What Is Inquiry?

Ask a roomful of science teachers to explain the meaning of inquiry, and you will probably get a roomful of different answers. And for that, we should not be surprised, because each one would answer the question according to his or her prior knowledge and experience in inquiry-based instruction. The purpose of Chapter 1 is to examine your present understanding of inquiry and compare and contrast it with the understanding of various national experts. This chapter is quite different from others you may have read about inquiry. In my attempt to model constructivist theory, I’m not going to tell you what you should think inquiry is. Rather, you must construct your own meaning and understanding by confronting your beliefs and attitudes about inquiry and making changes and accommodations to suit your own ideas. So, to begin constructing a definition of inquiry, you must start with your present understanding.

As an initial exercise, write down your present understanding and/or definition of inquiry. You may choose to write several statements on 3-by-5 cards (one statement per card), or you may choose to make a concept map to organize your thoughts.

Concept maps (Novak & Gowin, 1989) are schematic diagrams illustrating the relationships and interconnections of concepts for a particular topic. Novak (1998) reports that when teachers and students frequently used concept maps, they learned how to negotiate meaning, organize ideas, and become more effective learners.

When constructing a concept map it is important to

1. Place the main idea at the top or the center of the map.
2. Organize the words or terms from most general to most specific.
3. Use a linking word (verb, preposition, or short phrase) to connect and illustrate the relationship and linkages from one idea to another.
4. Use crossing links to make connections between words in different areas of the map.
5. Add to the map as new knowledge is constructed (see Figure 1.1).

Whether you use 3-by-5 cards or a concept map, it is important for you to determine your present conceptions regarding inquiry. When you are done, take a few moments and
Figure 1.1. Concept Map

nonlinear organization
preconceptions
review or summary
and
assess prior knowledge
as
post assessment
shows
as
evolution of child's thought
new knowledge is assimilated
modified throughout lesson
and
conceptual Maps
as
are
are
to
constructed
to
represent information and knowledge
illustrated by
webs or diagrams
connections visible
shows
construction of knowledge
introduce a chapter
are
used to
not-taking techniques
multidimensional
can be
by
graphic relationships among concepts
that show
used for
assessment
as
connected by
hierarchy from general to specific
linking words (verbs or prepositions)
by
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reflect on your statements and definition of inquiry. At that time, you may want to add or modify them in some way. You will save these statements and come back to them several times throughout the course of this book. Later in the chapter, you will use other statements from the Exploratorium, the National Research Council (NRC), and the American Association for the Advancement of Science (AAAS) to modify and refine your definition. As you continue through this book, you will use a constructivist approach to assimilate new information about inquiry and make accommodations in your own mental model while constructing a personal meaning for inquiry. At the end of this book, you will again be asked to reflect on your statements and definition of inquiry to assess your understanding “pre” and “post.”

WHAT THE EXPERTS SAY

The Exploratorium in San Francisco is a hands-on science museum and professional development center for inquiry-based learning. In Fall 1996, the Exploratorium's Institute for Inquiry held a forum in which researchers, teachers, and professional development specialists examined the topic of inquiry from the perspective of their different disciplines—science, mathematics, history, writing, and the arts. Prior to the forum, participants were asked to write short descriptions of inquiry from their professional perspectives. The following are selected descriptions that pertain specifically to science:

Philosophically, I find inquiry a wonderful metaphor for life. Interacting with phenomena in open-ended ways, following individualized learning paths and noticing everything that occurs, especially the oddities, is a fitting way to go through one’s days whether practicing science, the arts, or life. . . . I have become convinced that although inquiry can be a highly personalized experience, it has structures and elements that can be explored and described. The “magic” can be examined and transformed into tools for those who want to teach it and practice it. (Doris Ash, Science Educator, Exploratorium)

Inquiry . . . is a process of exploration which is guided by a personal interest or question. It involves risk taking and experimenting which can lead to pathways where the learner may discover meaningful concepts and understandings. (Marilyn Austin, Teacher-in-Residence, Exploratorium)

Inquiry is practiced naturally from birth as a primary way to develop an understanding of the world around us. Utilizing curiosity and intuition, all of the senses and instincts for observation, seeking and questioning and making use of memory. These are at the same time tools and skills for learning and understanding, which are naturally there but that can also be nurtured and encouraged through guidance. (Daniel DiPerro, Artist/Educator, Exploratorium)

