Appendix

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* National Science Foundation, the Division of Elementary, Secondary, and Informal Education. *Foundations: A Monograph for Professionals in Science, Mathematics, and Technology Education.* Arlington, VA: National Science Foundation, n.d. Reproduced with permission.
Also available at http://www.nsf.gov/pubs/2000/nsf99148/.

** Pearce, Charles R. *Nurturing Inquiry: Real Science for the Elementary Classroom.* Portsmouth, NH: Heinemann, 1999. Reproduced with permission.

Science Web Links

American Association for the Advancement of Science Netlinks
http://ehrweb.aaas.org/scinetlinks/curriculum/index.html

American Association for the Advancement of Science/Benchmarks for Science Literacy
http://project2061.aaas.org/tools/benchol/bolframe.html

National Science Education Standards
http://www.nap.edu/readingroom/books/nses

National Science Foundation
http://www.nsf.gov

Eisenhower National Clearinghouse for Math and Science
http://enc.org

Clearinghouse for Science, Mathematics, and Environmental Education
http://www.ericse.org/

Mid-Continent Research for Education and Learning
http://www.mcrel.org/resources/links/science.asp

The Exploratorium Institute for Inquiry
http://www.exploratorium.edu/IFI/index.html

The Franklin Institute Science Museum Learning Resources
http://www.fi.edu/learning.html

Concept to Classroom: Inquiry-Based Learning
http://www.thirteen.org/wnetschool/concept2class/month6/

University of Illinois' The Inquiry Page
http://w3.ed.uiuc.edu/inquiry/index.lasso

Inquiry-Based Learning and Teaching: Mathematics and Science Through Museum Collections
http://www.bsu.edu/teachers/burris/iwonder/

Frequently Asked Questions About Inquiry

Workshop 1. What Is Inquiry and Why Do It?

1. What is inquiry teaching?

Inquiry teaching is allowing students' questions and curiosities to drive curriculum. Inquiry begins with gathering information through applying the human senses—seeing, hearing, touching, tasting, and smelling. Inquiry encourages children to question, conduct research for genuine reasons, and make discoveries on their own. The practice transforms the teacher into a learner with students, and students become teachers with us. Inquiry teaching honors previous experience and knowledge. It makes use of multiple ways of knowing and taking on new perspectives when exploring issues, content, and questions.

2. How will inquiry teaching help my students learn?

In an inquiry-based classroom, students aren't waiting for the teacher or someone else to provide an answer—instead, they are actively seeking solutions, designing investigations, and asking new questions. Students quickly see the cycle of learning and that learning has cycles. Students learn to think and problem-solve. They learn that there is no one place or one resource for answers, but that many tools are useful for exploring problems. Students actively involved in making observations, collecting and analyzing information, synthesizing information, and drawing conclusions are developing useful problem-solving skills. These skills can be applied to future "need to know" situations that students will encounter both at school and at work.

3. Why is the time dedicated to this teaching methodology a good investment?

You are spending time supporting thinkers and helping their minds develop so that they can approach new learning creatively and energetically. Students are learning how to learn. You are supporting their quest for knowledge and their curiosity about their world. In traditional schools, students learn not to ask too many questions; instead, to listen and repeat the expected answers. Most of our schools focus on teaching a set of basic skills that do not serve the needs of modern society. Our modern society is faster paced, globally networked, technologically oriented, and requires workers who can problem-solve and think critically. Memorizing facts and information is not the most important skill in today's world. Facts change, and information multiplies at an incredibly fast rate—what's needed is an understanding of how to make sense of it all. Inquiry teaching and learning teaches students how to seek appropriate resolutions to questions and issues.

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Frequently Asked Questions About Inquiry

Workshop 2. Setting the Stage: Creating a Learning Community

4. What is my role in an inquiry classroom?

The success of your inquiry classroom comes from a shift in your role from the "sage on the stage" to the "guide on the side." You are the key facilitator of learning in the inquiry classroom. You are the leader, the coach, the question-asker, the seeker of resources, and the theory-builder.

Although there are still many times when you present information to students, you are not solely responsible to impart all of the information. Students participate as question-askers and seekers of answers. You thoughtfully orchestrate learning experiences based on the students' prior knowledge and interests, and the guidelines of the science standards. In addition, you document the students' progress with ongoing (formative) and final (summative) types of assessments. You create a rich variety of assessments for students to "show what they know."

5. How do I begin to build "a classroom community?"

Building a classroom community with your students aligns with a powerful principle of learning: Maintain clear expectations within high standards socially and academically. Begin the year by outlining clear "ground rules" with your students, making it clear that there is no tolerance for disrespectful or hurtful actions to others. For inquiry to be successful, students need to feel safe to take risks, share ideas, and believe ideas can lead to more ideas and questions, even if they are not correct. Virginia Lockwood, the first-grade teacher seen in the program, created a mantra she continually shares with her students: "Your actions and your words need to match your head and your heart." She suggests to address disrespectful behavior in the classroom immediately without being punitive. For example, you can stop your teaching if a child giggles at another, and remind students how the classroom should operate. When students are involved in building their classroom community, they are empowered that their ideas count—the foundation for inquiry.

