Engaging First Grade Students in a Geoscience Campus Field Trip

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ABSTRACT

We present a geology field trip for first grade students, which includes four hands-on, age-appropriate activities on rocks, minerals, soil and fossils. The content of this program called Geokids adheres to the California educational standards and fits the physical sciences unit on sand, silt and clay for first grade. Over 600 students from eleven schools participate yearly in Geokids which is taught by university graduate and undergraduate student volunteers. The feedback from both university instructors and first grade teachers has been very positive and we are in the process of expanding our audience to include schools in lower income areas.

BACKGROUND

Geosciences are a great place to introduce young children to science content, the scientific method and the mutual interactions between science and society. Children are already interested in dinosaurs, volcanoes and digging in dirt. At the School of Earth Sciences at Stanford University, we have developed a program that takes this natural curiosity to the next level, by incorporating it into the school experience. We offer a morning field trip to campus, called Geokids, for first grade classes to learn about fossils, soil, rocks and minerals from university students.

As is often the case in university outreach programs, Geokids began through a personal connection of one of us (Paytan). The focus on first grade began with Adina's daughter entering elementary school in 2000. Adina learned that the science curriculum in first grade includes a unit on sand, silt and clay; she offered to help the local school teach this unit with a field trip to the university. In a brainstorming session with interested graduate students, we decided to develop four hands-on, age-appropriate activities which fit within the National and California educational standards (Table 1) and complement the current classroom curriculum. In the first year of the program 2000-01, four classes from Almond School in Los Altos participated. In the second year, two more schools joined the program, and in 2005-06, eleven schools participated in the Geokids program (and more would if we could accommodate them). We serve about 600 students from 30 classrooms, with two thirds of the schools returning in 2006-07. About 25 university students volunteer to run the morning program.

Though Stanford University is not an informal learning center in the traditional sense, Geokids was designed to emulate the experience of an active field trip to a learning center. Students have the opportunity to explore on their own through participation in the activities. The worksheet approach used in museums is adopted for the mineral activity which takes place at the mineral collection on public display, while the other stations use a more classroom-style teaching method. In this paper, we describe in detail the activities at the four stations. We hope that the first grade students leave Geokids with a sense that Stanford University is a learning center and with a positive attitude toward science.

In general, field trips are a memorable experience for students. They get out of the classroom to learn about the world in different ways than from the usual classroom setting. These experiences form long lasting memories, regardless of subject matter or type (Falk and Dierking, 1997). Indeed, what they retain may go far beyond the objective of the lesson (Knapp, 2000). Field trips can result in an improved attitude toward the site visited and a positive reaction to learning more about a specific subject (Knapp, 2000). Social aspects of being out of the classroom environment have also been shown to have a great impact, sometimes greater than the subject content. We believe the environment of Geokids provides positive lasting memories, of both social and academic experiences in addition to enhancing the subject matter knowledge.

Geokids focuses on experiential learning for both student and instructor. Specifically, involving geoscience graduate students in teaching this program provides them with direct teaching and outreach experience that they rarely get as teaching assistants in college courses. Here, they are the instructors, leading the teaching experience. We provide training on the activities, and pair novices with more experienced instructors. This opportunity allows the university students to find their teaching voice (figuratively, not literally). Also, we are training graduate students about the value of their involvement in education and outreach as well as providing them with the pedagogical skills they will need as they pursue funding from agencies that require broader impact components (National Science Foundation, 2004).

We hope that by sharing our experiences we can inspire other geoscientists to develop similar programs. This program can be adopted as is, or changed to fit the needs of local elementary students and the expertise of the instructors.

FIELD TRIP ORGANIZATION

Geokids is a 2-hour morning field trip to the Stanford campus which can accommodate 40-60 students (2-3 classes). We offer this program free-of-cost to local public schools and we are fully subscribed with 15 field trips each academic year. The instructors are volunteer undergraduate students, graduate students, post docs and lab technicians. We have a pool of about 25 volunteers each year, many of them volunteering for several years. They are primarily from the various departments and programs in the School of Earth Sciences.

