second option if time permits, using another data collection sheet.

OPTION A

- Predict what would happen if you tried the experiment again but left out one of the chemicals.
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Summary

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Teacher and Learner Responsibility in Science Activities

	Learner	Teacher / Learner	Teacher
Who determines the question/problem?			★
Who determines the procedure/design?		★	
Who determines the results/analysis?		★	

Learner
The learner determines. The teacher may have a small role. (Note that, in this context, "Teacher" may also refer to lessons from science kits and other curriculum materials.)

Teacher/Learner
The teacher determines some parts and the learner determines some parts. There are a number of ways in which teachers and learners can share responsibilities. The following are some examples:

The question/problem
The students raise a number of questions after exploring materials. The teacher chooses one of these questions for the students to investigate.

The procedure/design
The teacher provides the procedure. The students decide how to record the data.

The results/analysis
The teacher tells students to expect to find a pattern in the data. The students figure out what the pattern is.

Teacher
The teacher determines. The learner may have a small role.

NOTE: This chart draws upon ideas from the following:

Alan Colburn. "How to Make Lab Activities More Open-ended." *CSTA Journal* (Fall 1997, pp. 4–6). Available online at www.exploratorium.edu/ifi/resources/workshops/lab_activities.html.

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Joseph J. Schwab. "The Teaching of Science as Enquiry" in *The Teaching of Science*. (Cambridge, MA: Harvard University Press, 1962.)

Changes Activity (Unshifted)

In this activity, you'll experiment with chemical reactions that take place in a ziplock sandwich bag. The sealed bag prevents any chemicals from escaping before you have a chance to observe the reactions.

Chemists gather evidence by observing. A chemical detective watches out for these four indicators (among others) of a chemical reaction:

change of color
change of temperature
formation of solids
formation of gases

A good chemist must be careful and take the time to look for each of these kinds of evidence.

Procedure

- Put on your safety equipment.
- Place ¼ teaspoon of sodium bicarbonate ($NaHCO_3$) and ½ teaspoon of calcium chloride ($CaCl_2$) into the ziplock bag.
- Pour 5 mL of phenol red into the medicine cup.
- Place the cup carefully in the baggie so that it stays upright, squeeze out as much air as possible, and seal the bag.
- Tip over the cup and mix the contents together.

Use the back of this sheet if you need more room to record your observations and discoveries.

Questions

1. Write detailed observations of the changes you see._____

2. What evidence have you gathered that a chemical reaction took place?_____

3. Predict what would happen if you left out the calcium chloride ($CaCl_2$). Try the experiment again, make careful observations of the changes you see and record them below. Predict what would happen if you left out the sodium bicarbonate ($NaHCO_3$). Try this, and record your observations and results.

4. What happens when you use ⅛ teaspoon of sodium bicarbonate ($NaHCO_3$)? What if you use 1 teaspoon of calcium chloride ($CaCl_2$)? Record everything that happens and the amount of each chemical added.

5. What have you discovered about chemistry from this experiment?_____

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Teacher-Identified Shifts

- Language of instruction is more open-ended.
- Learners design their own data sheets.
- Learners choose what they investigate.
- Learners are asked to report what they think is significant.
- There's no assumption that there's a "right" answer.
- There's an expectation that learners will have new questions when they're finished.

Teacher-Identified Benefits of Shifts

- Designing their own data sheets gives students a sense of freedom and also helps them focus.
- Because students aren't told what to look for, they have to observe and interpret their results very carefully.
- Students have to use higher-order thinking skills to interpret and analyze what they are seeing.
- Students have to describe in detail what they observe, then analyze and summarize what they did very carefully.
- To explain their results, students have to write more than just brief notes.

Teacher-Identified Benefits of Shifts (continued)

- Students have ownership of what they do.
- Students are encouraged to make discoveries.
- It's empowering to make your own discoveries.
- Having choices gives students confidence.
- Students have to think for themselves.
- Anticipating what results they might get keeps students involved.

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4. What happens when you use ¼ teaspoon of sodium bicarbonate ($NaHCO_3$)? What if you use 1 teaspoon of calcium chloride ($CaCl_2$)? Record everything that happens and the amount of each chemical added.

