An Integrated Instructional Approach to Facilitate Inquiry in the Classroom

by Rommel J. Miranda and Ronald S. Hermann
Although inquiry-based learning has been endorsed by science educators for decades, many teachers may still be uncertain about how they can effectively implement inquiry-based lessons in their classrooms. Perhaps one reason for the lack of inquiry-based lessons in the classroom is that inquiry is not a singular construct but rather a range of approaches that form a continuum (Bianchi and Bell 2008).

In confirmation inquiry, students are given a question, and the results are known in advance. Structured inquiry occurs when the questions and procedures are provided, but students generate an explanation supported by their collected evidence. Guided inquiry occurs when the teacher provides the question, but students design the procedures and develop explanations. Open inquiry consists of students developing questions, developing procedures, carrying out experiments, and communicating results (Bianchi and Bell 2008). Within this continuum, open inquiry is often believed to be the most difficult to facilitate in the classroom and the most time consuming; Settlage (2007) has argued that it is impractical for teachers to implement on a regular basis. Although open-inquiry activities can take a long time to complete, the depth of student understanding and the extent to which students are exposed to the skills and processes of science justify the time spent. Although it is not advisable to implement open inquiry without students first having sufficient experience with confirmation inquiry, structured inquiry, and guided inquiry, we have found that it is possible. In this article, we provide an approach that integrates the Know-Learn-Evidence-Wonder (KLEW) instructional teaching strategy within the 7E (Engage, Elicit, Explore, Explain, Elaborate, Evaluate, Extend) learning-cycle model to help teachers immerse students in a range of inquiry-based science experiences, particularly open inquiry, and demonstrate evidence of student reflection, learning, and understanding of a science topic.

The instructional approach
Science teachers are usually familiar with various forms of learning-cycle models, such as the widely recognized 5E model that comprises the stages Engage, Explore, Explain, Elaborate, and Evaluate (Bybee 1997), and an updated 7E model, which has two additional phases, Elicit and Extend (Eisenkraft 2003). Science teachers are typically aware of instructional teaching strategies that incorporate organizational charts to document student learning, such as the traditional Know-Want-Learn (KWL) chart and an updated variation to this strategy that emphasizes Evidence, the KLEW chart (Hershberger, Zembal-Saul, and Starr 2006). The KLEW instructional teaching strategy seeks to determine what students already know, what students have learned based on evidence, and what new wonderings students can investigate. The KLEW instructional teaching strategy is also aligned with both the National Science Education Standards (NRC 1996) and Framework for K–12 Science Education (NRC 2012). Specifically, it emphasizes the importance of engaging students in scientifically oriented questions and having them give priority to evidence, develop evidence-based explanations, participate in argumentation from evidence, and justify their proposed explanations.

Whereas science teachers might be cognizant of these instructional models and strategies, many are unsure of how or when to incorporate the KLEW teaching strategy within the 7E learning-cycle model. We believe that possessing an understanding of how the 7E learning cycle model and the KLEW teaching strategy are intricately intertwined can help science teachers more effectively facilitate inquiry in their own classroom and provide evidence of student learning. Our approach, which integrates the KLEW teaching strategy within the 7E learning cycle model, is illustrated in the opening art on page 66. The arrows in the diagram illustrate where aspects of the KLEW model enhance and support aspects of the 7E learning cycle model.

Example of instructional approach
Here we demonstrate how our approach of integrating the KLEW teaching strategy within the 7E learning-cycle model can help to facilitate a range of inquiry, particularly open inquiry, in the science classroom by using water filtration as an example (see Activity Worksheet). This topic fits well into an Earth science curriculum that focuses on having students recognize and describe the water cycle as the distribution and circulation of Earth’s water. This topic also fits well into the Framework for K–12 Science Education by integrating students’ understanding of the water cycle and global movements of water that are propelled by gravity in Earth sciences to their understanding of engineering practices (NRC 2012). This topic further incorporates
Day 1
Engage (7 minutes)
If you were stranded on a deserted island and could only bring three things with you, what would you bring? Why?