Inquiry, to me, means pursuing a question and figuring out the solutions to problems through a process of observation, development of explanations (theories), testing these through experimentation, discussing the outcomes and adjusting theories based on the outcomes. These various steps are
developed with the participation of all members of the class and always shared and debated in group discussions. . . . By listening to one another, and working to make sense of what others say, students are invited to broaden their notions of the topic and consider new ideas. (Mary DiSchino, Teacher, Graham & Parks Alternative School, Cambridge, MA)

Curiosity is the centerpiece of inquiry, and curiosity is indicated by a question or questions. . . . To inquire is to seek, obtain and make meaning from answers to one’s questions. (Hubert Dyasi, Director, Workshop Center, City College of New York, School of Education)

An inquiry approach to teaching stimulates curiosity by teaching children how to observe very closely, encourages children to take more than one quick look, provides adequate materials for exploration, and makes it safer for students to ask questions and to take risks. It helps them to make connections to events in their own lives, and gives them ownership of their learning. I believe that using inquiry can be a means for significant change in teaching in the schools, from providing an education that relies on memorization of facts to one that teaches thinking and problem-solving, and enhances the ability of students to relate what they learn to new problems that come up later. Equally important, teachers need to inquire into their own teaching methods . . . constantly reflecting on their own teaching. (Cappy Greene, Science Educator, Exploratorium)

Inquiry is a major means for learners to extend their understanding of the natural and made environment. It is essentially active learning, inseparably combining mental and physical activity. The motivation for inquiry is within the learner and the learner’s relation to the things around him or her. Inquiry starts with something that intrigues, that raises a question—something that is not presently understood, that does not fit with expectations, or just something that the learner wants to know about. . . . The process of inquiry involves linking previous information to the new experience in an attempt to make sense of the new. (Wynne Harlen, Director, Scottish Council for Research in Education, Edinburgh, Scotland)

Science inquiry consists of actions in the world that allow for multiple results. Any activity that is intended to lead to one result only should not be considered inquiry. The definition excludes almost all school laboratory work, because that usually is intended to demonstrate a concept, not general, novel or diverse activity. (George Hein, Director, Program Evaluation and Research Group, Lesley College, Cambridge, MA)

We were born doing science. By randomly touching objects and placing them in our mouths, we learned as toddlers what is hot or cold, sweet or sour, sharp or dull, rough or smooth. We learned almost everything through inquiry. Watching toys sink or float in the bathtub is/was a chance to investigate the principle of buoyancy. By playing catch, we made discoveries about gravity and trajectories. By building towers out of blocks, we explored principles of size, scale and center of mass. . . . Unfor-
fortunately, somewhere along the way we lose our natural curiosity about the world. It seems to happen when we are faced with our first science class. Science becomes a list of facts and formulas to memorize. Our natural instincts to do inquiry are suppressed. (Linda Shore, Co-Director, Teacher Institute, Exploratorium)

Now, go back to your statements and definition of inquiry and compare and contrast them with the statements above. How are your statements or definition of inquiry similar to those of the Exploratorium participants? How are they different? If you agreed with any of the statements you read, add them to your 3-by-5 cards or concept map.

**WHAT THE EXPLORATORIUM MEANS BY INQUIRY**

The Exploratorium (1998) also provides several statements regarding the definition of inquiry. As you read these statements below, use them to reflect on your own ideas of inquiry and to enhance your understanding. Again, you will be asked to reflect on the Exploratorium’s definition of inquiry-based learning and compare it with the definition of inquiry you wrote earlier. According to the Exploratorium,

Inquiry is an approach to teaching that involves a process of exploring the natural or material world, that leads to asking questions and making discoveries in the search of new understandings. Inquiry, as it relates to science education, should mirror as closely as possible the enterprise of doing real science.

The inquiry process is driven by one’s own curiosity, wonder, interest or passion to understand an observation or solve a problem.

The process begins by the learner noticing something that intrigues, surprises, or stimulates a question. What is observed often does not make sense in relationship to the learner’s previous experience or current understanding.

