Mining the Learning Cycle

Applying constructivist theory to mineral identification

"THIS IS BORING!" HAS BEEN THE consistent opinion of our students over the years when working with mineral identification. Initially we found it hard to believe that anyone could not be excited about minerals because students exhibit curiosity when first given a set to examine.

Rather than resign ourselves to the fact that not everyone shares an enthusiasm for rocks and minerals, we searched for a technique that would meaningfully teach students to understand mineral properties while alleviating the tedious nature of identifying mineral specimens. After seven years of experimentation, the answer finally lay in the learning cycle.

The learning cycle is a constructivist model that promotes the idea that learning takes place in three necessary phases (Barman, 1989):

1. *Exploration Phase:* Data-gathering or an activity on which to build knowledge involving observing, touching, and manipulating materials.
2. *Concept Development:* Students share information in their own words. Concepts are applied to the experiences in the exploration phase to develop student vocabulary.
3. *Application Phase:* Students apply the concepts to a new situation or design ways to answer their questions.

When the application phase is complete, the exploration phase resumes, building on students' acquired knowledge. With this cycle in mind, we redesigned our approach to teaching minerals.

BY DEBRA HEMLER AND HOBART KING

MINERAL PROPERTIES (EXPLORATION PHASE)

Pairs of students are given unknown mineral samples and mineral test kits and are allowed time to simply observe and explore. (Mineral kits and tool kits are constructed specifically for this activity as indicated in Figure 1.) Once students have become familiar with the mineral samples, we ask them to list any properties of the samples that would allow them to distinguish between the specimens.

Without any prior knowledge of minerals, mineral properties, or mineral test kits, students begin to explore the properties of the minerals before using the test kits. As we circulate around the room, we watch students observing the minerals. They immediately recognize that one specimen has magnetic properties (magnetite), one rubs off on their fingers (graphite), and two minerals split into thin sheets (muscovite and biotite). As exploration continues, they try scratching the glass from the test kit with the minerals. When students seem to have exhausted the properties they are able to list, we intervene.

We ask students to volunteer properties they have discovered, and we list them on the board. As we write them, we consciously group them into one of seven properties used to identify minerals (hardness, color, luster, streak, cleavage, fracture, and other). It is important for every group of students to contribute at least one property (even though it may be restating a previously given property). We record the language used by students in each response for future connections to scientifically accepted vocabulary. For example, students will use the terms *sparkly, shiny, metallic,* or *dull,* which we would lump together for the property luster.

When students have depleted their lists, we then reveal the fact that they have identified most of the properties that geologists use to identify minerals. For each of their lists, we identify the term that geologists use to describe that physical property of minerals. The students have generated the list of properties and now have an association for each property in their language, which has more meaning for them. We have not subjected them to a boring 50-minute lecture.

COOPERATIVE LEARNING (CONCEPT DEVELOPMENT PHASE)

The students now have personal constructs and language for each mineral property. They must now learn how to apply these properties to identify unknown minerals. We combine two student pairs to form a cooperative group of four. We explain that each newly formed group will be given a packet of unknown minerals. Before the students can identify these minerals, they must first research the mineral properties they have identified as important in identifying minerals. Each member in the group is responsible for becoming an expert on the two properties assigned to him or her: fracture and cleavage, color and hardness, luster and magnetism, or streak and other.

Students spend the remainder of the period searching their books and classroom resources for explanations of their assigned properties. Group members will depend on each other to know these properties for the identification of their minerals. We also let them know that on the following day they will teach the other members in their group about these physical properties. We make ourselves available to answer any questions or eliminate any confusion as students collect their information.

The following day, students break into their cooperative groups for a peer-teaching session. Each property expert explains his or her two properties to the rest of the group. When all groups have finished their instruction, we assemble as a class to clarify any questions that may have arisen during the peer-teaching sessions or address common misconceptions about mineral properties. We ask pertinent questions of the groups about specific properties to check their understanding of the concepts such as:

- Are all metallic minerals magnetic? (They generally discover during their exploration that the answer to this is "no.")
- Is color a good property for mineral identification? (Students will tend to answer "yes," so it is good to have several color varieties of quartz on hand.)
- Would a pearly luster be considered metallic or nonmetallic? (Often we find that students have not made the distinction between pearly and metallic; instead they lump them together, causing future frustrations with mineral identification.)

FIGURE 1.

Mineral samples and test kit for student groups.

Mineral Samples
graphite, galena, barite, biotite, feldspar, pyrite, muscovite, hornblende, calcite, magnetite, quartz, talc, hematite (specular and red)

Mineral Test Kit
nail, glass, streak, plate, penny, magnet, hand lens

MINERAL IDENTIFICATION (APPLICATION PHASE)

Students now have the tools necessary to experience the process of mineral identification. Rather than using the generalized mineral tables found in the back of textbooks, we opt to use a flowchart (Figure 2) that has been developed for use with these specific minerals employing a variety of mineral properties (King, Hemler, and Williams, 1997). Laminating the enlarged (ledger-size) flowcharts facilitates operation and cleanup because the graphite samples will mark unprotected papers.