The day begins with one of us welcoming the students and asking what they think geologists study. We briefly discuss geology as a career, emphasizing that
the instructors are students going into geology careers and talk about how geology impacts our every day life. With the help of the elementary school teachers, we divide the first grade students into four groups (10-15 per group); both students and university instructors wear name tags (this is coordinated with the elementary school teachers in advance). We give each student a field book to be used at the stations. The field book has age-appropriate language and images to guide explorations. Students record their observations in the field book just like a scientist does. To ensure smooth transition between activities, we have a set time schedule of 20 minutes at each of the four stations, 5 minutes in between stations as travel time, and a 15 minute mid-morning break with a running game we call Erupting Volcano. The break is very important for the young students who have lots of energy and need to run a bit, and sometimes need a snack to get them through the whole morning.

At each station, the Stanford instructors introduce themselves to the students and say something about how much they enjoy studying rocks, fossils, etc. and then begin the activity. Over the year, Stanford instructors have the opportunity to teach at various stations although they are welcome to remain at the station they are most comfortable teaching. Below we describe the activities at each station in detail. The National and California State educational standards for each activity are detailed in Table 1. The supplies are for a group of 15 students at each station. The field book is available at: http://pangea.stanford.edu/outreach.

<table>
<thead>
<tr>
<th>Rock Station</th>
<th>Science Content Standards for California Public Schools</th>
<th>National Science Content Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Earth Sciences 3a. Students know how to compare the physical properties of different kinds of rocks and know that rock is composed of different combinations of minerals. 3b. Students know smaller rocks come from the breakage and weathering of larger rocks.</td>
<td>Properties of Earth Materials</td>
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<tr>
<td></td>
<td>Investigation and Experimentation 4b. Students will record observations and data with pictures, numbers, or written statements.</td>
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</tr>
<tr>
<td>Mineral Station</td>
<td>Earth Sciences 3a. Students know how to compare the physical properties of different kinds of rocks and know that rock is composed of different combinations of minerals.</td>
<td>Properties of Earth Materials</td>
</tr>
<tr>
<td></td>
<td>Investigation and Experimentation 4. Students should develop their own questions and perform investigations.</td>
<td>* Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which make them useful in different ways.</td>
</tr>
<tr>
<td>Soil Station</td>
<td>Earth Sciences 3c. Students know that soil is made partly from weathered rock and partly from organic materials.</td>
<td>Properties of Earth Materials</td>
</tr>
<tr>
<td></td>
<td>Investigation and Experimentation 4. Students should develop their own questions and perform investigations.</td>
<td>* Soils have properties of color and texture, capacity to retain water, and ability to support the growth of many kinds of plants, including those in our food supply.</td>
</tr>
<tr>
<td>Fossil Station</td>
<td>Earth Sciences 3d. Students know that fossils provide evidence about the plants and animals that lived long ago and that scientists learn about the past history of Earth by studying fossils.</td>
<td>Properties of Earth Materials</td>
</tr>
<tr>
<td></td>
<td>Investigation and Experimentation 4. Students should develop their own questions and perform investigations.</td>
<td>* Fossils provide evidence about the plants and animals that lived long ago and the nature of the environment at that time.</td>
</tr>
<tr>
<td>Volcano Game</td>
<td>Physical Sciences 1b. Students know the properties of substances can change when the substances are mixed, cooled, or heated.</td>
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</tbody>
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Table 1. Geokids activities and the National and California Educational Standards.
ROCK STATION

Supplies:
5 sedimentary rocks, 5 igneous rocks, 5 metamorphic rocks
A few walnut-sized pieces of pumice and rhyolite
Granite, sandstone, gneiss, and other rocks for demonstration (obsidian, scoria, conglomerate, fossils, etc)
5 sets of 3 laminated name cards with the following written on them:
Igneous rocks are sometimes glassy and sometimes have big crystals
Sedimentary rocks are made of sand or pebbles cemented together
Metamorphic rocks have been squeezed and flattened
Photos of an erupting volcano, Half Dome at Yosemite, sand flats, and twisted rocks
2 clear cups with water
Crayons

Overview:
Students learn about the three rock groups and discuss a few identification characteristics. They test their knowledge by identifying three rocks. If there is time, students predict and observe how some rocks behave in water. We set up a classroom to have an open area where the students sit in a circle and pass around rocks and a second area with tables where students work in groups of 2-3 to identify their rocks. Each group has 3 rocks (1 sedimentary, 1 igneous, and 1 metamorphic) with a set of name cards and crayons.