Action is then taken through continued observing, raising questions, making predictions, testing hypotheses and creating theories and conceptual models. The learner must find [his or her] own idiosyncratic pathway through this process: it is hardly ever a linear progression, but rather more of a back and forth or cyclical series of events.

As the process unfolds more observations and questions emerge, giving occasion for deeper interaction and relationship with the phenomena—and greater potential for further development of understanding.

Along the way, the inquirer is collecting and recording data, making representations of results and explanations, drawing upon other resources such as books, videos, and colleagues.

Making meaning from the experience requires intermittent reflection, conversations and comparison of findings with others, interpretation of data and observations, and applying new conceptions to other contexts as one attempts to construct new mental frameworks of the world.

Teaching science using the inquiry process requires a fundamental reexamination of the relationship between the teacher and the learner.
whereby the teacher becomes a facilitator or guide for the learner’s own process of discovery and creating understanding of the world.

**WHAT THE NATIONAL SCIENCE EDUCATION STANDARDS SAY ABOUT INQUIRY**

In 1996, the NRC released the *National Science Education Standards (NSES)*. In regard to the inquiry standards, the NRC states,

Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (p. 23)

The NRC (1996) standards highlight the ability to conduct inquiry and develop an understanding about scientific inquiry:

Students in all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about the relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments. (p. 105)

The inquiry standards set forth by the NRC (1996) are divided into three separate grade levels or junctures. Each juncture identifies inquiry standards specific to that grade. The standards help science educators define what students should know and be able to do. Reading and analyzing the inquiry standards for a particular grade level can result in a deeper understanding of inquiry. Reading the inquiry statements from the *NSES* is strongly recommended. The standards can be purchased in softcover (www.nap.edu/bookstore) or downloaded from the National Academy Press. You may also be interested in the accompanying text, *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning* (see Resource A).

Now, go back to your definition and compare it with the statements above. How is your definition of inquiry similar to and different from the *NSES*?

**WHAT THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE SAYS ABOUT INQUIRY**

In 1990, the AAAS published the first of two documents, *Science for All Americans*, which outlined a long-term view for instructional reform in science. It also marked the
beginning of Project 2061 by the AAAS, which proposed recommendations for moving toward the goal of nationwide scientific literacy by the year 2061 (the year of the return of Halley’s Comet). Following Science for All Americans, in 1993, the AAAS released Benchmarks for Science Literacy. It did not define curricular needs but identified specific outcomes for science education and, like the NSES, provided local school districts, state education agencies, and national science educational organizations with a blueprint for systemic reform.

Like the NSES, Project 2061 addressed the need for integrating scientific inquiry and content. The AAAS (1993) describes scientific inquiry as being

more complex than popular conceptions would have it. It is, for instance, a more subtle and demanding process than the naive idea of making a great many careful observations and then organizing them. It is far more flexible than the rigid sequence of steps commonly depicted in textbooks as the scientific method. It is much more than just doing experiments, and it is not confined to laboratories. If students themselves participate in scientific investigations that progressively approximate good science, then the picture they come away with will likely be reasonably accurate. But that will require recasting typical school laboratory work. The usual high school science “experiment” is unlike the real thing. The question to be investigated is decided by the teacher, not the investigators; what apparatus to use, what data to collect, and how to organize the data are also decided by the teacher (or the lab manual); time is not made available for repetitions or, when things are not working out, for revising the experiment; the results are not presented to other investigators for criticism; and, to top it off, the correct answer is known ahead of time. (p. 9)

Like the NRC (1996) standards, the AAAS (1993) benchmarks are divided into separate grade levels or junctures. The AAAS uses four junctures as opposed to three used by the NRC. Both sets of standards are similar in approach and help educators define what students should know and be able to do for the particular content area and grade level. Reading the inquiry statements from Benchmarks for Science Literacy is strongly recommended. The standards can be purchased through or downloaded from the AAAS Web site (www.aaas.org). You may also be interested in accompanying AAAS texts, Inquiring Into Inquiry Learning and Teaching in Science (see Resource A).

MYTHS ABOUT INQUIRY-BASED LEARNING

So far, we have been discussing what inquiry is. Now, we address what inquiry is not by exploring several commonly held myths and misconceptions about inquiry-based learning. If your statements or concept map reveals any of the myths and misconceptions described next, you need to alter them accordingly.