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	Learner	Teacher / Learner	Teacher
Who determines the question/problem?			★
Who determines the procedure/design?			★
Who determines the results/analysis?			★

Changes Activity (Shifted)

	Learner	Teacher / Learner	Teacher
Who determines the question/problem?			★
Who determines the procedure/design?		★	
Who determines the results/analysis?		★	

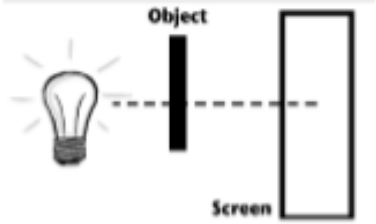
Any shift in responsibility from teacher towards learner will give students more practice in developing inquiry skills

Subtle shifts are possible, manageable, and VERY effective

Measuring Shadows Activity (Unshifted)

Procedure

1. Keep the light source in the same spot and move the object. Measure and record the size of the shadow with the object at the listed positions.



Distance from light to screen	Distance from light to object	Size of object	Size of shadow
240 cm	60 cm	15 cm	
240 cm	80 cm	15 cm	
240 cm	120 cm	15 cm	

2. What patterns do you see in the sizes of the shadows?

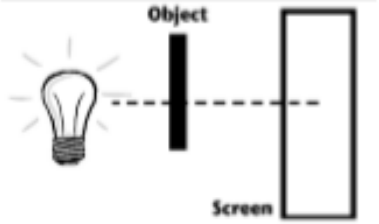
3. Move the light source and keep the object in the same place. Measure and record the size of the shadow with the light source at the listed positions.

Distance from light to screen	Distance from object to screen	Distance from light to object	Size of object	Size of shadow
160 cm	120 cm	40 cm	15 cm	
180 cm	120 cm	60 cm	15 cm	
240 cm	120 cm	120 cm	15 cm	

4. What patterns do you see in the sizes of the shadows?

Measuring Shadows Activity (Shift 1)

Note: Gray areas indicate shifts in the activity.



Procedure

1. Keep the light source in the same spot and move the object. Measure and record the size of the shadow with the object at different positions. Choose positions that will help you see patterns in your result.

Distance from light to screen	Distance from light to object	Size of object	Size of shadow
240 cm		15 cm	
240 cm		15 cm	
240 cm		15 cm	

2. What patterns do you see in the sizes of the shadows?

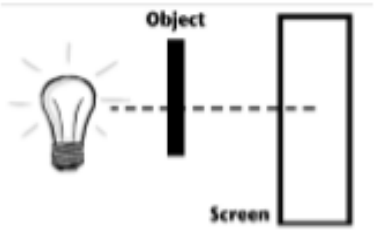
3. Move the light source and keep the object in the same place. Measure and record the size of the shadow with the light source at different positions. Choose positions that will help you see patterns in your result.

Distance from light to screen	Distance from object to screen	Distance from light to object	Size of object	Size of shadow
	120 cm		15 cm	
	120 cm		15 cm	
	120 cm		15 cm	

4. What patterns do you see in the sizes of the shadows?

Measuring Shadows Activity (Unshifted)

Procedure



1. Keep the light source in the same spot and move the object. Measure and record the size of the shadow with the object at the listed positions.

Distance from light to screen	Distance from light to object	Size of object	Size of shadow
240 cm	60 cm	15 cm	
240 cm	80 cm	15 cm	
240 cm	120 cm	15 cm	

2. What patterns do you see in the sizes of the shadows?

3. Move the light source and keep the object in the same place. Measure and record the size of the shadow with the light source at the listed positions.

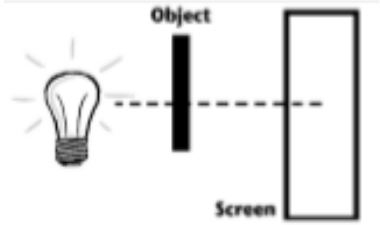
Distance from light to screen	Distance from object to screen	Distance from light to object	Size of object	Size of shadow
160 cm	120 cm	40 cm	15 cm	
180 cm	120 cm	60 cm	15 cm	
240 cm	120 cm	120 cm	15 cm	

4. What patterns do you see in the sizes of the shadows?

Measuring Shadows Activity (Shift 1)

Note: Gray areas indicate shifts in the activity.

Procedure



1. Keep the light source in the same spot and move the object. Measure and record the size of the shadow with the object at different positions. Choose positions that will help you see patterns in your result.

Distance from light to screen	Distance from light to object	Size of object	Size of shadow
240 cm		15 cm	
240 cm		15 cm	
240 cm		15 cm	

2. What patterns do you see in the sizes of the shadows?

3. Move the light source and keep the object in the same place. Measure and record the size of the shadow with the light source at different positions. Choose positions that will help you see patterns in your result.

