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Rock On!: Providing Concrete Experiences Prior to Introducing Formal Geology Definitions

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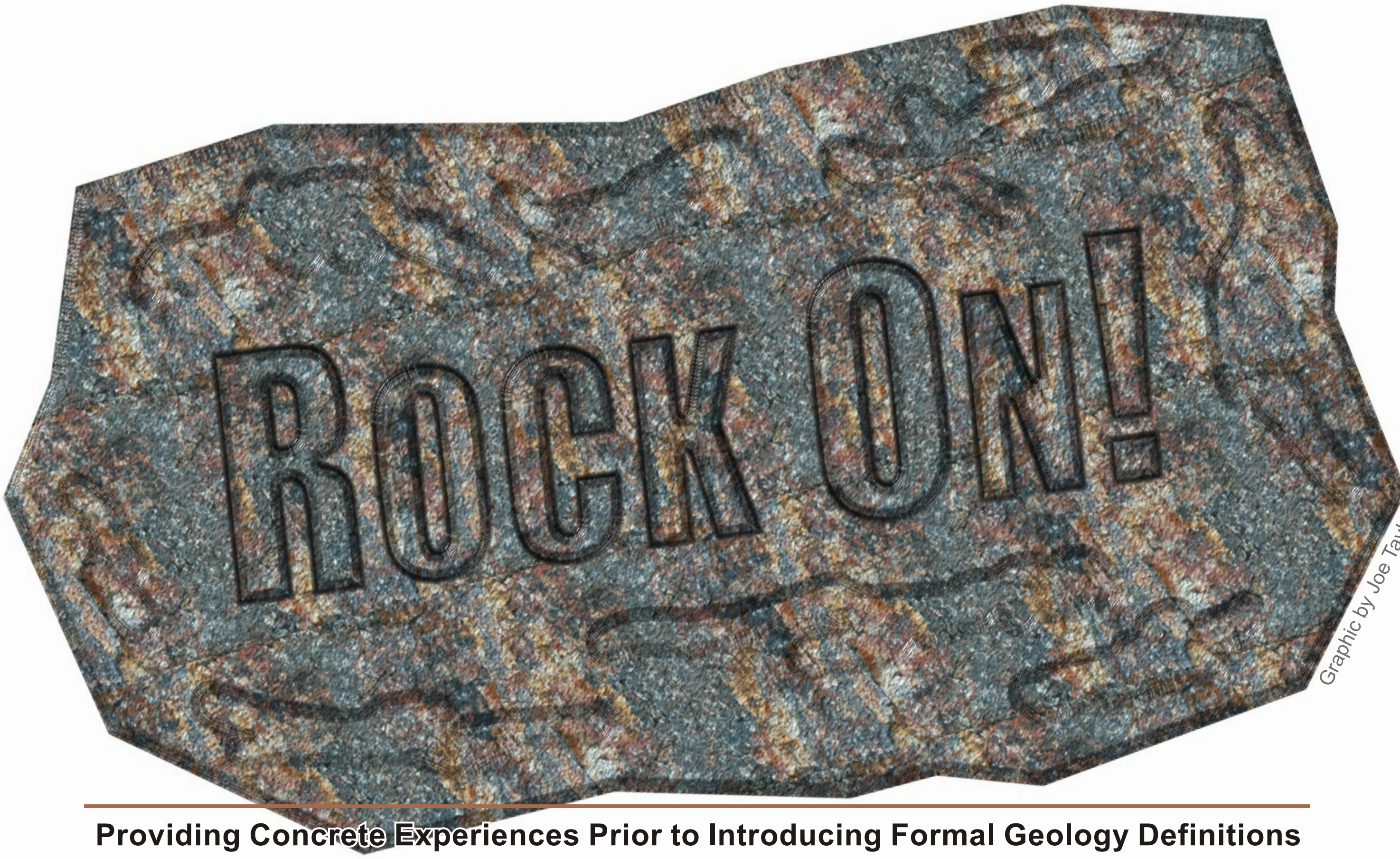

