Defining Inquiry

Exploring the many types of inquiry in the science classroom

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According to the National Research Council, "inquiry into authentic questions generated from student experiences is the central strategy for teaching science" (2000, 29). Many educators, however, misunderstand what is meant by inquiry, believing that the term applies to almost anything they do. Publishers of textbooks also promote their wares as being inquiry oriented. But educators should beware—because of the misuse of the word *inquiry,* teachers and school districts wishing to purchase materials from textbook publishers must carefully determine how the term is being used.

So what exactly is inquiry? "Inquiry" refers to the work scientists do when they study the natural world, proposing explanations that include evidence gathered from the world around them. The term also includes the activities of students—such as posing questions, planning investigations, and reviewing what is already known in light of experimental evidence—that mirror what scientists do. "Inquiry requires identifying assumptions, use of critical and logical thinking, and consideration of alternative explanations" (National Research Council, 2000, 23). Figure 1 (page 36) further explains the National Research Council's definition and can assist teachers in diagnosing whether or not essential features of inquiry are included in science lessons and the degree of the teacher-centered or student-centered learning that takes place (2000, 29).

Types of inquiry

In addition to familiarizing themselves with Figure 1, teachers should also be knowledgeable of how the different types of inquiry are referred to in teaching resources and literature. Inquiry terms referred to in books and journals are usually defined in the following four ways.

Open or full inquiry

Open or "full" inquiry can be defined as a student-centered approach that begins with a student's question, followed by the student (or groups of students) designing and conducting an investigation or experiment and communicating results (National Research Council, 1996; Colburn, 2000). This approach most closely mirrors scientists' actual work. Open inquiry requires higher-order thinking and usually has students working directly with the concept and materials, equipment, and so forth. Having students ask the questions that guide their own investigations is the key to open inquiry.

For example, a physics teacher displays a variety of materials, such as spheres, ramps, metersticks, tape, and wooden blocks. She asks students what questions they could devise using the materials provided (ideally after a prior experience with the materials). One small group of students wishes to investigate how the height of the ramp influences the distance a sphere travels before it stops. Students devise a plan using the materials provided or approved materials that they gather on their own, carry out their investigation, and record their data. When the investigation is complete, the data is analyzed. With the class ready to critique, students make a claim based on their data, sharing the processes and outcomes.

Guided inquiry

In guided inquiry the teacher helps students develop inquiry investigations in the classroom. Usually, the teacher chooses the question for investigation. Students—in one large group or several small groups—may then assist the teacher with deciding how to proceed with the investigation. Teachers find that this is a time when specific skills needed for future open-inquiry investigations can be taught within context. Guided inquiry is a natural lead-in to open inquiry. When students must learn about more complex phenomena that cannot be investigated directly in a classroom, a teacher (or students) can provide applicable scientific data from a variety of sources to use in the investigation.

An example of guided inquiry might be an Earth science teacher who provides students with various brachiopods that are grouped in plastic bags. The labels on the bags indicate the different depths of the strata from which the brachiopods originated. Using brachiopod data gathered by students and the information about the depths of the strata, students generate explanations of how the environment may have changed over time. The teacher asks what types of observations they might make to state a claim about the environment. The students and the teacher decide to examine, draw, and identify the brachiopods in the bags, taking note of special features, such as spikes and the general shape of the creatures in each bag. Their findings and claims are communicated to other groups in a whole-class presentation and discussion.

Coupled inquiry

Coupled inquiry combines a guided-inquiry investigation with an open-inquiry investigation (Dunkhase, 2000). By beginning with an invitation to inquiry along with the guided inquiry, the teacher chooses the first question to investigate, specifically targeting a particular standard or benchmark (Martin, 2001). After the guided inquiry, a more student-centered approach is taken by implementing an open-inquiry investigation. This approach of guided inquiry followed by open inquiry results in student-generated questions that closely relate to the standard or benchmark from the first investigation. Specific concepts can be explored in a more didactic fashion allowing students to connect their concrete experiences to abstract concepts, similar to a learning-cycle approach. The coupled-inquiry cycle is as follows: 1) an invitation to inquiry, 2) teacher-initiated "guided inquiry," 3) student-initiated "open inquiry," 4) inquiry resolution, and 5) assessment. This cycle can then lead back to more student-initiated open inquiry (Dunkhase, 2000; Martin, 2001).

An example of coupled inquiry that follows this cycle would be the following:

1. *Invitation to inquiry:* In a physical science class students make predictions based on their prior understandings about whether certain materials will interfere with a magnetic field causing a paperclip suspended a few centimeters away from a magnet to fall. They also explain their reasoning as to why they think each material would interfere with the magnetic field.