Activity:
1. Students are seated in a group away from the rock samples and we discuss what rocks are made of and how to tell them apart. We explain that different rocks are made of different minerals and geologists can tell the difference between them by looking at the colors and the texture of the rock. We point out that in some rocks we can see the minerals. We use the analogy that minerals are chocolate chips in a cookie (the rock). (1 minute)
2. We explain the rock cycle, using examples of granite, gneiss, and sandstone (and other samples, but not too many). We define the three types of rocks. Beginning with granite or a volcanic rock, we ask how rocks can be formed and show the pictures of a volcano and a mountain. Showing granite and obsidian, we talk about how cooling rate relates to grain size. The children read the descriptions of each rock type on the name cards. (5 minutes)
3. The children divide into small groups (2-3) and go to a table which is equipped with a set of 3 rocks and 3 cards. The students identify which type of rock each one is. We encourage the teachers/parents to work with a group. It is important that each group gets some one-on-one help from an adult. (8 minutes)
4. When each group has matched their rocks with the rock type card, we ask each group why they matched them as they did. It is important for them to try to verbalize and express how and why they matched them. We try to get them to make observations about the rocks (focus on color, texture, how heavy the rock is). Time permitting, the children are also asked to compare the rocks on their table to each other. For sedimentary rocks, they are asked to predict where the rocks formed, or what kind of places these rocks look like they might be from (for example, a sandstone looks like it is made of sand from the beach). (2 minutes)
5. After a group has completed the identification, they draw their favorite rock in the field book. We help them focus on features (lines, crystal size) (Figure 1). We do not let them trace the rocks to prevent crayon-covered specimens. (2 minutes)
6. If there is time, we ask if rocks can float. Why or why not? We show them the pumice and rhyolite and have them make a prediction as to what will happen when they drop both rocks into the water. We drop the rocks in the water to show that the pumice floats. We pass around the pumice and ask them why they think it can float. (3 minutes)

MINERAL STATION

Supplies:
Gypsum - 5 pieces, about 2 inches square
Halite - 5 pieces, about 2 inches square
10 pennies
1 container of talcum powder
1 container of salt
1 tube of toothpaste
15 clipboards
Pencils/crayons

Overview:
Students observe many different minerals. They are introduced to the difference between a rock and a mineral. They look at color and hardness as a way to distinguish minerals. This activity should take place at a mineral display area.

Activity:
Introduction (6 minutes)
1. We begin this station with an introduction to minerals using examples that they may be familiar with such as salt. We emphasize the difference between rocks and minerals, and how minerals are different from each other. Some questions we ask are: Can you name a mineral? What is a mineral? How is a mineral different than a rock? What is in toothpaste? What is in baby powder? What is salt? We show them these products and relate them to the minerals.
2. Next we have the students think about how to tell minerals apart. We present samples of halite and gypsum. We tell them that they will be looking at two properties that help geologists tell the difference between minerals. The properties are color and hardness.

3. We divide the children into two groups and each instructor stays with the same group for the two exercises.

Hardness (7 minutes)
1. We begin by showing two minerals, gypsum and halite, and asking them how we can test for hardness. We tell them what the minerals are used for and pass around samples. Each student should have a sample of each mineral. We always make sure to tell them not to lick the halite, or else one of them will try it.
2. Next, we direct them to try to scratch each one with their fingernail and with a penny. Students record their observations in their field book. Halite is slightly harder than gypsum. (It is very hard to scratch halite with a penny, whereas the gypsum scratches easily. Also, a fingernail will not scratch halite, but you can scratch the gypsum with a fingernail.)
3. Concluding, we explain that even though gypsum and halite look similar, hardness is one way geologists can tell the difference between the two minerals.

Color (7 minutes)
1. We describe that minerals come in different colors and color is another way to describe and identify minerals.

2. Using the permanent display of the mineral collection, students look for a yellow mineral, a green mineral, and a purple mineral. They write down the name of three minerals in their field book. We encourage the teachers and parents to help.
3. To wrap up, we ask them if they want to share any general observations they made while looking at the mineral collection. Did all the green minerals look the same? Did they notice anything about shape? We find that asking "Which is your favorite?" is a good question to have everyone in the group answer. We have to be patient with the shy ones and help with pronunciation of the mineral names.

SOIL STATION

Supplies:
- 2 clear storage boxes (bigger than a shoe box)
- Hand trowel to dig soil
- 10 metal forks or spoons
- Crayons
- Water
- 3 mineral powders (1. Iron(III) oxide, red, hematite, 2. Iron(III) oxide, yellow, monohydrate, 3. Iron disulfide, iron pyrite) (order from chemical supply company)
- Cups to mix minerals with water
- 10 paintbrushes
- White paper for painting

Overview:
We do this activity outside on picnic tables, yet it could be done in a classroom. At one table, students observe living and non-living materials in soil. At the other table, students paint with minerals. We divide the group of students into two and switch after 10 minutes. The paint does not take long to dry, so at the end of the day we gather up all the paintings and give the stack to the teacher.