<table>
<thead>
<tr>
<th>Item</th>
<th>Reason</th>
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<tbody>
<tr>
<td>1</td>
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<td>2</td>
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</tbody>
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Elicit ↔ Know (8 minutes)
List and describe anything that you know about water filtration or have witnessed on television, or in the movies, the news, or real life that relates to water filtration.

<table>
<thead>
<tr>
<th>Water filtration</th>
<th>Describe</th>
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<tbody>
<tr>
<td>1</td>
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<td>2</td>
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<td>3</td>
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</table>

Illustrate and describe what you think is inside a home water filter and how you think a home drinking-water filtration system works to purify water.

Explore (30 minutes)
Materials needed for each group:
chemical splash safety goggles for each student; 3 pint-size funnels; 3 150-mL beakers; 15 x 15 cm (6" x 6") piece of cloth fabric; 1/2 cup of gravel; 1/2 cup of play sand; dirty water

Procedures
1. Don your chemical splash safety goggles and then place each item (cloth fabric, gravel, play sand) separately into three pint-sized funnels.
2. Predict how well you think each item (cloth fabric, gravel, play sand) will be able to filter out the soil from the water and why.

<table>
<thead>
<tr>
<th>Item</th>
<th>Prediction</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cloth fabric</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Gravel</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Play sand</td>
<td></td>
</tr>
</tbody>
</table>
3. Pour 1 cup of dirty water into each funnel and collect the filtered water in a labeled beaker.
4. Record your observations and then clean up your work area. Dispose of dirty water and sand as directed, and wash hands thoroughly with soap and water.

<table>
<thead>
<tr>
<th>Item</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Cloth fabric</td>
<td></td>
</tr>
<tr>
<td>2 Gravel</td>
<td></td>
</tr>
<tr>
<td>3 Play sand</td>
<td></td>
</tr>
</tbody>
</table>

5. Which item (cloth fabric, gravel, play sand) was most effective in filtering the soil out of the water?
6. Illustrate and explain why you think this item was the most effective in filtering the soil out of the water.
7. Which item (cloth fabric, gravel, play sand) was least effective in filtering the soil out of the water?
8. Illustrate and explain why you think this item was the least effective in filtering the soil out of the water.

**Explain Learn and Evidence (15 minutes)**

Explain what you have learned about water filters by listing your observations on a dry-erase board or flip chart, along with the evidence and data that you have collected.

**Day 2**

**Elaborate Wonder (35 minutes)**

After viewing the cross sections, pictures, and illustrations of natural sediment filters, please write down three things you wonder about regarding the images you just saw and the materials (cloth fabric, gravel, play sand) you used to filter the soil from out of the water from the Explore section:

<table>
<thead>
<tr>
<th>What do you wonder about?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>2</td>
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<tr>
<td>3</td>
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</tbody>
</table>

*Students design their own experiments using an open-inquiry template.*

**Evaluate (25 minutes)**

Based on your experimental results from both the Explore and Elaborate sections, compare your water-filtration design to a home water-filtration system.

**Extend (homework assignment)**

Using the internet, books, or other resources, explain what stormwater runoff pollution is, and identify several causes of the problem. Next, illustrate and describe how you would design a new storm-water filtration system that could specifically help to prevent storm-water runoff pollution.
crosscutting concepts, such as patterns, where students can observe patterns and prompt questions about relationships and the factors that influence them; cause and effect; mechanism and explanation, where mechanisms can be tested by students across given contexts and can be further used to predict and explain new events in new contexts; and systems and models, where students are provided with tools for understanding and testing ideas that are applicable throughout Earth sciences and engineering (NRC 2011). The following 7E lesson was facilitated in an eighth-grade Earth science classroom that was beginning to learn about the water cycle. This lesson took two days to complete, 120 minutes total, assuming that most student groups completed the Engage, Elicit, Explore, and Explain sections on the first day and the Elaborate, Evaluate, and Extend sections on the second day. Individual student performance and student group presentations were assessed using a rubric.