*Doing hands-on science is the same as doing inquiry.*

Providing students with an opportunity to do hands-on science does not necessarily mean they are doing inquiry. Many science activities are very structured. They tell the students what questions to answer, what materials to use, and how to go about solving the questions or problems. In most cases, they even provide charts or tables to record the
observations, measurements, or data. This type of cookbook activity provides step-by-step procedures and follows a linear path to a solution. Although most inquiry activities are hands-on, not all hands-on activities are inquiry oriented.

**Inquiry is using the scientific method.**

As stated by the AAAS (1993), doing inquiry does not necessarily imply following the steps of the scientific method. Inquiry uses the logic of problem solving that comes from the scientific method but does not necessarily use the delineated, specific steps of the scientific method. The scientific method does have a role in the inquiry-based process; however, there is more to inquiry than a sequential set of procedures. Chapter 6 further explains the role of the scientific method in inquiry.

**Inquiry is unstructured and chaotic.**

In some schools, the sign of a good teacher is one who keeps a classroom quiet and under control. Classroom management skills are essential for inquiry learning, but an active, child-centered classroom should not be equated with chaos or unstructured instruction. When students do hands-on and manipulative-based science, we can expect the noise level to rise somewhat. Inquiry may appear on the surface to be open-ended and unstructured. However, as student involvement increases, so does the need for the teacher to manage classroom movement and communication. When teachers use inquiry-based strategies, they may find that teaching requires more preparation and anticipation of possible student questions than traditional teaching approaches do.

Bell and Gilbert (1996) report that teachers new to inquiry often feel less in control when students move about the room, make decisions about their work, and are encouraged to challenge the work of others. Although most teachers actually maintain control, they may perceive otherwise. To establish inquiry-centered environments, teachers must accept changes in their role and changes in the atmosphere of the classroom.

**Inquiry is asking students a lot of questions.**

A common misconception held by science teachers is that inquiry teaching requires asking a lot of questions. They may have sat in many science classrooms where teachers fired off question after question. Asking a lot of questions does not necessarily make an inquiry lesson. Chapter 9 presents several examples of effective questioning strategies, such as probing, prompting, and redirectioning, that support inquiry settings. In inquiry-centered classrooms, teachers provide open-ended experiences that lead students to raise their own questions and design investigations to answer them.

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If I let my students do inquiry, I have to be ready to answer all the questions they raise.

This is a response of many teachers. Inquiry-based instruction does not just mean finding the right answers, it means seeking the right questions. As you become more confident in using inquiry, you will find yourself less a source of information and more a facilitator of learning. That does not mean that good inquiry teachers do not concern themselves with content. Understanding content and scientific concepts are fundamental to inquiry. Doing inquiry empowers the students to answer their own questions. The teacher becomes the guide and mentor for that process.

**Inquiry is fine for elementary- and middle-level students, but high school science teachers don’t have extra time in their courses.**

For many secondary school science teachers, lecture and discussion methods are the primary means of delivering content instruction to their students. These teachers see lec-
turing as the most effective and efficient way to transmit large amounts of science information to their students in a relatively short period of time. Lecturing is the method by which many teachers learned science when they were in high school and when they were studying to become science teachers. So, on the basis of prior experience, we should not be surprised that so many science classes are lecture based.

Secondary school science teachers often talk about time constraints. With more and more concepts being added to the curriculum, many science teachers say they are pressed to cover a great number of concepts in a school year. It is true that inquiry-based learning takes more time; however, developing higher-level thinking skills, having students pose questions, plan solutions, and gather and organize data are skills that must be nurtured over time. There are no shortcuts to developing critical thinking skills. To create inquiry-based curricula or classrooms, teachers need to use their time effectively while centering on topics and concepts at the core of the curriculum.

You can’t assess inquiry-based learning.

Inquiry-based learning can be assessed like any other concept or topic in science. To assess student progress in inquiry-based learning, however, teachers need to use alternative methods of evaluation. For inquiry-based learning, popular objective-type multiple-choice questions do not adequately assess inquiry-based learning. Inquiry-based teachers often rely on portfolios, writing journal entries, self-evaluations, and rubrics in conjunction with objective-type questions to assess students’ academic progress. Examples of each of these alternative assessment measures are presented in Chapter 7.