Setup:
1. We collect soil that has a variety of worms, insects and other components into the clear storage boxes.
2. We mix some of the powdered mineral with water in the small cups until it reaches a thin consistency that is easy to paint with.

Activity:
What's in the Soil? (10 minutes)
1. Each student gets a spoon or fork to dig in the soil.
2. We lead a discussion about the soil and the animals as the students are digging. We try to identify with the students' help what they find. Soil is composed of many components, including many which are alive. There are two main types of animals found in soils, and they are called shredders and digesters. The shredders break down large pieces of plant material into smaller ones. Shredders include caterpillars, pill bugs (sow bugs), and millipedes. Digesters are mainly the earthworms, and they go through the soil eating the small particles and putting out new soil that is full of plant food, which is why worms are so good for gardens. Sometimes we find a third category of animal which is a predator such as a centipede; it eats other animals, alive or dead, that live in the soil. The centipedes are the only creatures that we don't allow the students to pick up with their hands, since these can bite (we...
Overview
Box to carry the clay fossils back to the school
Tablecloth
Plastic hand lenses
2 permanent fine-tipped markers
Assorted shells
Plastic dishes (weight boats or petri dishes) - 1 for each
Trilobite model
Trilobite nodule (with internal and external molds)
Ammonite (~20 inches in diameter)

FOSSIL STATION
Supplies:
Photos or transparencies of Tyrannosaurus rex, Stegosaurus, footprint fossils, and plant fossils
Ammonite (about 20 inches in diameter)
Trilobite nodule (with internal and external molds)
Trilobite model
Plastic dishes (weight boats or petri dishes) - 1 for each student
Modeling clay (air drying type) - 1 inch ball for each student
Assorted shells
2 permanent fine-tipped markers
Plastic hand lenses
Crayons
Tablecloth
Box to carry the clay fossils back to the school

Overview:
We begin the discussion by asking them what they know about fossils and showing them a fossil. How fossils are made? Have you ever found a fossil? We explain that hard parts fossilize and soft parts decay, while discussing the importance of imprint or trace fossils. We emphasize that much of what we know about early life is from impressions or traces like footprints and burrows. (2 minutes)

1. We show pictures of assorted fossils and ask the students to identify the pictures. We emphasize the difference between hard parts (bones-shell) and "soft" trace fossils (leaf imprints and foot prints). If time permits, we let them tell us what they know about dinosaurs with the pictures of the Tyrannosaurus rex and the Stegosaurus. Again, we remind them that everything we know about dinosaurs is from fossils. (3 minutes)

2. We show them a closed trilobite nodule and ask if they know what it is. We open it and explain that it is a fossil Trilobite. Trilobites lived from ~542-241 Mya. They went extinct at the same time as 90% of all living species in what is called Great Permo-Triassic extinction. We point out the body fossil (internal mold) and the imprint fossil (external mold). Using their field books, students try to identify the trilobite based on body shape in comparison to two pictures. We also have a model of another trilobite so that more students can work at the same time. (3 minutes)

3. We put all the fossils the children prepared in a box and ask if they know what it is. We explain that we can take the fossils back to the school. (5 minutes)

Imprint Fossil and Ammonite (12 minutes)

1. Imprint Fossil: We show examples of hardened "fossils" and explain how the students will make imprint "fossils" with shells and clay. Students press the clay flat, about 1/4" thick, and then press shells into the clay. We write their names on their weight boats. (6 minutes)

2. Ammonite (~500 - 65 Mya): We bring a small group over to the large ammonite and let them touch it. We ask them what they think it may be. We describe how we think it grew and moved in the water. We have them look at three pictures of ammonites in their field books, and have them figure out which picture it matches. We show them how to look at the patterns on the ammonite with their hand lenses. (6 minutes)

ERUPTING VOLCANO! - MID MORNING ACTIVITY
Overview:
This game is about temperature and how molecules move more quickly at hotter temperatures. The students simulate the movement of the magma while it heats up, erupts from a volcano, and cools down into solid rock. We do not mention anything about pressure or temperature of the rocks below the surface, in order to keep it simple and fun.