6. How can teachers keep all students involved in an inquiry classroom?

Cooperative work groups foster a sense of community and include all students. Students don't "get lost in the crowd." Small groups of two work well to begin. The groups are given a task. Each student is assigned a role. For example, one student might be the recorder. The other student might be the presenter to the class. As you develop the interpersonal skills of the students and the complexity of the project, you may want to expand the group size to three or four. A few examples of student roles may include: leader (student who keeps the group focused on the task); recorder (student who keeps a record of discussion or findings of the group); facilitator (student who helps resolve conflicts); graphic designer (student responsible for art or design of project); and presenter (student responsible for sharing group's findings with the class).

Frequently Asked Questions About Inquiry

Workshop 3. The Process Begins: Launching the Inquiry Exploration

7. How can I begin to build techniques of inquiry into my existing lessons?

A key technique to encourage inquiry in your existing lessons is to focus on the nature of conversation in your classroom. In a traditional teacher-centered classroom, notice how all eyes are always on the teacher, who presents information. For inquiry to be successful, the classroom needs to shift from a teacher-centered to a student-centered environment, whereby students contribute to the questioning and generate hypotheses. If you have a specific lesson plan with dictated outcomes, take time to let students linger in their conversations, encouraging them to wonder and think. Ask them questions, such as "Why do you think that?" and "What does it make you wonder?" Steer away from "popcorn" conversation, that is, undeveloped student responses, such as "I think this" and "I think that." Encourage students to build on each others' ideas by probing, "How do we know that?" This process helps students develop the habits of mind or attitudes of scientific thinking.

8. What resources are available to support my science content knowledge?

There are a variety of search engines on the Internet to support your teaching and the development of background knowledge. One very "kid- and teacher- friendly" Web site is Yahooligans—http://www.yahooligans.com—which may be used as a search engine to explore a specific topic. In addition, suggested science categories are provided under the Science and Nature link. Another valuable Web site has been developed by the American Association for the Advancement of Science Netlinks—http://ehrweb.aaas.org/scinetlinks/curriculum/index.html—which has aligned the science benchmarks with Web links that have been reviewed by educators. Also, seek out resources from local nature centers, botanical gardens, zoos, and other outside science organizations. These agencies provide educational outreach and support to schools. In addition, there is a wide assortment of non-fiction books available on science topics. The Childrens' Book Council and National Science Teachers Association offer a list of award-winning non-fiction science titles each year, which you can inquire about at your local library

9. How can science kits that are not specifically designed for inquiry be extended to encourage inquiry?

Many science kits are full of excellent materials. Try to engage students in conversation about these materials before you engage in activities with designated outcomes. Kits that are not designed for an inquiry approach to teaching and learning tend to encourage predetermined "hands-on" projects, whereas inquiry requires students to generate questions—and more questions—before they look for the answers. For example, in a traditional classroom, students might look at a diagram and then listen to a lecture about a topic. To encourage inquiry, you can give students an opportunity to ask their own questions about phenomena—students then act as problem-solvers rather than fact-finders.

Frequently Asked Questions About Inquiry

Workshop 4. Focus the Inquiry: Designing the Exploration

10. How is inquiry science teaching different than "hands-on" science teaching?

"Hands-on" doesn't always mean "minds-on." In a "hands-on" situation, the teacher might be conducting the investigation, with students following along, as they would with a recipe. In inquiry teaching and learning, students are thinking and questioning. They are coming up with the questions to investigate. Students devise these investigations that in fact are hands-on, but not prescribed by the teacher. Inquiry teaching and learning naturally follows the students' learning path, as they design, problem-solve, and collaborate.

11. Why shouldn't I just tell the students the "facts"?

Besides boring students, they often won't believe you anyway. They may hear you and even regurgitate the facts, if that is what you're asking them to do, but they only come to know something when they make it their own. Students need to work out discrepancies in previously held ideas and new observations they are making about their world and environment. An old adage states: "Tell me and I forget, show me and I remember, involve me and I understand." The last part of this statement is the essence of inquiry-based learning.

Workshop 5. The Inquiry Continues: Collecting Data and Drawing Upon Resources

12. Why is it important for students to learn how to access information and find their own resources?

We are living in an age in which available information is expanding at a remarkable rate. If students don't learn how to access and process information, they will be at an incredible disadvantage. Learning "just the facts" isn't enough anymore because the "facts" are changing. If students only learn how to memorize, when they leave school they have the knowledge base that is the equivalent of an outdated encyclopedia.

Students need to learn how to ask and answer new questions that arise. To answer the questions, they will need to learn how to filter the vast resources to find the information that they need. They will need to evaluate the resources for accuracy. Finally, they need to learn how to process sources of information to make thoughtful decisions in the future.