Inquiry is the latest “fad” for science education.

Those who have studied the history of science education know that questioning, discovery learning, and inquiry date back to the early days of the Greek scholar Socrates. The progressive education reformer John Dewey is credited as being one of the first American educators to stress the importance of discovery learning and inquiry (Dewey, 1900, 1902, 1916). In his early work, Dewey proposed that learning does not start and intelligence is not engaged until the learner is confronted with a problematic situation. Inquiry was also the basis for several elementary science programs funded by the National Science Foundation in the mid-1960s. During this “golden age” of science education, programs such as Science—A Process Approach (SAPA), Elementary Science Study (ESS), and Science Curriculum Improvement Study (SCIS) were all based on the philosophy of integrating inquiry teaching and learning with science process skills.

On the secondary school level, premier high school biology programs such as the Biological Sciences Curriculum Study (BSCS; 1970) are deeply rooted in instructional methods of learning that stress the importance of inquiry-based instruction.

Inquiry is “soft science” and not content related.

We sometimes hear critics of inquiry-based instruction call inquiry “science lite” or sarcastically ask “Where’s the beef?” Inquiry, according to both the NSES and Benchmarks for Science Literacy, is one of the areas identified as content. That elevates inquiry to the same level as knowing the concepts, principles, and theories of life, earth, or the physical sciences. According to the AAAS (1990),

Science teaching that attempts solely to impart to students the accumulated knowledge of a field leads to very little understanding and certainly . . . science teachers should help students to acquire both scientific knowledge of the world and scientific habits of mind at the same time. (p. 203)
If students are to gain an appreciation for science and compete in a scientific and technical society in this new millennium, they will need to be provided with a curriculum that promotes active learning, problem solving, raising questions, and seeking ways to solve their questions. Inquiry-based science is an effective means to enhance scientific literacy. Additional research has led to the conclusion that inquiry promotes critical thinking skills and positive attitudes toward science. Although inquiry is no panacea, it is one more strategy teachers can use, at the appropriate time, to engage students in investigations and satisfy their curiosity for learning (Haury, 1993).

Inquiry is for high-achieving students and not for students with learning disabilities.

The recommendations set forth by both the NRC (1996) and the AAAS (1993) apply to all students regardless of age, cultural or ethnic heritage, gender, physical or academic ability, interest, or aspirations. The AAAS (1990) stresses that the recommendations apply in particular to those who have historically been underrepresented in the fields of science—mainly students of color, females, limited-English-proficiency students, and persons with disabilities. According to NSES, “Given this diversity of student needs, experiences and backgrounds, and the goal that all students will achieve a common set of standards, schools must support high-quality, diverse, and varied opportunities to learn science” (NRC, 1996, p. 221). The ability to think creatively and critically is not solely for the high-achieving student. Inquiry-based instruction can and should be done equitably at all levels.

**INQUIRY AS A THINKING SKILL**

Learning through inquiry empowers students with the skills and knowledge to become independent, lifelong learners. Finding solutions to their own questions will also allow students to gain an appreciation for the discovery process. Through discovery, students are easily able to assimilate and anchor their prior experiences and knowledge with newly formed experiences and knowledge.

Hunkins (1995) says,

> The good thinker, possessing attributes enabling him or her to create and use meaning—to add to knowledge and culture—possesses a spirit of inquiry, a desire to pose questions central to [his or her] world. The good thinker ponders [his or her] world, actual and desired, querying things valued and desired. (p. 18)

Hunkins goes on to say,

> These individuals realize that productive inquiry essentially starts with the articulation of personal concerns or questions. In many ways, this is a major shift, for students have been taught to wait for the authority, usually the teacher or textbook author, to furnish the problem, define the questions, and suggest the solutions. Indeed, in many schools, students are not challenged to make meaning; rather, they are asked to remember the meaning of others. (p. 19)