We play this game during the mid-morning break. The students need a break from the classroom. This way they can run and have fun, while thinking about volcanoes. The group size can be from 10 to 60 children. One round takes about 3-4 minutes, so we play the game two or three times, depending on student interest and time. As you tell the story/read the script, you should act out the motion.

Setup:
We roll clay balls, ~1 inch in diameter and place in plastic dishes. This is to conserve clay and to ensure that the students have enough to work with successfully.

Activity:
Introduction (8 minutes)
Today you are going to be part of a rock. When things - rocks, plants, air, and all the little parts that make up your body - are cold, they move very slowly. And as they get warmer and warmer, they move more and more quickly. I'm going to tell you when you are hot moving your body - are cold, they move very slowly. And as they get warmer and warmer, they move more and more quickly. I'm going to tell you when you are hot moving magma in the earth near a volcano. Right now you are solid rock, and then something shifts in the earth and you start to move closer to the surface. You should begin slowly moving in place, just by rotating the top of your body. Then as you get hotter, you will slowly begin to rotate, and then make small circles. You are getting hotter and hotter. You are now flowing magma in the...
magma chamber. You are very hot and are starting to move even faster. And then, the volcano erupts. Run! You are now hot lava running quickly down the side of the volcano. (Let the children run for a minute). Now, you are cooling off and slowing down. You are a solid rock now and stop moving.

FEEDBACK

Geokids is a great program for both the Stanford students and the elementary students. The feedback from both groups has been very positive. Several graduate students have participated for a few years in a row. Undergraduate students try to sign up for days even if this will mean that they will have to miss their classes (this is NOT encouraged). They enjoy sharing their excitement with young students and getting to look at geology through the eyes of a first grader.

During the 2006-2007 academic year, we surveyed the teachers the week after they participated in the Geokids field trip. We asked them to fill out a short online survey so that we can begin to understand how effective the program is. Eight teachers responded, representing five schools from the two school districts that we primarily serve. We have summarized the results and provided a table with representative responses to the questions (Table 2).

Overall, the teachers are very pleased with Geokids. The survey results indicate that all but one teacher did pre-trip geology activities, ranging from teaching the three rock types to using many of the lessons in the FOSS unit on Pebbles, Sand and Silt. Most students participated in post-trip activities which included writing about their experiences at Stanford. Two teachers also had students include in the K-W-L chart (Know - Want to Know - Learned) information related to their Geokids experience. Overall, the teachers thought that the best part of the day was hands-on activities with the fossil activity most often mentioned. All teachers told us that the activities were very appropriate for their students. Also, they applauded the instructors’ ability to engage the students and their ability to ask and answer questions at the right level.

On a more ancillary note, we have only heard positive feedback from the schools and parents. The students send pictures and letters, telling and showing what they remember. We share this feedback with the instructors because it inspires them to continue volunteering in the program. One school gave all the instructors gift certificates to the fruit smoothie store on campus as a thank you gift. Many teachers bring their first grade classes year after year and now we have a waiting list. We plan to implement a lottery scheduling process for future academic years.

NEXT STEPS FOR GEOKIDS

Our audience has been elementary schools from the surrounding districts of Palo Alto and Los Altos. We are beginning to expand our audience to include schools in the lower income areas of east Menlo Park and East Palo Alto. With these schools, we now have the challenge of helping with providing a means for transportation. In the more affluent schools, parents drive the students or the cost of a school bus is not prohibitive. As our audience expands to include less privileged school districts, we may face other unforeseen challenges.

While preparing this article, we more fully realize the need to do a formal assessment of the program. Some of the questions we would like to answer are: Does Geokids change a child’s attitude toward science? Does Geokids address any misconceptions? Does Geokids create any misconceptions with the volcano game? Do children make connections between their own lives and the activities they participate in at Geokids? We would like to incorporate this information into the Geokids program, including volunteer recruitment. Graduate students are more likely to volunteer if they know their efforts are effective in improving student attitudes toward science (Andrews et al, 2005).

From the idea to help just one school, Geokids has grown to provide a substantial learning experience for the local community. "It [Geokids] is definitely the most educational field trip available that connects with our first grade curriculum," wrote a returning teacher from Lucille M. Nixon Elementary School in Palo Alto. The strength of the Geokids Program also resonates with the volunteer instructors as a successful program. A former graduate student described her experience with Geokids as "highly rewarding when those little first graders grasp concepts that we have trouble getting college students to understand."

ACKNOWLEDGEMENTS

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REFERENCES


