"INVENTION" ACTIVITIES in an INTRODUCTORY LAB: Minerals, Rocks, Biodiversity, & Earthquakes

Sara Harris & Brett Gilley, Earth & Ocean Sciences, University of British Columbia, 6339 Stores Rd, Vancouver, BC, V6T 1Z4, Canada.
sharris@eos.ubc.ca, bgilley@eos.ubc.ca

What are "Invention" Activities?

"Invention activities" are learning opportunities through which students recognize and develop deep, underlying structure for themselves (Schwartz and Martin, 2004). Often these activities are constructed with contrasting cases, selected or designed to encompass the relevant variability and help students notice critical features. This approach differs from (and essentially reverses) the more common "tell-and-practice" sequence in teaching and learning, in which an expert solution is presented, then students practice applying it. The "invention" approach has been shown to improve retention and transfer.

We developed four activities for a university-level introductory earth science lab course that have the features of invention activities. All these activities use simple materials and are easy to set up and facilitate.

Pre-test → 11 weeks of lab activities (some "invention" activities) → Post-test

Start-of-term … *End-of-term*

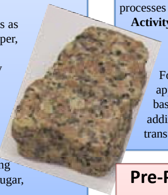
I. Is It A Mineral?

Goals: *By the end of this activity, students will be able to:*

1. Classify common objects as either minerals or non-minerals
2. Justify classifications based on an object's characteristics
3. Define "mineral"

Activity summary:

In small groups, students make decisions on how to classify seven common objects as either minerals or non-minerals. The objects are: quartz, glass, wood, granite, copper, plastic, and ice. Students receive no prior instruction, and thus need to use their observations and their current conceptions of minerals in order to make and justify their classifications. After small groups have completed their classifications, a full-class discussion ensues, revealing differences among the groups, from which emerges a definition of "mineral".



In-Class Assessment:

Give students additional common objects and ask them to classify them as mineral or non-mineral, and justify their classification (to see if they are right/wrong for the right/wrong reasons). Examples could include: bone, coal, steel, oil, salt, sugar, paper, gold ring, etc.

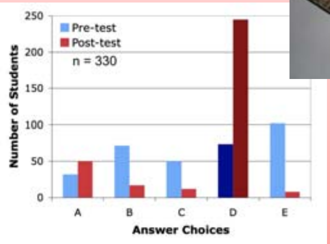
Pre-Post Assessment Results for "Is It A Mineral"

Pre-test written on first day of class; Post-test on last day

Which of the following groups contains only minerals?

A) Quartz, Water, Ice
B) Diamond, Granite, Steel
C) Diamond, Water, Granite
D) Quartz, Ice, Iron Pyrite (fool's gold)
E) Quartz, Steel, Iron Pyrite (fool's gold)

Image: Sara Harris



67% gain

67% of students who answered incorrectly on the pre-test, answered correctly on the post-test

II. What are THESE rocks (and how did they form)?

Goals: *By the end of this activity, students will be able to:*

1. Infer how rocks formed based on observed characteristics
2. Group rocks into categories based on inferred process of formation
3. Explain how one rock could be transformed into another rock, for any rock combination

Activity summary:

Activity 1: Small groups of students are given 4 rock hand samples per group (granite, conglomerate, sandstone, phyllite). They are told that the four rocks represent the 3 basic categories of rocks, which geologists have categorized based on processes of formation. Based on their observations, they decide which two rocks formed from similar processes. Students receive no prior instruction, and thus need to use their observations and their current conceptions of how rocks form in order to make and justify their grouping. After small groups have completed this task, they report their decision. A full-class discussion ensues, revealing differences among the groups, from which emerges the three rock types and basic processes of formation for sedimentary, igneous, and metamorphic rocks.

Activity 2: Students are given 3 more rocks to put in the appropriate groups, then challenged to draw the rock cycle using their groupings of seven total rocks.

In-Class Assessment:

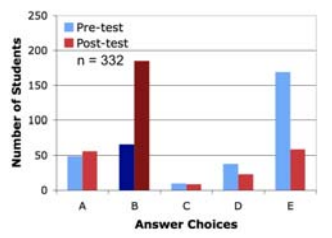
For Activity 1, give students additional rocks and ask them to classify them into the appropriate groups. Examples could include: gneiss, basalt, pumice, schist, etc. For Activity 2, give students additional pairs of rocks and ask how one could be transformed into the other.