Engage (7 minutes)
The teacher engages students by showing them a picture of a “deserted island” downloaded from the internet using the Google Images search engine and asks, “If you were stranded on a deserted island and could bring only three things with you, what would you bring and why?” In groups of three, students discuss, rank, and record on the Activity Worksheet the top three things their group would bring and their reasons for inclusion. After a few minutes, the teacher facilitates a whole-class discussion with students regarding their responses to the question. Typically, most student groups mention that they would bring water with them to survive. The teacher then refers back to the picture and asks students, “Why can’t you just drink ocean water?” Students often respond that there is salt in ocean water and that if you wanted to drink it, you would have to filter out the salt from the ocean water.

Elicit ← Know (8 minutes)
The teacher elicits prior knowledge by asking students to list and describe anything they know about water filtration or have witnessed on television, or in the movies, the news, or real life that relates to water filtration. Students work in groups of three and record their responses on their Activity Worksheet. The teacher conducts a whole-class discussion with students regarding their responses. Students generally mention television shows such as Survivor, Man vs. Wild, and Lost and describe how people have to filter dirty water to drink it. Students also frequently mention water-filtration products used in homes, such as coffee machines, swimming pools, and water purifiers. The teacher then shows students a picture of a home water-filtration system that students found on the internet using the Google Images search engine. The teacher instructs students to illustrate and describe what they think is inside the water filter and how they think a home water-filtration system works to purify water. Students work in groups of three and record their responses on their Activity Worksheet. After a few minutes, the teacher elicits students’ prior knowledge about water filtration by facilitating a whole-class discussion with students regarding their responses. As students share their responses with the class, the teacher records their ideas under the “K” in a KLEW chart displayed in the classroom.

Explore (30 minutes)
Through a structured-inquiry activity, students explore water-filtration systems. The teacher provides the questions and procedures to students but allows students to make observations and conclusions themselves. The teacher fills up a pitcher with water, adds one cup of sterilized soil, and stirs vigorously until the soil is evenly distributed throughout the water. Next the teacher shows students the following three items: 15 × 15 cm (6” × 6”) piece of cloth fabric, ½ cup of gravel, and ½ cup of play sand. (The total amount of these materials needed to facilitate this 7E lesson plan for five classes of 30 students each is three yards of cloth fabric, a 5 lb. bag of gravel, and a 5 lb. bag of play sand, which costs approximately $17.) The teacher then instructs students to place each of these items separately into three pint-sized funnels and to predict how well they think each item will be able to filter out the soil from the water and why.

Students cooperatively work in groups of three and record their predictions and reasons on their Activity
Worksheet. The teacher reviews laboratory safety procedures with students and tells them to wear chemical splash goggles, not to drink the water, and to wipe up any spills immediately. The teacher also informs students about cleanup procedures and explains that when they finish the activity, they should pour the used gravel and play sand into their respective clearly labeled buckets in the front of the classroom—not to pour any materials into the sink. (Note: The gravel and play sand that are collected in separate buckets at the end of the laboratory can be used in the future after the water completely evaporates.) The teacher further tells students to clean and dry the funnels with paper towels over a trash can (not the sink) and to wash their hands thoroughly when they are finished. The teacher then instructs students to pour one cup of dirty water into each funnel and to collect the filtered water in a 150 mL beaker. Students record their observations, analyze data, generate conclusions on their Activity Worksheet, and clean up when they are finished the activity.