Hester (1994) reminds us that inquiry involves
Critical thinking processes such as methods of diagnosis, speculation and hypothesis testing. The method of inquiry gives students the opportunity to confront problems and generate and test ideas for themselves. . . The emphasis is on ways of examining and explaining information (events, facts, situations, behaviors, etc.). Students when taught for the purposes embodied in inquiry, are encouraged to evaluate the usefulness of their beliefs and ideas by applying them to new problem situations and inferring from them implications for future courses of action. (pp. 116-117)

"INQUIRING WITH FRUIT"

Now that we have expanded our understanding of inquiry, let’s consider a hypothetical group of eighth-grade students exploring the properties of fruit, raising questions, testing their ideas, and discovering new concepts in density. The objective of this lesson is to allow students to explore the properties of fruit and raise questions to investigate. In this session, students are given the task of predicting whether a particular group of fruits will float or sink when placed in a 2-gallon tub of water. (The names of the teacher and students are fictitious.)

During the lesson, Mr. Roberts assesses the students’ prior knowledge and preconceptions about fruits that float and sink. He poses the question, “What would happen if I place this apple in the tub of water?” The unanimous response is that the apple would float. By demonstration, their prediction proves correct. Next, it is time to move on to less familiar fruits. Each student has an opportunity to observe (using all five senses) a lemon, a kiwi, a grape, a banana, an orange, and a mango and make predictions about whether each one will float or sink when placed in a tub of water. After the students assign each fruit with either an F or S marked on their worksheets, they pair and share, exchanging their fruit predictions. During this part of the activity, students must provide explanations of their thinking to support their individual predictions. Differences in predictions are discussed to produce a group consensus for each fruit. At the end of 10 minutes, each group is asked to record its predictions, test each fruit, and record its observations.

As the students test each prediction, they record their results by constructing a table with two columns, floaters and sinkers (see Figure 1.2).

At this point, Mr. Roberts encourages the students to go beyond the initial exploration and raise their own “What if” and “I wonder” questions. In one group, Kayla asks, “Does the outer peel of a fruit affect whether it will float or sink?” She leads her group through a brainstorming session to determine ways to test whether a peeled versus an unpeeled banana will float or sink. They decide to place one peeled and one unpeeled banana in the tub and compare the results. They soon observe that both bananas float and conclude that the peel makes no difference.

As Kayla observes the floating banana with the ends pointed downward in the water, she calls Mr. Roberts over to her table and asks why the banana floats upside down (see Figure 1.3).

Mr. Roberts probes her thinking to determine the root of the question. Kayla admits that she thought the banana would float with the ends upright, like a “banana boat” (see Figure 1.4). Roberts quickly realizes that she was using her prior understanding about bananas and boats to predict that the ends of the banana would float upright, like a boat!

Kayla’s group proceeds to discuss floating and sinking in relation to the term density. They all know that objects less dense than water float and objects more dense than water...
Mr. Roberts suggests that they apply the principle to the floating banana. There is still confusion, however, about why the banana doesn’t float like a boat. Frank poses the question to the teacher, “What would happen if we cut the banana in half?” Rather than answering the question, Mr. Roberts assumes that the group can answer the question without his help, so he responds, “How could you find out?” Frank shares his thoughts about the floating banana and suggests a procedure to test his question.

As the group decides on a plan of action, Frank pulls the banana from the tub and cuts it in half. Just before Frank is about to place the two halves back in the water, Mr. Roberts says, “Wait! What do you think will happen to each half of the banana?” Debbie predicts that each half will float with the pointed end downward. Rob asks her to support her prediction. Debbie responds by saying that the ends will probably act the same as they did when the banana was whole. Figure 1.5 shows how the two halves look after they’re placed in the water.

The observation spurs “Wows” and more “What if” questions. Next, Sara asks, “What if we cut each of the halves in half again?” Frank then cuts each banana in half again and, just before lowering the banana quarters into the water, he jokingly asks the other group members, “What is going to happen when I drop these two halves into the water?” Their inquiry leads to more observations (see Figure 1.6).

Seeing the ends of the banana at the bottom of the tub and the two middle quarters floating on top leads the group to conclude that the banana must be more dense at the ends and less dense in the middle. They analyze their results and use an illustration to draw a model of the density of a banana (see Figure 1.7).

