DEVELOPING A GEOLOGIC OUTREACH PROGRAM

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ABSTRACT

A geologic outreach program was initiated within the Geology/Geography Department of Eastern Illinois University to deliver geologic demonstrations and activities presented by undergraduates to area classrooms in elementary, middle, and secondary schools. The presentations are developed to aid classroom students by the delivery of inquiry methods of geology teaching. The presentations are available on a website so teachers can use them when no guest presenter is available. The program has been well received by area teachers.

Keywords: Education-precollege

INTRODUCTION

Eastern Illinois University (EIU) is a state university located in Charleston, Illinois in the east central part of the state. Charleston is the largest city in the county (and for a radius of 60 miles) with a population of about 20,000. The students at EIU comprise about half of the population. The surrounding area is rural with some smaller cities and towns. About 8% of the population in the area are engaged in farming. The rest are employed in small manufacturing, education, government, services, and retail. The Charleston area also contains a number of recreational parks. It is important to preserve the geologic environment around Charleston for continued agricultural and recreational use. In order to develop a citizenry knowledgeable about environmental issues, schools must have the resources to effectively teach students about the Earth. Because Charleston is located in a predominantly rural area, resources are not as available as they would be in a larger city. Geologic outreach efforts to area schools should be developed and maintained in order to make geologic resources available to the schools.

I initiated a geologic outreach program in the Geology/Geography Department of EIU. The purpose is to deliver geologic demonstrations and activities presented by EIU undergraduates to area classrooms in elementary, middle, and secondary schools. By presenting the demonstrations and activities the undergraduate students acquire confidence and gain knowledge in both geology and in public speaking. The K-12 students participating in the presentations learn about geologic principals through questions, discussion, and activities. The younger students are exposed to the enthusiasm and aesthetic appreciation the undergraduate students have for their subject. Classroom teachers are exposed to a variety of geologic presentations in their classrooms that they can use later in the classrooms themselves.

In addition, descriptions of demonstrations and activities are available on a website so teachers can use them when no EIU student is available. The website, maintained by the Geology/Geography Department of EIU, contains other teacher resources such as commercial sources of equipment and materials, summer employment for teachers in fields related to Earth Science, and links to interesting Internet sites for students.

BACKGROUND

Science is taught in elementary, middle and secondary schools in order to: a) create a scientifically literate population, b) impart to students the ability to find and evaluate observations critically, and c) encourage future scientists and engineers. In one study, 26% of scientists and engineers identified participation in science hobbies, generally before age twelve, as the reason they became interested in science. Another 6% identified career awareness through reading up on a career or career visits by scientist as the factor influencing them to become scientist or engineers (Naizer, 1993). Both of these factors shown to encourage future scientists and engineers may be promoted by geology students bringing hands-on geologic activities to classrooms.

The outreach efforts allow secondary, middle, and elementary students to attain knowledge of geological principals and enthusiasm for science through hands-on activities and discussion. It is known that students have a variety of learning styles and appealing to more than one learning style facilitates learning in students. Science is especially amenable to appealing to learning styles as experiments and activities demonstrating scientific principles may be performed in the classroom. This expands the number of approaches to science available to the students.

The National Research Council advocates inquiry methods as one of the methods of teaching science (National Research Council, 2000). While geologic activities of large portions of Earth or over long periods of time (4.6 billion years) may be unfeasible to bring into a classroom, geologic activities and demonstrations exist that show earth processes within the classroom.

Teaching of science has traditionally involved objectivism in which knowledge of universal laws of nature, held in the mind of the teacher, is transmitted to the student through lectures, teacher-centered interactions, and teacher-given demonstrations. Objectivism assumes that knowledge developed in a student's mind exists in a one-to-one correspondence with the real world (Roth, 1993). One of the goals of science teaching is to impart previously discovered scientific principles and concepts to the student. Lectures help to provide a

structure which gives further direction to student learning. Teaching methods that are teacher-centered effectively pass on principles and should be used in conjunction with other methods.