**Explain ↔ Learn and Evidence (15 minutes)**

The teacher reviews the questions from the Explore section via a whole-class discussion and incites student groups to articulate and explain what they have learned about water filters based on their observations and collected evidence and data. Student groups display this information on dry-erase boards or flip-chart paper and explain their findings to the rest of the class. The teacher records students’ responses under the “L” and “E” in the KLEW chart displayed in the classroom. When describing the cloth fabric, one group of students stated, “The water is almost completely clear, but it takes a long time to filter because the cloth absorbs some of the water.” This group of students further inferred, “Water molecules must be smaller than soil particles because the water molecules passed through the cloth, while the soil particles did not.” Regarding gravel, another group of students said, “The water is not as clean as the water from the cloth, but gravel filters water at a much faster rate because the gravel did not absorb as much water.” Students further concluded, “The gravel appears to capture the larger particles of soil, but not the smaller particles of soil because the water is still a little bit dirty.” Regarding play sand, a group of students explained, “The sand filters water more slowly, like the cloth, because it absorbs water. However, some of the sand must have gotten through the filter because the color of the water appears to look like the color of the sand.” These students further explained, “The sand got rid of the large chunks of soil really well, but since sand got into the water, the water molecules and sand particles must be smaller than soil particles.” After student groups present their findings to the class, the teacher introduces new vocabulary terms (i.e., infiltration, sediment, porous, percolation, permeable, aquifer) related to the topic of water filtration.

**Elaborate ↔ Wonder (35 minutes)**

Our approach for integrating the “W” from the KLEW teaching strategy within the Elaborate phase of the 7E learning-cycle model can be effectively used to implement open inquiry by providing an ideal opportunity for students to apply their knowledge to new domains, which includes raising new questions and hypotheses to explore. Thus the teacher facilitates open inquiry by showing students cross sections, pictures, and illustrations of natural sediment filters, which help to produce underground spring water that the class found on the internet using the Google Images search engine. The teacher then asks students to write down new wonderings that they have regarding the photos and the materials used to filter water from the Explore section. After a few minutes, students share their wonderings and record their responses under the “W” in the KLEW chart in the classroom. The teacher reiterates laboratory safety and cleanup instructions to students and informs them that they can use any of the materials they used in the Explore section. Students engage in engineering activities...
to design and carry out their own experiments on water filters by using an open-inquiry template (Hermann and Miranda 2010), document their results, and share with the rest of the class what they have learned based on their observations and evidence and data they have collected. For example, one group of students constructed a water filter using a combination of sand, cloth, gravel, and a funnel. These students discovered that sand particles still ended up in their filtered water, but this water was much cleaner than water filtered through the cloth alone. Another group built a water filter using a combination of cloth, gravel, and a funnel and discerned that the filtered water appeared to be extremely clear. (See also “Everyday Engineering: Charcoal—Can It Corral Chlorine?” by Moyer and Everett [2011].)

**Evaluate (25 minutes)**

The teacher shows students a water-purifying filter that is cut open to expose the activated charcoal inside. The teacher then instructs students to reflect on their previous experimental results from both the Explore and Elaborate sections and to compare their water-filtration design with the home water-filtration system.

**Extend (homework assignment)**

Students are challenged to explore how to prevent storm-water runoff pollution from rain or melting snow that does not immediately soak into the ground but rather flows across hard surfaces (i.e., streets, lawns, roofs) and washes pollutants (i.e., fertilizers, sediment, pet waste, cigarette butts, litter, oil) through storm drain systems and into local streams and drainage basins. The teacher tells students to read more about the problem via the internet, books, or other resources and to explain what storm-water runoff pollution is and to identify several causes of the problem. The teacher further instructs students to illustrate and describe how they would design a new storm-water filtration system that could specifically help prevent storm-water runoff pollution.

**Conclusion**

Instructional inquiry models are curricular and instructional practices that can promote, facilitate, and engage students in scientific inquiry and science content. However, current, existing learning-cycle models do not specifically incorporate essential instructional teaching strategies that promote or document strong conceptual understanding and process-skill development for all students. Our approach, which embeds the KLEW instructional teaching strategy within the 7E learning-cycle model, provides teachers with a mechanism to focus on instructional practice and student engagement with a range of inquiry-based activities, especially open inquiry, and typically results in rich and rewarding experiences for both students and teachers.

**References**


**Resource**

Playlist of related videos compiled by the editor—http://bit.ly/x5QnCX

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