

“Inquirize” Your Teaching

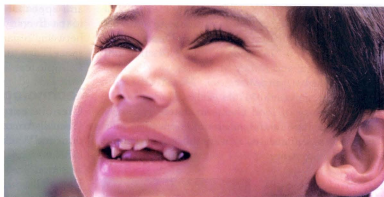
A guide to turning favorite activities into inquiry lessons

By Susan Everett and Richard Moyer

Consider the following classroom scenario: After reading about cloud formation, students are given a glass jar with a small amount of hot tap water in it and ice sealed in a plastic baggie. The teacher drops a lit match into each group's jar, creating particulates in the air on which the water can condense. Students quickly place the baggie of ice over the opening—creating a temperature gradient—and observe the formation of a cloud in the jar. Students are asked to write how the cloud in the jar is like the clouds they read about in their text.

Now consider this scenario: The teacher conducts the cloud demonstration and initiates a discussion about what the students have observed. Students are encouraged to focus on the factors that they think may affect the formation of the cloud in their jars. Students then investigate a factor of their choice and discuss results with the class before reading their text.

The difference between these two scenarios is not trivial. While both are hands-on activities, they are not both inquiry activities. In the first example, students are following a procedure but are not involved in answering a question for themselves—a key element in inquiry. In contrast, the children in the second example are actively investigating a question to which they do not know the answer.



The first activity is probably like many you will find in textbooks, websites, activity books, as well as some of your old favorites that have been around for many years. These activities, while hands-on, are primarily demonstrations that verify some science concept. It is usually possible to adapt these kinds of activities into inquiry investigations that answer questions for students, as in the second scenario. It has been *inquirized*—turned into an inquiry investigation.

The *National Science Education Standards* (NSES) (NRC 1996) note that the basic elements of inquiry include: ask a question, conduct an investigation, make observations and collect data, use data to develop an explanation, and communicate results. We've found the 5E learning cycle model useful for designing lessons that include the above inquiry

abilities. The learning cycle includes five phases, an *engage* that focuses students on a question, an *explore* where that question is investigated, an *explain* where the data from the investigation are analyzed and interpreted, an *extend* and *apply* where concepts are connected to other concepts as well as to the real world, and finally, an *evaluate* where the understandings are assessed.

In this article, we describe how to “inquirize” a demonstration activity with steps that can be applied to any activity (Figure 1).

Explore Phase

You need to begin with an *explorable* question, one that can be answered for students by means of a simple hands-on activity. Check to see if the activity actually answers a question for the students, as this is critical to inquiry. If it does not, it must be altered

so that it does. Consider the cloud in the jar demonstration in the first scenario above. At first glance it seems that this activity answers the question "How do clouds form?" However, the first cloud activity demonstrates what components form a cloud but does not offer an explanation of how the components interact to form the cloud. It simply shows that they do. Therefore, we need to alter the activity so that it does answer a question. We can do this by having students change one of the variables to see how it affects the formation of the cloud. For example, students could manipulate the temperature of the water and note the effect on the cloud. Now, the explorable question becomes "What effect does water temperature have on cloud formation in the jar?" Or, students could vary the size of the jar, number of matches, the amount of ice, the amount of water, and so on. To make the investigation more student-centered, you could use the explorable question, "what factors affect cloud formation in the jar?" In that way, the students could investigate a variable of their own choosing.

Teachers should tightly control matches at all times whether this activity is used as a demonstration or as a student inquiry in which teachers add the matches. Before planning this activity, check to make sure matches are allowed in your classroom. Teacher and students should wear goggles when working with matches.

Engage Phase

Next, plan how you will engage the students. Note that we are suggesting that you plan the *engage* after you plan the *explore* phase. The reason for this

Figure 1.

Ten steps for inquiring activities.

(Moyer, Hackett, and Everett 2007).

Preplanning

1. Consider your concept and objective.
2. Identify a possible activity that teaches your concept.

Explore Phase

3. Determine whether the activity answers an explorable question.
4. Alter the activity into an investigation that does answer a question for the students. Formulate an explorable question or questions. Consider safety of the original activity and of your modifications.

Engage Phase

5. Now you can write the engage portion of your lesson. Its main purpose is to focus students on the explorable question(s) and how they will try to answer it.
6. Demonstrations, real-world contexts, discussions, discrepant events, photos, and the like are all possible methods to be used in the engage phase.

Explain Phase

7. Begin the explain phase of the lesson with a discussion of the students' results. Students typically discover what happens but are likely to need help understanding why it happened.
8. This is an appropriate time for students to read and be introduced to any necessary vocabulary.

Extend and Apply Phase

9. Consider how the new understandings relate to other concepts and applications to the real world.

Evaluate Phase

10. If possible, use performance assessment in your evaluation.

is that the purpose of the engage is to set up the explorable question. In practice, "engage" will occur first, but you cannot set up a question before you determine what it is.