Pre-Post Assessment Results for "What are THESE rocks?"

Pre-test written on first day of class; Post-test on last day

How did this rock form?

A) It cooled quickly after erupting from a volcano.
B) It cooled slowly deep underground.
C) It cooled quickly under water.
D) It is made of broken pieces of other rocks.
E) It is made of minerals that were recrystallized under high pressure.



45% gain

45% of students who answered incorrectly on the pre-test, answered correctly on the post-test

III. Quantifying Biodiversity

Goals: *By the end of this activity, students will be able to:*

1. Explain the key factors to consider when quantifying biodiversity
2. Compare real samples using both a self-generated biodiversity index and a standard biodiversity index

Activity summary:

In small groups, students "invent math" to quantify the diversity of fake samples composed of various office supplies. They apply their biodiversity index to a new fake sample that was not considered in the creation of their index. This activity is preparation for learning about and using a biodiversity index developed and used by experts. In the second activity, students make observations of two contrasting phytoplankton samples, quantify the diversity of the samples, and compare them.

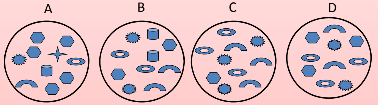
In-Class Assessment:

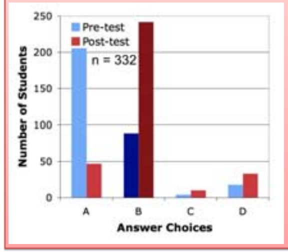
Give students a new set of samples and ask them to rank them from high to low diversity.

Pre-Post Assessment Results for "Biodiversity"

Pre-test written on first day of class; Post-test on last day

Which of the following samples (A, B, C, or D) is the **most diverse**?





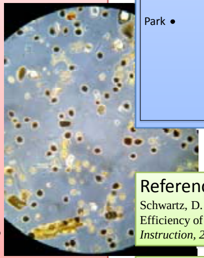


Image: David Cassis

63% gain

63% of students who answered incorrectly on the pre-test, answered correctly on the post-test

IV. Where was that Earthquake?

Goals: *By the end of this activity, students will be able to:*

1. Explain how differences in travel times can be used to estimate distance traveled
2. Locate a starting point on a map using paired arrival time data

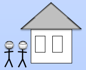
Activity summary:

In small groups, students "invent" a way to figure out the location of a house, based on the walking times of two housemates to various locations near their house. This cover story is an analogy for using the arrival time differences between P and S waves to locate an earthquake epicenter. Students then create and compare graphs analogous to a Jeffreys-Bullen diagram and come up with a generalized way to use this type of graph to find distances. The activity prepares students for learning how to locate an epicenter and makes the relationship between distance and arrival times meaningful, since they have to figure out how to use arrival time differences to estimate distance.

In-Class Assessment:

1. Give students another location in the same scenario, a different distance away.
2. Change Polly and/or Sam's speeds and apply to the same scenario.
3. Give students some data for another of the pairs of friends and ask them to locate this different house on the same map.

Where do Polly and Sam live?



They always leave the house together, but **Polly walks 4 km/hr** and **Sam walks 3 km/hr**

Destination	When Polly arrived	When Sam arrived
Ice Cream Store	12:40 pm	1:00 pm
Beach	3:00 pm	3:06 pm
Library	10:44 am	11:11 am
Park	7:35 am	7:48 am

No Pre-Post Assessment Results Yet

References

Schwartz, D. L., and T. Martin, 2004. Inventing to Prepare for Future Learning: The Hidden Efficiency of Encouraging Original Student Production in Statistics Instruction. *Cognition and Instruction, 22(2)*, 129-184.

Acknowledgements

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COMPLETE ACTIVITY DOCUMENTS: http://nagt.org/nagt/programs/hands-on2011/index.html OR http://nagt.org/nagt/programs/teachingmaterials/56387.html (Minerals) ../56406.html (Rocks) ../57575 (Biodiversity) ../58610 (EQs)

Image credits: Brett Gilley unless otherwise noted

a place of mind
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