Science teaching also attempts to create a structure within the student's mind that orders the physical world and develops critical thinking and problem solving skills. Piaget originated the theory of constructivism to describe education as facilitating the development of these structures in the student's mind (von Glasersfeld, 1996). Constructivism states that learning most effectively takes place when the student is actively involved in construction of his or her mental organization of real observations (Resnick, 1983, Saunders, 1992). Learners respond to stimuli from the real world by building cognitive structures to make sense of the world. Changes in a student's worldview occur when the cognitive structure is contradicted by new stimuli from the real world. When this occurs, the student can either not care enough to resolve the conflict, reject the stimuli as being invalid and continue to accept the old cognitive structure, or redesign the cognitive structure in order to be in harmony with the previously conflicting stimuli. It is the disequilibrium between world stimuli and cognitive structure that encourages students to develop their cognitive structure of the world. Education occurs when cognitive structures develop in harmony with the observations from the world (Saunders, 1992).

Constructivist education relies on what the student is actively thinking and observing. It may not occur effectively if the teacher only lectures and the student unthinkingly takes notes. There are educational methods that encourage students to actively participate in building their own cognitive structures. Saunders (1992) states that they include hands on, investigative labs, active cognitive development, and group work. These methods, together, are called inquiry. The National Research Council (2000) states that "…the emphasis on inquiry asks that we think about what we know, why we know, and how we have come to know."

Students can make their own observations through first hand, direct sensory experiences. Students may be given an activity where they are encouraged to prove or disprove some hypothesis, ideally a hypothesis of their own devising. Supporting or disproving a hypothesis involves observations, analysis, and critical thinking. The student's cognitive structure representing the world may be challenged or supported by observations made in the laboratory. If challenged, the cognitive structure may be rebuilt internally so as to harmonize with the observations. Weaver (1998) stated that most students would like to see more hands-on experiences in their science courses. Inquiry can be implemented by highly structured, teacher directed investigations or by investigations where students direct themselves (National Research Council, 2000).

An example of directed experience in the geology classroom is the identification of minerals using physical test methods. The teacher can stimulate thought by asking questions. How would the students group the minerals? By color? By size? By texture? The student can then be told how the minerals are identified traditionally but it should be emphasized that the method is used because it is useful. The method may be changed in the future if a more useful method is devised. The deductive method of inquiry is used by discussing the principles of identification and giving examples (Chiappetta, 1997). When given a collection of minerals, the student may then be challenged to identify them. A student will make observations and then make a hypothesis of the identity of a mineral. Further observations will support or contradict the hypothesis. Eventually, through trial and error, the student will be able to identify the minerals (though not always correctly). He has built a cognitive structure for minerals and their properties. He has done it by being actively engaged.

Weaver (1998), Julyan and Duckworth (1996), and I have observed that some students will enjoy the experience of formulating their cognitive structures through active learning while others dislike the process intensely and plead to just be given the answers for memorization. This ability to cope with constructivist education may depend on past educational experience of the individual students. It may also depend on personality differences between students who can accept uncertainty easily and students who cannot.

Active cognitive involvement is another feature of constructivist education (Saunders, 1992). Students who are actively thinking about the subject are more likely to retain the ideas. Teachers facilitate active involvement by involving all students in group discussions, by posing questions that challenge cognitive structures, by asking for interpretation of data, by asking for alternate explanations, and by asking for possible hypotheses. Students working in small groups are actively involved challenging each other's cognitive structure. Students involved in activities are usually required to be mentally engaged. Teachers should refrain from giving the answer but rather ask the students to develop their own answers. Identification of minerals is a geologic exercise which requires mental engagement.

Group work is another aspect of constructivist education. Small group work is a means to encourage students to be mentally active. Individuals cannot fade into the background in a small group. Active discussion occurs in a small group as the students verbally display their own cognitive structures. The variety of structures modeled by other students may lead to disequilibrium. Disequilibrium, in turn, may lead to reconstruction of the cognitive structure. Term papers created by small groups of students are often qualitatively better (and as-

sumed a better learning experience) than papers turned in by individuals. Laboratory work by small groups often provides a forum for encouraging good discussion. Unfortunately, it can also lead to avoidance of work by some irresponsible students (Picard, 1999).

Constructivist methods may consist of a single demonstration or physical activity before the entire classroom by the instructor. Or they may consist of small groups of students manipulating objects in self-discovery. The experience of manipulating his own demonstration through an activity and drawing personal conclusions helps the student retain knowledge.

