Think-Alouds in Inquiry Science
A cognitive coaching strategy—the think-aloud—helps foster critical thinking in science.

By Lisa Martin-Hansen and Jill Caton Johnson

As teachers, we know that learning through an inquiry approach is helpful for our students. However, not all students are accustomed to learning through inquiry. Some have never experienced an inquiry investigation in science. How can we assist them in the transition from solely learning content to actually applying content and using higher-order thinking skills?

A strategy called “think-aloud” can help students progress toward thinking for themselves in questioning, devising investigations, analyzing data, and supporting conclusions with evidence. Think-alouds make apparent the abstract processes of the students’ own thinking as students ask questions from their head out loud and practice answering them. A think-aloud is a way of asking questions that guides students to justify their thinking.

In class, teachers model the think-aloud process for students by articulating their own thinking during readings, science inquiries, and other subjects. As students watch their teachers model the think-aloud process, they gradually get more comfortable identifying their own thinking processes and over time begin to think more critically themselves.

Follow the Teacher
Think-alouds are used as a strategy to help increase students’ reading comprehension skills (Baker 2001; Harvey and Goudvis 2000; Keene and Zimmerman 1997; Pressley 1999). In a classroom, modeling a think-aloud during text reading in science would sound something like this:

"Today, we’re going to read about how animals spend their time in winter. I’m going to stop every once in a while to ask a question out loud. This is normally what is going on silently inside my head when I read. When I ask questions to myself, it helps me to know what parts are important and interesting to me.

After I show you how I ask questions, I will start reading again and then ask one of you to share a question out loud that you are thinking in your head as you read. This way, we’ll practice the think-aloud process together. Then we’ll try it again when we read an article on another topic."

After the introduction, the teacher reads aloud some selected text. For example, “How Do Animals Spend the Winter?” from www.sciencechomesimple.com (see Internet Resources):

“The weather gets colder, days get shorter, and leaves turn color and fall off the trees. Soon, winter is here. Snow covers the ground. People live in warm houses and wear heavy coats outside. Our food comes from the grocery store. But what happens to the animals?”

The teacher then says, “Here are some thoughts I’m thinking in my head right now: Maybe the animals go somewhere else? Or maybe animals go to sleep? What do you think?” before continuing the reading:

“Animals do many different, amazing things to get through the winter. Some of them migrate. This means they travel to other places where the weather is warmer or they can find food.”

“As I read this, I’m thinking in my head, ‘Hey, migrate is what I was..."
thinking about when I thought animals might go to different places in the winter so that they’re warmer. So some animals do move to other places to stay warm in the winter.”

Once students have watched the teacher model the think-aloud process, they will be able to use the think-aloud process themselves during reading and science inquiry.

**Invitation to Inquiry**

We worked with fifth-grade students who used the think-aloud process as part of a science inquiry dealing with acids and bases. The experience began as students read an article that linked a decline in songbird population to acid rain (see Internet Resources).

As the students read the article, we incorporated the think-aloud strategy by periodically pausing and asking students to come up with questions about acid rain and its ultimate effects on birds. Students asked questions like, “Where does the acid come from?” and “Does acid rain hurt birds?”

We wrote their questions on chart paper and said, “These are good questions to ask. Let’s read a little more and see if our questions are answered.” If the questions were answered, we paused and had the students consider again whether the questions were answered. If they were not answered, we asked, “Where could we find out this information?” and (when possible) proceeded to locate answers to their questions.

When everyone had finished reading the article, students made “claims” based upon evidence from the article. One goal of the think-aloud process is to help students learn how to justify the answers to their questions—by asking for evidence you are helping students achieve that goal. If the students don’t seem to remember evidence from the reading, the teacher can say, “Let’s look back at what we just read to see if we can find any information that might support or not support the statement.”