Frequently Asked Questions About Inquiry

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

13. What kinds of questions can I ask to facilitate an inquiry discussion?

Questions are at the heart of inquiry learning and teaching. While questions are often part of the traditional classroom, the sources and purposes are quite different. In the traditional classroom, the teacher often uses questions to provoke feedback about a reading or an activity. In the inquiry classroom, the teacher asks questions that are more open ended and reflective in nature, such as "What are you thinking, and why do you think that?" "What do you notice, and what does it make you wonder?" "How is this helping us as scientists?" You might have students use folders where they can keep their lists of questions and ways to find answers.

For further resources, see:

The Art of Questioning
by Dennis Palmer Wolf, *Academic Connections,* Winter 1987, pp. 1-7
http://www.exploratorium.edu/ifi/resources/workshops/artofquestioning.html

Workshop 7. Assessing Inquiry

14. How do I assess the students' prior knowledge and interests?

Many teachers find the use of a KWL chart a rich source of indicators of students' prior knowledge and interests. On a piece of chart paper the teacher writes: "K: What do we *know* about _____ (selected science topic)?" When the students are providing "facts" on the topic, the teacher writes down comments without judgement or correction. (Example: "What you're saying is....") If the students are corrected at this stage, they will stop contributing for fear of embarrassment, and the teacher's ability to assess prior knowledge will be diminished.

Student areas of interest are assessed with "W: What do we *want to know* about _____ (selected science topic)?" In a similar fashion, the teacher writes the question on the paper and students offer questions on the topic. The teacher can watch for nonverbal student reactions to the question. If several students turn their heads toward the questioner, look up, etc., this may be an area of wide appeal. If only the questioner seems interested, this student may need assistance to conduct an independent study investigation.

Progress may be witnessed through the "L: What we have *learned* about _____ (selected science topic)?" Findings on the topic may be recorded on this chart paper. Additional questions that arise during investigations may be included.

Frequently Asked Questions About Inquiry

Workshop 7. Assessing Inquiry, cont'd.

15. What are some examples of performance assessment?

Performance assessment has numerous definitions but here are the most common. Performance assessments can be based either on observations of the process while skills are being demonstrated, or on the evaluation of products created. It is the "doing" that counts, and the index of achievement typically is a performance rating or profile of ratings reflecting levels of quality in the performance. Many teachers involve the students in designing "quality indicators" prior to the performance.

In the case of product evaluations, the student creates a complex, achievement-related product that is intended to meet certain standards of quality (determined by the teacher based on learning goals for the student). Clearly it is important for you to have well-defined learning goals for the students. These goals constitute the essence of the kinds and substance of the assessments. Performance assessment is designed to find out if the student can use the information in new and/or different ways. An example might be to design an investigation that answers a question (posed either by the student or teacher). The level of performance is assessed using a rubric, and might for example, assess problem-solving, science process skills, communication, or a combination of these. Performance is less about right answers and more about process and thinking.

16. Why are both formative and summative evaluations important?

Formative assessment is ongoing and helps inform teachers of students' process and acquisition of understanding. Formative assessment holds students accountable through the learning process. As you facilitate learning, you monitor the progress of the learner. Learning and assessing learning outcomes go hand-in-hand. Effective teachers are alert to the needs of particular students and the needs of the whole class. Formative assessment in the form of observation or note-taking can help you identify if there is an individual need, so you can work with that student one-on-one. If the whole class is experiencing a similar problem, you can provide a whole-class mediation. The essential point is that formative assessment informs important instructional changes. The focus of summative assessment considers the student outcomes from an inquiry-learning experience, such as the degree to which the processing of learning skills has been developed; the degree to which the habits of mind or "ground rules" of science have been mastered; and the degree to which students have developed the content knowledge. An effective summative evaluation is a narrative assessment—narrative provides a report for the student, family, and teacher, describing the way a student demonstrates what he/she knows and how it relates to his/her other knowledge and ways of analyzing ideas.

Frequently Asked Questions About Inquiry

Workshop 7. Assessing Inquiry, cont'd.

17. How do I "grade" an inquiry lesson?

A rubric can easily be translated into grades. It's best if it is only one aspect of the grade—in other words, there can be a number of performances and other assessments that would figure into a grade. Usually, in inquiry, the teacher has multiple goals. If one of the goals is to learn content, then you can use the traditional assessments like tests, quizzes, diagrams, etc. If a goal is to learn process skills, you will probably have a rubric that specifies the process skills that would be evident in the investigation, and the written product that goes with their investigation. If the intention is for the students to apply information they have already learned, then the criteria in the rubric might focus on the accuracy of information, and the correlations between the data and the conclusions, etc. In an integrated curriculum, you might also use the written product to assess writing, spelling, and grammar. You should also consider involving students in the creation of the rubrics.

Workshop 8. Connecting Other Subjects to Inquiry

18. Is it possible to integrate other subject areas into science inquiry lessons?

It is imperative to integrate other subjects into science inquiry, yet it is important to use these subjects as a tool to facilitate inquiry investigations and not to dispense with other subject curricula. That is, you should follow your reading, writing, and mathematics curricula to build solid skills, so students can use reading, writing, and mathematical skills fluidly and with comfort when performing scientific inquiry.

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