The Mitten Problem

By Page Keeley

Assessment serves many purposes in the elementary classroom. Formative assessment, often called assessment *for* learning, is characterized by its primary purpose—promoting learning. It takes place both formally and informally, is embedded in various stages of an instructional cycle, informs the teacher about appropriate next steps for instruction, and engages students in thinking about their own ideas. Formative assessment can take many forms. One form that has been used successfully in science education is the formative assessment probe. The *Uncovering Student Ideas in Science* series published by NSTA provides science educators with an extensive bank of formative assessment probes (see Internet Resource for information on the series). These probes are used to reveal the ideas students bring to their learning before instruction (preconceptions) as well as the conceptions formed throughout the instructional cycle. Merely gathering this information does not make a probe formative. It is only formative when the information is used to improve teaching and learning. Each month, this column features a probe and describes how elementary science teachers can use it to build their formative assessment repertoire and improve teaching and learning in the elementary science classroom. See NSTA Connection for more background on using formative assessment probes.

"If Deb O'Brien had begun her lesson on heat in the usual way, she might never have known how nine long Massachusetts winters had skewed her students' thinking. Her fourth graders would have learned the major sources of heat, a little bit about friction, and how to read a thermometer. By the end of two weeks, they would have been able to pass a simple test on heat. But their preconceptions, never having been put on the table, would have continued, coexisting in a morass of conflicting ideas about heat and its behavior" (Watson and Konicek, p. 680, 1990). In 1992 I read an article about this lesson in *Phi Delta Kappan* that transformed my teaching and to which I credit today, the genesis of my popular formative assessment series, *Uncovering Student Ideas in Science.* The article was titled *Teaching for Conceptual Change: Confronting Children's Experience.* The students were convinced that if they put thermometers in their hats, coats, sweaters, or mittens, the temperature would rise. Not only did they believe the temperature would rise, but they were sure it would go "way up" and get "wicked hot." The students were surprised to find the temperature had not changed when they removed the thermometers. They decided the thermometers were not left in their "warm clothes" long enough. After all, one student explained, when the doctor takes your temperature, you have to leave the thermometer in your mouth a long time. Each time the students found the thermometer reading did not go up, and each time they substituted a new theory to explain their idea that "warm clothes" warm us up.

The teacher refrained from telling them the difference between objects that keep heat in (insulators) from objects that emit heat. She kept probing, giving them opportunities to test their naïve ideas, and had them confront the inconsistencies in their theories. The testing and discussion went on for three days. Finally the children reached an impasse and had no alternative theory to replace the ones they had. The teacher now stepped in and offered them two choices: (1) their theory that heat can come from any object, including hats and mittens, and (2) a new theory she offered that heat can come from warm things, like our bodies, and become trapped inside objects like hats and mittens. She asked the students to write about what they now believed and their reasons for their beliefs. She then asked them to stand in one of the

back corners of the room that best matched their thinking: theory 1 or theory 2, or stand in the front if they were unsure. One by one the children moved to different areas of the room, sometimes changing their mind and moving to a different area as they thought through their ideas.

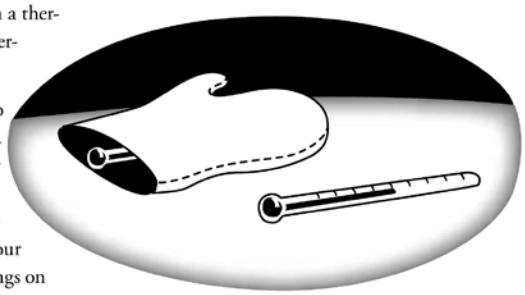
Instead of telling the students that theory 2 is the correct explanation, the teacher asked the students who chose this new explanation to think about how they could test this new theory. The children came up with the idea of putting thermometers inside their hats, which they wore on their heads, when they went out to recess. And so they did and the inquiry continued. Well, this is a short summary of a remarkable lesson, and I encourage you to read the whole article. What struck me as a teacher at that time was that this was more than just what I knew as inquiry-based teaching, this was inquiry teaching for conceptual change—a constructivist form of inquiry! It still posed investigable questions, involved students in collecting and analyzing data, encouraged explanations and communication, and eventually led students to a deeper understanding of the phenomenon. The teacher artfully designed the inquiry experience by first taking into account her students' preconceptions. Often this important first step is missed as teachers launch into inquiry. She then made sure the inquiry provided an opportunity to confront them with their ideas as they tested their predictions until eventually some students were willing to embrace a new explanation when their old one no longer worked for them.