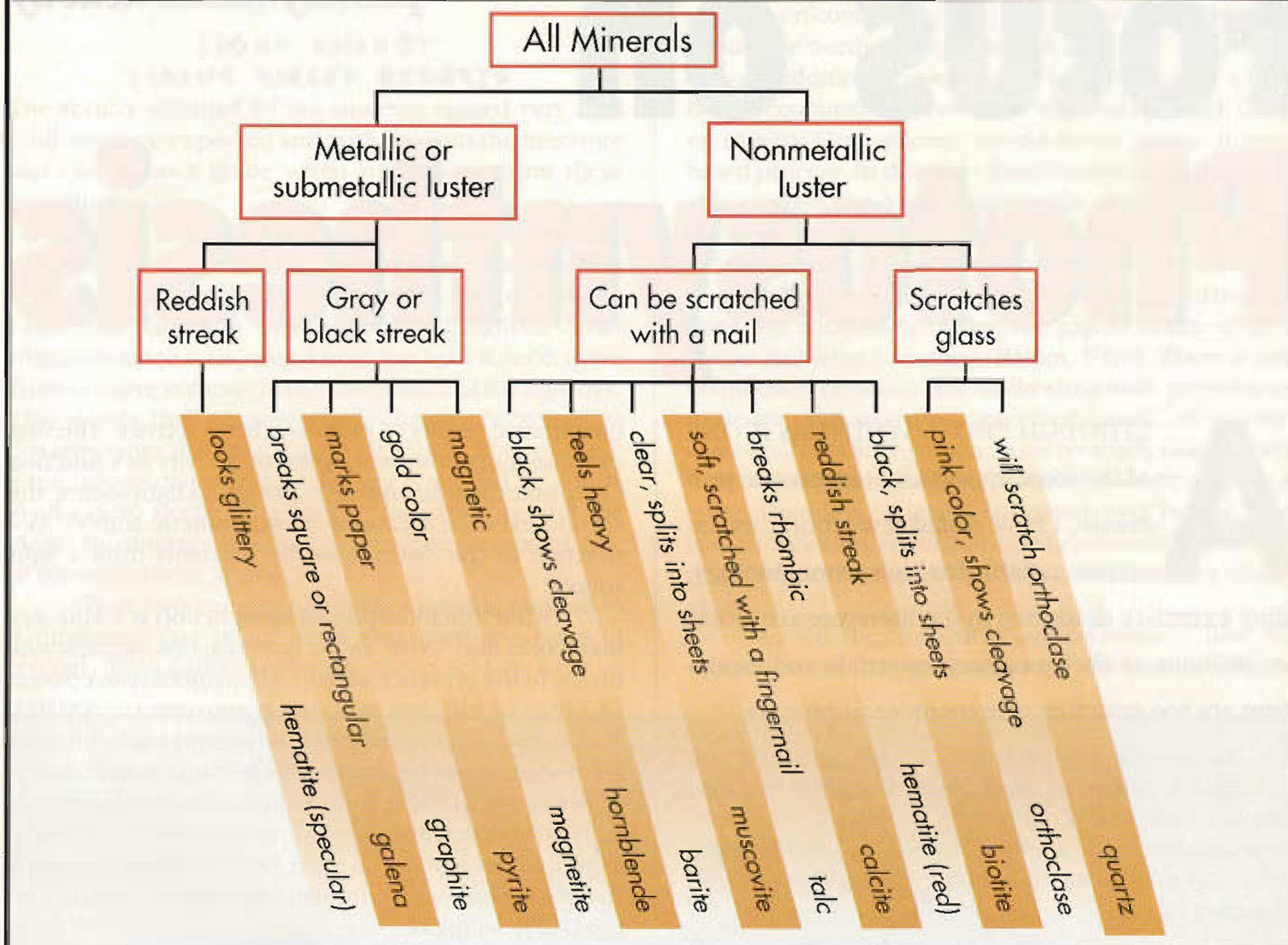
Each student cooperative group receives two flowcharts, mineral specimens, and test kits. Within their groups they work in pairs to key out the unknown specimens. Mineral samples are placed in the flowchart area marked "All Minerals," and students begin to move each specimen down to the next appropriate hierarchical level until each mineral is on its respective mineral name. The two groups within the cooperative group then compare their answers to see if they have keyed each specimen to the same mineral name. Here the property experts can troubleshoot and help the group reach a consensus.

At this point we circulate around the room answering questions or settling any conflicts. This is a good time to address additional misconceptions as students begin discussing whether a mineral is metallic or nonmetallic. For example, we might ask why one group of students placed certain minerals in a given category to correct any misunderstanding before it becomes deeply rooted. It is not critical for students to get the right answer initially; it is important for them to understand the properties and process involved in identifying mineral samples. Once the groups have finished, we discuss any problems or misconceptions they discovered they held about mineral properties.

As an extension that can also be used as a means of assessment, we give students five new minerals identified with their mineral names and a large, clean piece of paper. The cooperative groups must now modify the flowcharts they used in the exercise to accommodate the five new minerals. To complete this task student groups must first identify the new mineral samples' properties and incorporate these properties into the flowchart. This

FIGURE 2.

Mineral identification flowchart.



activity is valuable because students demonstrate that they truly understand the systematic approach to mineral identification.

In traditional mineral labs, teachers subject students to structured work without sufficient time for exploration and discovery. This learning cycle approach, however, gives students some control over their learning experience. It allows them the opportunity to explore long and deeply enough so that they are comfortable with the concepts before they are asked to apply them. In other teaching approaches, the teacher gives a protracted sermon on 15 different mineral tests (all at once) and then hands out an identification table and expects students to be systematic.

Our students have become responsible for their learning and view this exercise as a challenge. They come away with pride in the fact that they successfully identified the unknown minerals, and we have the satisfaction of knowing that students understand mineral properties and the *process* of mineral identification. Consequently, students no longer leave our classes with a negative attitude toward mineral identification. Half of the battle in science education is improving science habits of mind. This activity has proven for us to be a step in that direction. ✧

Debra Hemler teaches environmental Earth science at Preston High School, 400 Preston Dr., Kingwood, WV 26537, e-mail: dhemler@wvnvm.wvnet.edu; and Hobart King is an assistant professor of geology at Mansfield University, 214 Belknap Hall, Mansfield, PA 16933, e-mail: hking@mnsfld.edu.

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