The most important function of the engage phase is to focus students on the explorable question and how the investigation will attempt to pro-

vide answers. Consider your students' prior knowledge and understandings in designing the engage phase. In the first scenario, students were introduced to the activity by reading their textbook. In this case, students were not asked to use their prior knowledge of clouds, express their ideas about cloud formation, or make predictions



Figure 2.

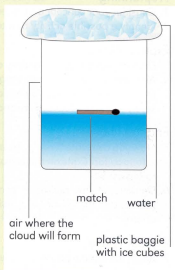
Inquirized cloud lesson (for Grades 4–8).

Engage Phase

Demonstrate the formation of a cloud in a jar and initiate a discussion. Ask students about their prior understandings of cloud formation. Lead them to a consideration of the factors that might affect the cloud formation. Discuss how students might proceed to investigate one or more of these factors (e.g., water temperature, amount of water, amount and location of ice). For example, if students select water temperature, they might determine the effect on the formation of the cloud when they use ice cold water, room temperature water, and warm tap water. Be sure students are aware of the explorable question: "What factors affect cloud formation in the jar?" To focus students on their questions, you might write them on the board, have students record them in a journal, and as you interact with each group, ask them to tell you what question they are trying to answer with their investigation.

Explore Phase

Have students select a factor to investigate and develop a procedure to answer the explorable question. Students should have their procedures approved before they begin by individually sharing their plans with the teacher. At the time of this discussion, help students determine what data to collect and how it might be organized. In this case, the results for the dependent



variable (cloud formation) will be qualitative—students will write descriptions of their clouds and whether they formed or not.

Explain Phase

Have students share their results for the factors they tested as they attempted to answer the explorable question. Using these results as a springboard, help students understand that three components are necessary for cloud formation: sufficient water vapor, a change in temperature (temperature gradient), and particulates in the air on which the water can condense (condensation nuclei). You may help students draw these infer-

ences by asking them to refer to their observations and note what factors are always present when a cloud forms in the jar. Or, have students consider the conditions under which no cloud formed in the jar. This is an appropriate time for the students to read their texts.

Extend and Apply Phase

Relate cloud formation to students' experiences with hot showers and "foggy" bathrooms. In addition to seeing the cloudy atmosphere of the bathroom, they will recall seeing condensation on mirrors and other surfaces. In this case, the water molecules are condensing on a surface instead of a particulate in the air. Other examples include dew on the grass and seeing your breath when it is cold outside.

Evaluate Phase

Present students with a glass of ice water and have them observe the formation of condensation on the outside of the glass. Have them investigate what factors lead to its formation in much the same way they investigated the cloud formation. Ask students to explain how the formation of the condensation is similar to cloud formation—both require moist air, a temperature gradient, and a surface on which the water molecules can condense. (Note that in dry climates it is very difficult to get any condensation on a glass of ice water.)

about what might occur in the activity. In the second case, they observed the (perhaps unexpected) formation of the cloud and were asked to speculate on the variables involved. These students were asked to consider what they already know in light of the demonstration and use some of these ideas in the investigation. To determine if you have adequately focused students, you might ask them to describe what they are going to do in the exploration. They should be able to tell you how their actions are helping them answer the explorable question and not merely that they are on step number three of a procedure.

Explain Phase

The explain phase should always begin with a discussion of the students' results. For example, students may find that denser clouds were formed when they used warmer water. Students may deduce that this is due to increased evaporation. The teacher's role is to facilitate the students making these connections by asking questions and guiding students to consider prior knowledge.

Note also that in the inquiry scenario, students read their text after they have explored thoroughly. The exploring gives students a reason to read their text. It provides both a motivation and a conceptual foundation for the reading. Thus, the reading is set up by the exploration and its analysis, resulting in the reading being more meaningful.

Extend and Apply Phase

Many of your old favorite activities will not have any useable suggestions for extension and application of the concept. Because learning is thought

Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996):

Content Standards

Grades 5–8

Standard A: Science as Inquiry

- The abilities necessary to do scientific inquiry
- Understandings about science inquiry

Standard D: Earth and Space Science

- Structure of the Earth System

Teaching Standards

Standard A:

Teachers of science plan an inquiry-based science program for their students.

of as assimilating new information into prior knowledge, it is helpful to make this an explicit part of your teaching pedagogy. The purpose of the extend and apply phase is to relate the newly learned concept to similar concepts as well as real-world applications. For example, in the cloud activity, you can make connections to the condensation in a bathroom after a hot shower, foggy conditions, or condensation on a cold glass of ice water.

Evaluation Phase

Again, most of the demonstration ideas you may find will not include assessment ideas. Many of the ideas you considered for your real-world contexts or applications can serve as useful performance assessments. In the cloud lesson here, you could present students with a glass of ice water and have them investigate factors that result in condensation forming on the glass. They would then be asked to explain how this process is similar to the cloud formation.

Inquirized Investigations

The lesson outlined in Figure 2, shows how the above steps lead to a complete 5E learning cycle lesson. Following the above processes, you can inquire all of your old favorite activities.

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