Having their observations fit their newly developed model, the group members are confident that they understand why the banana floated “upside down.” Mr. Roberts suggests that the group look up the formula for density and actually measure the mass and volume of the banana pieces to confirm its model mathematically and share its discovery with the rest of the class. Excited with their new findings, Kayla, Frank, Debbie, Rob, and Sara search their textbooks for the formula for density.

<table>
<thead>
<tr>
<th>Floaters</th>
<th>Sinkers</th>
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<tbody>
<tr>
<td>Figure 1.2: Floaters and Sinkers</td>
<td>INQUIRING WITH FRUIT RESULTS</td>
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</tbody>
</table>
“Inquiring With Fruit” is just one example of an exploration that encourages students to raise questions. In analyzing the group’s work, the *inquiry cycle* shown in Figure 1.8 represents aspects of most inquiry-based investigations:

1. *Inquisition*—stating a “What if” or “I wonder” question to be investigated
2. *Acquisition*—brainstorming possible procedures
3. *Supposition*—identifying an “I think” statement to test
4. *Implementation*—designing and carrying out a plan
5. *Summation*—collecting evidence and drawing conclusions
6. *Exhibition*—sharing and communicating results

During the inquisition phase, students usually initiate their inquiry by posing a question. It is often stated as a “What if” question and can originate from observing an open-ended exploration, a discrepant event, a demonstration, or a teacher-directed activity. Teachers often plan explorations that end with an observation that is counterintuitive to the student’s normal experience. The event seeds a *disequilibrium* in the student’s mind.
and causes him or her to ask “Why?” Educators often call this a teachable moment, when the student raises a question and opens his or her mind to imagination. In the “Inquiring With Fruit” investigation, the inquisition phase is initiated by the predicting activity.

During the acquisition phase, students rely on their prior experience to brainstorm possible solutions to the inquiry. Here students ask, “What do I already know about this situation that could help answer the question?” In the acquisition phase of the fruit activity, Kayla’s prior conceptions about bananas and floating affect how she perceives the outcome of the group’s question.
During the supposition phase, students consolidate the information under study to propose an “I think” statement. This phase generally includes a design of the plan to answer the question under investigation. During the fruit activity, Frank provides leadership to the group in identifying possible statements to test.

During the implementation phase, students design a plan to solve the phenomenon in question and carry out the plan.

During the summation phase, students record and analyze their observations to compare them with the original “What if” question. Mr. Roberts also encourages further investigations by suggesting that the group confirm its results by calculating the density of each banana piece. During the summation phase, students are often led to other discrepancies and “What if” questions, returning the group back to the inquisition phase.

During the exhibition phase, the students communicate their findings and new information in the form of a written report, a poster display, or an oral report. In the fruit activity lesson, the group is anxious to share its discovery and new knowledge about density.

The inquiry cycle can serve as a general format for teachers planning inquiry-based investigations for their students. You should be reminded that the model serves as a general approach to raising and answering questions. Following the inquiry cycle, students often enter and reenter the phases at different aspects of their inquiry process. Thus the cycle serves as a model to guide students through their inquiries and investigations.

A DEFINITION OF INQUIRY

To me, inquiry is the science, art, and spirit of imagination. It can be defined as the scientific process of active exploration by which we use critical, logical, and creative thinking skills to raise and engage in questions of personal interests. Driven by our curiosity and wonder of observed phenomena, inquiry investigations usually involve

- Generating a question or problem to be solved
- Choosing a course of action and carrying out the procedures of the investigation
- Gathering and recording the data through observation and instrumentation to draw appropriate conclusions

As we communicate and share our explanations, inquiry helps us connect our prior understanding to new experiences, modify and accommodate our previously held beliefs and conceptual models, and construct new knowledge. In constructing newly formed knowledge, students are generally cycled back into the processes and pathways of inquiry with new questions and discrepancies to investigate.

Finally, learning through inquiry empowers students with the skills and knowledge to become independent thinkers and lifelong learners. Teachers can encourage students to use communication, manipulation, and problem-solving skills to increase their awareness and interest in science and set them on their way to becoming scientifically literate citizens.

The inquiry approach requires a different mind-set and expectations on the part of the teacher. Later, we describe the role of the teacher and the student in inquiry-based classrooms in more detail.

NOTE