Seeking evidence is also an important part of the inquiry process for scientists. By pointing out that making claims based on evidence is something scientists do, you are helping students to understand more about the nature of science. Similarly, the teacher can use the think-aloud process to highlight other aspects of the nature of science by asking such questions as, “What would scientists do in this situation? Why do you think they would do that? What does this tell us about how science works?”

**Guided-Inquiry Testing**

After the introductory reading, students conducted a guided inquiry exploring the pH of various liquids. The think-aloud strategy was incorporated throughout the activity as students tested lemon juice and baking soda solutions with a cabbage juice indicator. First, we wrote the target goal of the day on the board: *How do we determine whether something is an acid or base?*

As the class reviewed the procedure, the teacher said, “These directions ask us to add 5 ml of lemon juice to 15 ml of water. Then we’re supposed to add 4 ml of baking soda to 16 ml of water. I’m wondering if we have to use these measurements. Would it matter if we changed them? What do you think?”

While students will probably opt to follow the directions first, asking questions such as these helps students to be more minds-on during the investigation while also opening their minds to how to ask additional questions for their own investigations in the open-inquiry portion of the lesson.

As they conduct the investigation, the teacher can pause and think aloud, “As I’m wondering how to set up my experiment, I’m thinking to myself, ‘Why do we want to keep one cup as water only?’” Students typically answer, “We want to see if the other cups turn out different from the plain water.” Then, the teacher introduces the term control in an experiment.

Another think-aloud occurs when the teacher asks, “How should we record our data? Is there some way to measure using numbers? (quantitative data). Is there some way to draw pictures, use color, describe in words? (qualitative data). Students will often answer, “I don’t see how we can mark down anything using numbers. We can tell what color the baking soda and water changed, but we can’t put a number on it.” As an additional activity, students could be asked to create a numbering system to “rate” the colors on a scale similar to a pH scale.

A third think-aloud asks, “What do you observe?” and then the teacher discusses students’ observations. For example, students might make such comments as, “I saw the baking-soda water turn blue” or “The lemon water turned bright reddish purple.” When discrepancies among data occur, such as one group’s lemon-juice solution is purple and another group’s is redder, the teacher discusses possible reasons for the differences.
teacher will think-aloud: Why do you suppose this is so?

Students typically suggest such ideas as, “The scientists might have made a mistake when they were measuring” or “The scientists might have had stuff that was a little different.” Remind students that scientists are people who, like us, “see” different things in the same data or describe data in different ways.

Finally, after the above explorations, the teacher introduces the idea of acids/bases using the experiment as the basis of the discussion. For example:

“Some solutions or materials are more acidic and will turn an indicator like cabbage juice a reddish color. Lemon juice is a type of acid. The more acidic it is, the more red the indicator becomes.

“The baking soda solution was a base. How did the indicator react to this solution? Yes, it turned more purple or blue. The more basic a solution is, the more blue it becomes.”

Open Inquiry

To follow the guided inquiry, have students think of additional questions regarding acids and bases and provide additional supplies for acid/base testing, such as cola, dish soap, and so on.

Have students individually write questions on a piece of paper and then share the questions with the class. Typically, students share such questions as, “Which is the most acidic?” “Which is the most basic?” “What happens if you add different amounts of baking soda to different amounts of water?” Revisit students’ questions from the earlier reading session, and add any new questions to that list. As a class, label which questions may be investigated by either a/an:

T – A test or investigation
O – Make an observation in nature or in some present state without specific controls (e.g., for the best information about an animal in their habitat, one would not set up an experiment, but would instead devise a way to carefully observe the animal in its natural habitat).
R – Use another resource such as internet references, text references, etc., to answer the question.

Now, divide students into small groups and have them create a plan for a test or an observation. To help students choose their questions and create their plans, the class can do one question together first. For example, “If we wanted to see what happened with different amounts of baking soda in each solution, how might we set up that investigation?” After talking through the procedure together and asking students to consider how to create a data table to record the information, then the students will be more prepared to work independently in small groups.