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Providing Concrete Experiences Prior to Introducing Formal Geology Definitions

by **Rachel Banasiak** and **Jody Beimer**

ABSTRACT: How can teachers mentally engage students in order to promote a deeper understanding of rock classification systems? Hands-on activities, while essential, are not enough. Students must have "minds-on" experiences as well (NRC, 1996). Inquiry lessons that encourage investigating, questioning, discovering, negotiating, making claims based on evidence and applying information to new situations encourage the mental engagement required for learning. The activity presented here has students meaningfully investigate and come to understand similarities and differences between metamorphic, sedimentary and igneous rocks before being introduced to those terms. In doing so, it focuses students' attention on understanding rather than memorization. *This article promotes National Science Education Standards A, B and D and Iowa Teaching Standards 1, 2 and 4.*

The Importance and Benefit of Inquiry-based Science Instruction

Teaching and learning science through inquiry has received a lot of attention. *The National Science Education Standards*, (NSES) (NRC, 1996) state that:

> "Inquiry is central to science learning. When engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others." (p. 2)

The importance of inquiry is articulated in Teaching Standard B of the NSES, "Teachers of science guide and facilitate learning. In doing this, teachers…challenge students to accept and share responsibility for their own learning…." (p.32) In short, effective inquiry-based science instruction promotes deep understanding rather then simple memorization.

Perkins (1997) defines understanding by emphasizing the learner when he notes:

> Understanding shows its face when people can think and act flexibly around what they know. In contrast, when a learner cannot go beyond rote and routine thought and action, this signals lack of understanding (p. 42).

Stepans (1994), when considering learning, adds:

> In order for learning to occur, the gap between the learner (where the learner is, what the learner is capable of understanding) and the concept presented should be manageable for the learner to bridge with the instructional experiences that are provided. (p. 5)

Similarly, we note the importance of considering students' developmental level when planning and carrying out instruction. According to Elkin (1989), developmental theorists believe that learning environments should be matched to the child's level of mental ability - particularly, the students' ability to think abstractly. Taking into consideration what we know about how people learn, we believe this investigation is appropriate for grades 68.

Moving Toward Inquiry

When students are first introduced to rocks, oftentimes the first thing they learn are the definitions associated with the rock type. When learning about rocks, inquiry is often overlooked. We remember as students in elementary and middle school our teachers bringing out all types of rocks usually in some sort of fishing tackle box. We were soon told that rocks are categorized as metamorphic, sedimentary and igneous. We were informed these types of rocks form differently and possess different characteristics. Using a basic rock chart, we followed steps in identify the rocks.

We remember following the steps from worksheets and oftentimes a classmate would blurt out, “Oh look, this rock must be metamorphic because that is what this chart tells me.” While following a flow chart to identify rocks has value, we worry that the more important understanding of the characteristics of the three categories and their importance is lost?

As teachers, we asked ourselves several questions, “What did the scientists do before they created the rock charts? How did the scientists perform their basic inquiry about rocks? Why not ask the students to use the same judgments that geologists used before they decided on definitions and categories? In this activity, we have students inquire to piece together physical properties of rocks. By having students investigate rock properties, we encourage active mental engagement and critical thinking about how rocks might be organized. When students engage with the creative process of designing organizational schemes, they better understand the challenges and processes of real science.

Investigating Rock Categories

To begin the investigation, each group of two students is given three rocks (one metamorphic, one sedimentary, and one igneous). We ask the students to make detailed observations of the rocks and explain that they have a balance, beakers, and water available to investigate characteristics of the three rocks. We tell students that they may ask for additional materials if they wish. When they do, we ask them to explain what they intend to do with the requested materials. To encourage students to write what they do and observe in their science journals, we ask students how they will remember precisely what they did and observed for later use. While students working, we move around the room, carefully monitoring student progress and posing questions to probe and push student thinking.