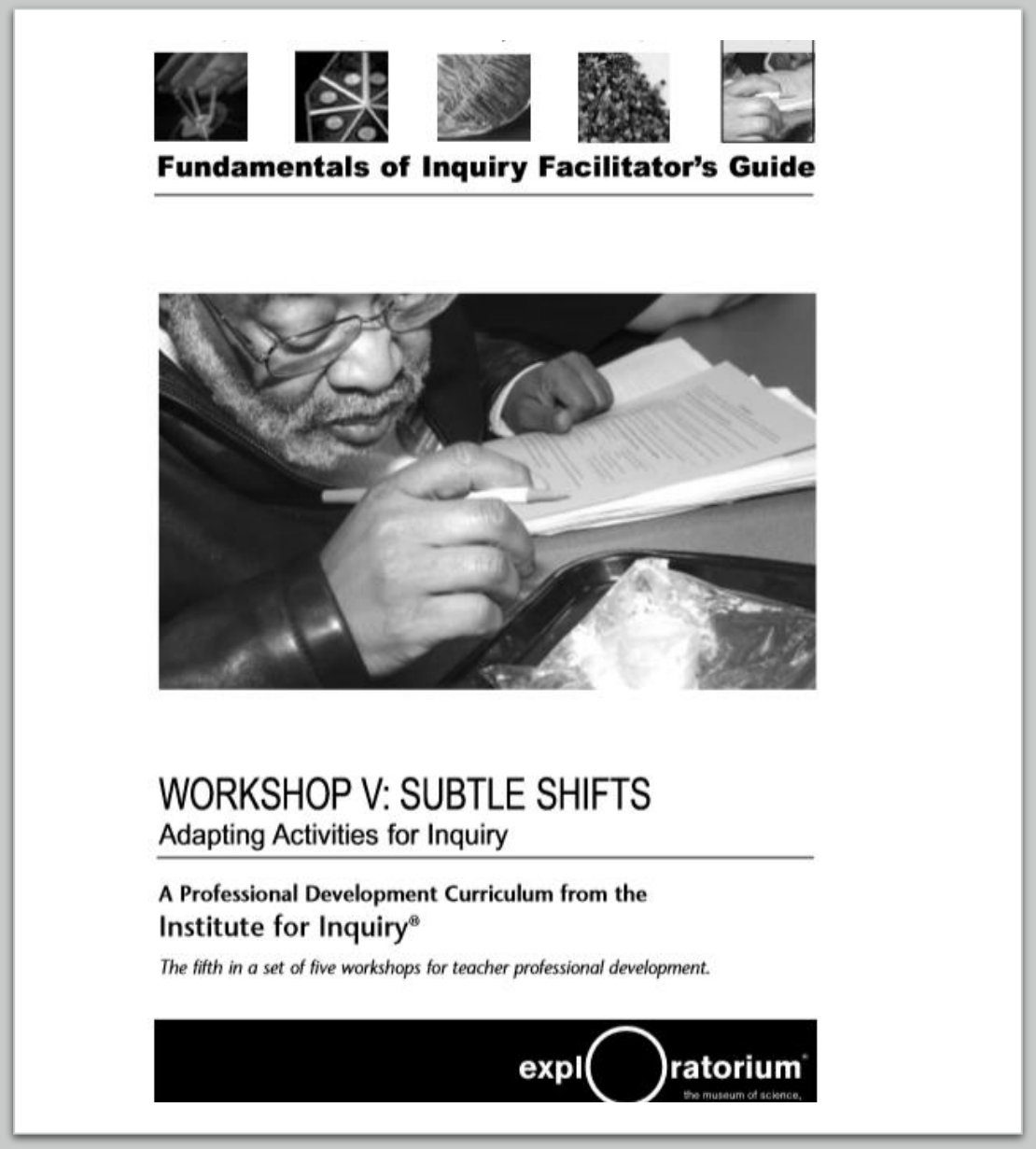
Distance from light to screen	Distance from object to screen	Distance from light to object	Size of object	Size of shadow
	120 cm		15 cm	
	120 cm		15 cm	
	120 cm		15 cm	

4. What patterns do you see in the sizes of the shadows?

Subtle Shifts:
Adapting Activities for Inquiry

Take Home Messages

- To help learners develop the abilities to do scientific inquiry, teachers need to give students responsibility for using the process skills of science
- Teachers can make small shifts in existing activities to help learners strengthen the process skills needed for scientific inquiry
- Lessons can be modified in specific ways to achieve particular purposes



Fundamentals of Inquiry Facilitator's Guide

WORKSHOP V: SUBTLE SHIFTS

Adapting Activities for Inquiry

A Professional Development Curriculum from the Institute for Inquiry®

The fifth in a set of five workshops for teacher professional development.