As students choose a question and create their procedures, the teacher can review each one for safety issues and investigative design. A typical student’s question based on this inquiry is: “If we added more lemon juice to our lemon/water cup, would the color change more?” After talking through the procedure together and asking students to consider how to create a data table to record the information, then the students will be more prepared to work independently in small groups.

The teacher can ask, “What do you think will happen? What color would you expect it to change? What would that mean?” in order to guide students to think deeply about their posed question. Follow with, “You will need to include your ideas about why and how you think the color might change when you add more lemon juice to your solution in the area where you are recording your prediction.” Another think-aloud possibility is “What types of questions did you ask yourself as you created your procedure?” Students will answer, “I wondered what we needed to use for our comparison (the control).” If students come up with ideas that aren’t “fair” or safe, it is up to the teacher to ask the appropriate questions to guide them to a “fair” and safe investigation. Ask, “How can we be sure no acids or bases get into your eyes?” The students answer, “We need to wear goggles.” The teacher responds, “Okay, include that information in your plan.”

Now have students implement their plan. Some students may wish to change their procedures along the way. This reflects the way science is conducted (the nature of science). However, if a procedure is changed, students need to have you review their plan again and write an explanation why they changed part of their investigation.

After everyone has implemented their plans, discuss the experience through more think-alouds:

• What qualitative/quantitative data did you gather?
• How can these data be communicated?
• What do you think a scientist might do in order to gather data in this investigation?
• Reflect upon your original question and analyze your data. What claims can you make? What evidence backs up your claim(s)?
By promoting think-alouds along the way, students were considering what they were doing and why they were doing it.

Inquiry Resolution

Once everyone has completed an open inquiry, direct instruction on the topic takes place. Usually, this means reading from a textbook, or in our acid/base example, it could also be examining a pH chart and discussing the increments. As students read the text, the teacher asks students to refer to their investigations to see if what they found corresponds to what they read in their books.

Afterward, the teacher refers back to the day’s target goal of answering How do we determine whether something is an acid or base? Students will quickly offer such suggestions as, “Test it with cabbage juice.” “Test it with an indicator.” “Use something that changes color when it’s an acid or a base.”

Next, the class revisits the questions listed on the chart paper. What answers have they found? Are any of their results in conflict with what scientists say? Conflicting information will sometimes be found. The teacher will often have information that the students do not that can be presented to students to have them consider why their answers may be different. Other issues may emerge, such as safety precautions regarding acids and bases in home cleaners. Create new investigations if appropriate. Continue to consult textbooks and other sources to expand upon the concepts of physical change, chemical change, acids, and bases.

Application/Assessment

Have students test additional materials for pH. For example, students could test lime juice instead of lemon juice or another brand of dish soap. Before testing, have students make predictions about whether the substances are more acidic or basic based on the knowledge they gleaned from their inquiries. Pause and ask them to “think aloud” again about questions they have about these substances or about how they might test. Then let students test their predictions. After completing the assessment, ask students to think aloud about what they might consider after they’ve written down a claim and supported it with evidence. For instance, “Does my evidence support my claim? Do I explain so that another student can make sense of my answer?”

The think-aloud strategy is one way to guide students as they work through challenging, higher-order thinking experiences. As students conduct inquiry investigations, think-alouds assist in providing the scaffolding necessary to build students’ thinking skills in comprehension, analysis, and evaluation. By providing this cognitive coaching, not only are we enhancing students’ skills in inquiry investigations, but we are also promoting metacognitive skills in both reading and science.

Connecting to the Standards

This article addresses the following National Science Education Standards (NRC 1996):

Teaching Standards Standard B:

Teachers of science guide and facilitate learning.

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Resources


Internet

Acid and Base pH chart

www.visionlearning.com/library/module_viewer.php?mid=58

Cornell News Release

www.news.cornell.edu/releases/Aug02/acid_rain_birds.hrs.html

Science Made Simple

www.sciencemadesimple.com/animals.html

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