After about 5 -10 minutes of observations, we call the class to attention and ask, “What are some observations of your rocks that you have made?” Students usually report observations pertaining to color, mass and shape. We now have to push students toward identifying *defining* characteristics. We tell them that scientists have created three categories of rock and that each rock is representative of a different category. We then ask, “How valuable are your observations for differentiating the three *kinds* of rocks?” or “How effective would your previous observations be in differentiating a new rock in one of three categories?” Students realize that their observations are not adequate and will sometimes ask permission to make further observations. If students do not ask for more time, we ask students how their further observations might be different now that they know each rock is from a different category. Students easily note the need for more detail and that mass or shape observations are not beneficial. We then provide more time for students to make more detailed observations.

As students work on making new observations, we move around the room asking students what characteristics they are noting that may be useful for demarcating each category of rock. If groups are struggling, we might provide scaffolding questions such as, “What are some features of the rocks that seem most different from rock to rock?” or more guiding, “How would you describe the feel of the different rocks? What about the rocks make them feel different from each other?” Using questions, we can spark the idea to focus on particle size and texture while continuing to encourage mental engagement with the task.

After several minutes of further observations, we have each pair of students combine with another group of two to compare observations. Each group of four students now has six rocks (three rocks from each of the former groups of two students), and we have students determine which rocks would be paired together in the same category. Completing this task usually entails extensive discussion of former observations, demarcating characteristics, and further observations. After some time, we have a whole class discussion to create a list of characteristics for each of the three categories of rocks. To generate this list, the teacher holds up a rock from one of the categories and asks, “What characteristics of this rock would help you group it into one of your three categories of rocks?” After many student ideas, the next type of rock is used, and then the last. A sample list from a class of 8th grade students is below:

Rock Group 1	Rock Group 2	Rock Group 3
large grains	small grains	rough
tiny grains	angular grains	rough, but smooth texture
burnt orange in color	very light	denser that rocks in Group 2
light gray before placed in water	floats on water	displaces 2 mL of water
rounded and large grains	sandy brown color	rounded and small grains
angular grains	both large and small grains	both large and small grains
three different colored grains	dense	smooth
gritty	rough texture	brown and dull
only dull crystals	contains metallic & dull crystals	both shiny and dull crystals

Working from the list that has been generated, ask students to identify contradictions and discuss which of the ideas is most accurate and why. By having students use and analyze the list they have created, they are being encouraged to think critically and use higher-order thinking skills.

Now that students have wrestled with the task of identifying key differences that permit the rocks to be categorized in one of three groups, label rock group one as sedimentary, rock group two as igneous, and rock group three as metamorphic. Because students now have a conceptual basis for the vocabulary, students are more likely to remember the newly introduced vocabulary, the identifying characteristics, and why categorizing the rocks has value. This can lead into an interesting discussion regarding the history and nature of science (e.g. scientists did not find three categories, but instead developed this system to make sense of data). Furthermore, students will be better equipped to engage with future instruction concerning abstract ideas such as how the different types of rocks are formed and the rock cycle.

The Teacher's Role

For any class discussion to be productive, thought-provoking questions such as those provided are not enough. The teacher must also provide students the opportunity to answer, by pausing for 3-4 seconds after each question and response. Furthermore, teachers must use positive, non-verbal behaviors to elicit student responses. Looking expectantly and excitedly around the room conveys that student ideas are wanted and valued.

While teachers ought to acknowledge student ideas either verbally or non-verbally, rejecting or confirming student answers may have negative impact on class discussions. The teacher should initially accept all student responses, promote further discussion, and help students identify problems in their thinking by asking follow-up questions. By asking for clarification or asking how different ideas compare, the teacher can gain insight into student thinking and help students make new connections between ideas.

Final Thoughts

Rather than starting with definitions and terms, this activity starts by having students investigate properties of rocks. Beginning with concrete experiences encourages meaningful engagement in determining characteristics of rocks that are useful for classifying them in the three categories identified by geologists. Yet, concrete experiences are not enough. Learning through inquiry does not mean that students, on their own, arrive at accepted science ideas. The teacher must engage students by posing questions that help students make connections and achieve the desired learning outcomes. Effective inquiry teaching raises students' interest in science, promotes mental engagement, draws out students' thinking, and results in a deeper understanding of targeted science content and the nature of science.

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