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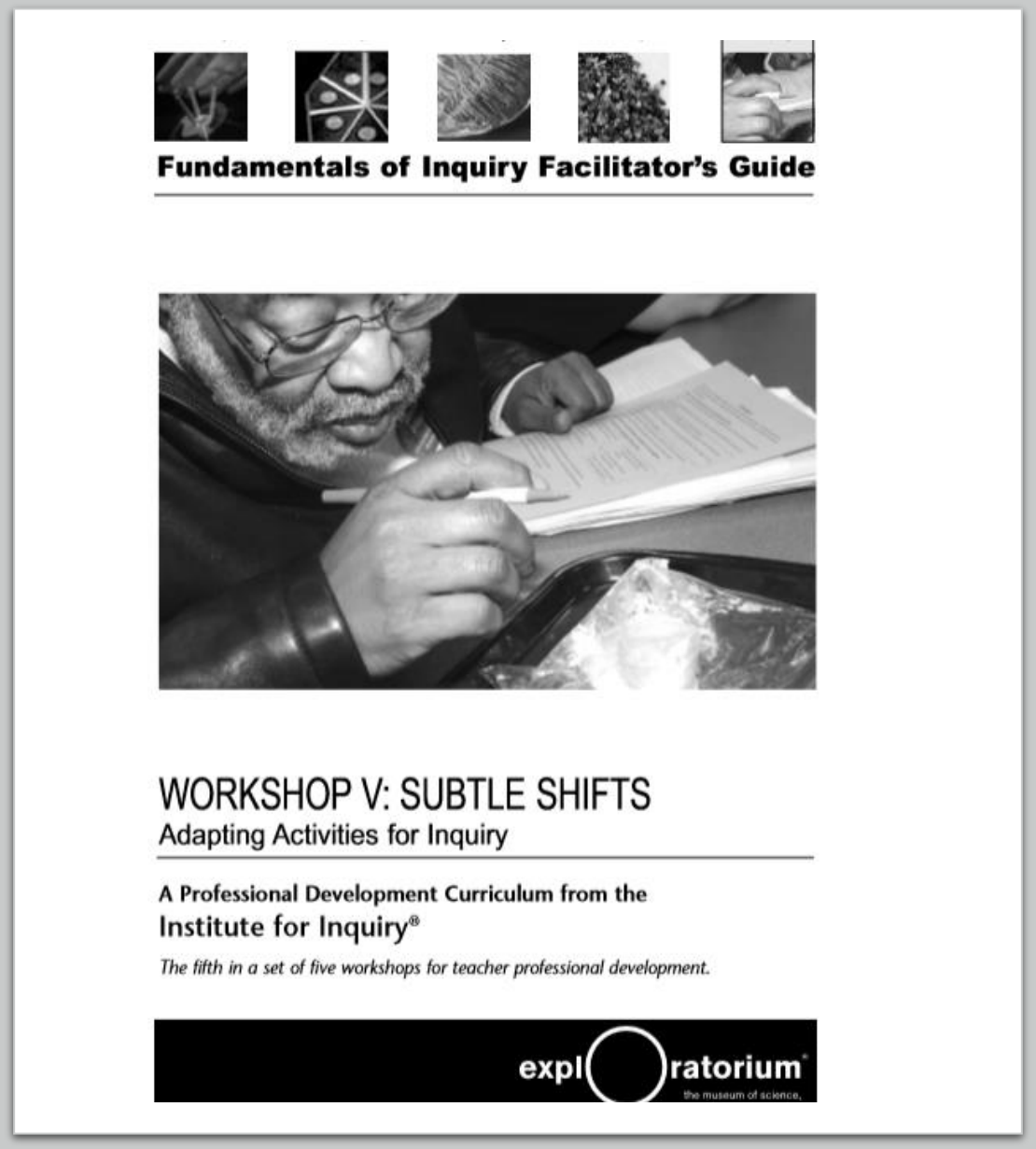
https://www.exploratorium.edu/sites/default/files/pdfs/ifi/Subtle_Shifts.pdf

Subtle Shifts:
Adapting Activities for Inquiry

Take Home Messages

- Lessons can be modified in specific ways to achieve particular purposes
  - **asking questions**
  - **planning and conducting experiments**
  - **analyzing data to draw conclusions**
  - **communicating results to others**

This will be focus of webinar session 3



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Q&A

THANK YOU!!!

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