Figure 1.

The "Mitten Problem" Formative Assessment Probe

The Mitten Problem

Sarah's science class is investigating heat energy. They wonder what would happen to the temperature reading on a thermometer if they put the thermometer inside a mitten.



Sarah's group obtained two thermometers and a mitten. They put one thermometer inside the mitten and the other thermometer on the table next to the mitten. An hour later they compared the readings on the two thermometers. The temperature inside the room remained the same during their experiment.

What do you think Sarah's group will discover from their investigation? Circle the response that best matches your thinking.

A The thermometer inside the mitten will have a lower temperature reading than the thermometer on the table.

B The thermometer inside the mitten will have a higher temperature reading than the thermometer on the table.

C Both thermometers will have the same temperature reading.

Describe your thinking. Provide an explanation for your answer.

Note the thermometer should be placed entirely inside the mitten.

After reading that article and delving deeper into learning about conceptual change, I decided to start each inquiry lesson with a probing question that would reveal alternative ideas my students might bring to their learning experience. I decided I could use these alternative ideas as springboards into inquiry. I wrote the "Mitten Problem" (Figure 1) back in 1990 after reading this article and sure enough, I got similar responses from my eighth graders as the teacher in the article did with her fourth graders. I let my students test their prediction and muddle through with uncertainties until they were ready to accommodate a new explanation. I felt energized by seeing how I could create a community of learners who felt comfortable defending their ideas and arguing with others as they held on tenaciously to their explanations or embraced new ones.

Challenge Conceptions

The "theory of immaculate insulation" remains prevalent among students. Research indicates that students often believe that some materials and objects, such as blankets or mittens, are intrinsically warm.

Likewise, they believe that some objects and materials, such as metals, are cold (Driver et al. 1994).

One effective way to gain insight into how students understand concepts in order to facilitate conceptual change in the classroom is to investigate just the opposite—how do their misunderstandings develop? Where does this idea that objects like mittens generate their own heat come from? It's quite reasonable to think this when we think about our everyday experiences. What do we do when we are cold? We put on a sweater, mittens, or cover ourselves with a blanket. We use language like "warm clothes" or "warm up your hands with these mittens." Using probes such as the "Mitten Problem" can reveal these tenaciously held ideas that come from children's everyday experiences and make sense to them. (The teacher notes that accompany a probe also provide summaries from the cognitive research that explain the commonly held ideas students have related to a concept.)

Probes such as the "Mitten Problem" are what I call a P-E-O probe: Predict, Explain, Observe. Students commit to an outcome, provide an explanation for their prediction of that outcome, and test their ideas by making observations. When their observations do not match their prediction, new explanations (and sometimes more testing) are needed. You can find many P-E-O probes in the *Uncovering Student Ideas in Science* series to use to spark inquiry in your classroom and facilitate conceptual change in the process.

Since the publication of "The Mitten Problem," I have had the pleasure to get to know and work with one of the authors of the transformative article, *Teaching for Conceptual Change,* Dr. Dick Konicek-Moran. Dick is a retired professor emeritus from the University of Massachusetts and is a natural teacher. I often refer to him as my "muse" since his seminal article (which is now used in many teacher preparation programs as well as the Exploratorium's Institute for Inquiry) led me down the path to develop formative assessment probes. Furthermore, Dick has published an outstanding resource through NSTA Press for elementary teachers that also promotes conceptual change through inquiry and uncovers many of the commonly held ideas noted in the research literature (see Internet Resource). The *Everyday Science Mysteries* series uses a short story genre to provide an opportunity for students to explore their ideas and work toward conceptual change as they take ownership in the inquiry. The formative assessment probes and mystery stories complement each other and can be used together. For example, the story *Warm Clothes?* (Volume 3) provides an opportunity for children to finish the story by testing their ideas about whether warm clothes generate heat. Together these resources will help you facilitate inquiry that encourages students to look for inconsistencies between what they believe they will find out and what their observations actually reveal to them. Some students (and teachers) will find this frustrating and will continue to defend their strongly held ideas. For others, the experience will change their thinking, including the way teachers think about teaching and learning! Try the probe, the mystery story, and read the article. I hope you, too, will be transformed. ■

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References

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Internet Resource

Everyday Science Mysteries
www.nsta.org/publications/press/mysteries.aspx

NSTA Connection

Read the introduction to *Uncovering Student Ideas in Science, Volume 1,* and download a full-size "The Mitten Problem" probe at *www.nsta.org/SC0311.*