FIGURE 1

Essential features of classroom inquiry and their variations.

Essential feature	Variations			
1. Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials, or other source	Learner engages in questions provided by teacher, materials, or other source
2. Learner gives priority to evidence in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze
3. Learner formulates explanations from evidence	Learner formulates explanation after summarizing evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence
4. Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
5. Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to use sharpened communication	Learner given steps and procedures for communication
More ——————— Amount of learner self-direction ——————— Less				
Less ——————— Amount of direction from teacher or material ——————— More				

2. *Guided inquiry:* Students re-create the teacher's apparatus in which a paperclip tied to a string "hovers" over a magnet. A thread is tied to the paperclip with the free end taped to the table, holding the thread taut. Some adjustment of the distance between the magnet and the paperclip may need to be made so that the paperclip is suspended in air (while still tied to the thread) but does not touch the magnet. There should be at least 2 cm between the magnet and paperclip through which students pass a uniformly sized piece of material to see if the paperclip will fall. Materials passed through the space include cardboard, tin, aluminum, granite, Styrofoam, a mirror, steel, iron, and a circuit board. Students record their results.
3. *Open inquiry:* The class meets to discuss the results of the guided inquiry. They create new questions and decide which questions are testable within classroom constraints. Students then choose a question to investigate, create a plan (including a way to record data), and record a prediction about what they think will happen. After the investigation is complete, students create a claim and an explanation of the claim.
4. *Inquiry resolution:* Groups of students share their claims and findings regarding their open-inquiry investigations. Additional content material is provided in the form of a textbook reading or Web

search regarding magnetism. Students also search for information to verify whether the content material supports their claim.

5. *Assessment:* The teacher poses a problem that students solve by applying their understanding of magnetism. An example would be: Students must design and build a compass using magnets, plastic-coated wire, and Styrofoam. Students demonstrate that the compass can locate true north. Students determine what safety precautions must be taken regarding the use of materials and the compass.

After the assessment is complete, another inquiry cycle can begin. This is usually a coupled inquiry or perhaps another open inquiry.

Structured inquiry

Structured inquiry, sometimes referred to as directed inquiry, is a guided inquiry mainly directed by the teacher. Typically, this results in a cookbook lesson in which students follow teacher directions to come up with a specific end point or product. Sometimes this approach is appropriate to use in the classroom; however, student engagement in the task is limited to following teacher instructions. Simply following directions in a cookbook manner does not actively engage students' minds. Therefore, one could argue that structured inquiry does not include much true inquiry. More student thinking takes place when the teacher allows students to make choices and decisions in classroom investigations (Clough and Clark, 1994). Ways to create a more student-centered approach include asking students to help devise the procedure necessary for an investigation; taking away a prepared data table so that students must consider how to create their own table, asking students to determine which data should or could be gathered instead of prescribing the method, and asking students to explain how an experiment could be improved for a better investigation.

For example, in a biology class students create a model showing what happens if a person has cirrhosis of the liver. The students have a sheet of paper with step-by-step directions and procedure. First, they fold the filter paper and properly place each paper into a cup, creating two funnels with two receptacles. Next, they put a specific amount of crushed carbon into one funnel and a specific amount of carbon pieces into another funnel. The students then pour 8 mL of blue water (food coloring and water) into each funnel. They record the results and answer the questions at the end. The teacher may ask the class to discuss the results when the model is complete.

Different types of lessons, and therefore different types of inquiry, are used for specific needs in the science classroom

Meeting students' needs

Different types of lessons, and therefore different types of inquiry, are used for specific needs in the science classroom. The continuum in Figure 1 shows that inquiry spans from more student-centered types of inquiry to more teacher-centered types. Understanding the different aspects of inquiry can help educators vary the types of teaching and learning experiences to better meet the needs of all science students.

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References

Clough, M., and R. Clark. 1994. Cookbooks and constructivism. *The Science Teacher* 61(2): 34–37.

Colburn, A. 2000. An inquiry primer. *Science Scope* 23(6): 42–44.

Dunkhase, J. 2000. Coupled inquiry: An effective strategy for student investigations. Paper presented at the Iowa Science Teachers Section Conference, October, Des Moines, Iowa.

Martin, L. 2001. Coupled-inquiry diagram. The changes in open inquiry understandings and teaching among preservice secondary science teachers during their preservice school practica and student teaching. Unpublished doctoral dissertation, Iowa City, The University of Iowa.

National Research Council. 2000. *Inquiry and the National Science Education Standards.* Washington, D.C.: National Academy Press.

National Research Council. 1996. *National Science Education Standards.* Washington, D.C.: National Academy Press.