THE OUTREACH PROGRAM

I proposed to start an official geologic outreach program at EIU in 1999. Previously, students and faculty would present in area classrooms randomly but there was no organization of the presentations. In 1999 I requested a grant to buy the materials for classroom presentations and to compensate my time and the time of undergraduate students. The grant proposal was successful; I hired three EIU students and the outreach program efforts began.

The outreach program allows me to train undergraduate students in geologic presentation and leadership skills by soliciting their suggestions for the demonstrations and involving them in research of area schools to find all elementary, middle, and secondary schools and contacts within a reasonable drive (1 hour) of EIU. Information on schools included contacts (usually principals), addresses, and telephone numbers where available. This list is now stored as a computer spreadsheet and directly used to advertise the program by mail each semester.

The mailed advertisements are created by EIU students with my help. The advertisement states which demonstration topics are available to area classrooms and gives a contact for arranging a demonstration.

As soon as the advertisement was delivered to area schools during spring semester of 2000, presentations were requested by area teachers on the subjects of minerals, fossils, and groundwater processes. In the first semester there were more requests by area teachers than the three EIU students could deliver.

Often schools request presentations in all classrooms of the same grade level (i.e. all the 4th grades in the school). Where schedules allow, the EIU students go individually into all classrooms of that grade level and give simultaneous presentations. All the presentations for each topic have variations designed to be age appropriate using the EIU students' and my experiences with children. I also discuss typical learning behaviors of each age level of the younger students with the EIU students. Presentations are further modified by the EIU students using feedback from the younger students during presentations and classroom teacher feedback after presentations. All the presentations included hands-on activities to actively engage the classroom students.

Before the presentations begin, the EIU students give the classroom teacher an evaluation form for the outreach program. The evaluation form is very simple and asks the classroom teachers to write what was good about the demonstration that should be repeated. It also asks the classroom teachers what improvements they would suggest. This form is filled out by the classroom teachers and returned to EIU. The evaluation written on the form by the classroom teachers provide feedback to the EIU students so that they can improve their presentation style and content. It also provided feedback to me for use in improving the outreach efforts.

The presentations are initially modeled by me and modified by the EIU students to fit their particular teaching styles. The mineral presentations all involve specimens of minerals both large (about 3 inches wide) for holding in front of the classroom and small (about 1 inch wide) for use by classroom students in small groups. The EIU students talk about pretty, interesting, or common minerals while holding a sample in front of the classroom. They may also pass out bags of small specimens along with a handout with physical properties of minerals. The handout is kept as simple as possible to appeal to elementary students. Small groups of classroom students may be encouraged to identify the mineral specimens independently. It was observed that elementary classroom students often successfully identified a collection of 10 minerals more quickly than adults do using physical testing methods. Testing of mineral specimens with HCl was not included because of safety considerations.

The mineral demonstrations have variations to make them age appropriate. Students in grades K-3 are often more interested in the physical appearance of the mineral. Students in grades 4-6 are often more interested and capable of performing identification of the minerals. The number of unknown minerals to be identified at one time may range from 8 minerals in a 4th grade classroom to 12 minerals in a 6th grade classroom. Students in grades 4-6 are interested in where the mineral may be found. And they are interested in the use of the mineral. Chemical information can be included in a mineral demonstration to middle school students. And secondary students are interested in the chemistry, the economic and environmental significance, and the location of the minerals.

The fossil demonstrations were totally developed by the EIU students because of their interest in the topic. The EIU students show large fossil specimens in front of the classroom and walk down the aisles with them. They discuss the development and environment of the fossils as well as promising local locations to find fossils. Fossil reproductions or robust fossil specimens are passed around the classroom for students to handle. The EIU students have devised a variety of activities for the presentations. For use in K-3 classrooms, one EIU stu-

dent created 2-dimensional paper fossils. He layers the paper fossils in between layers of construction paper before the classroom students to simulate burial by sediment. The layers are then removed, one by one, uncovering the paper fossils to simulate erosional processes that reveal fossils.

The groundwater presentation utilizes a standard, commercial, groundwater model composed of a clear, thin, Plexiglas case containing sand, gravel, and clay layers. These layers are sedimentary layers; the clay is relatively impermeable representing aquitards and the sand and gravel are relatively permeable representing aquifers. Water is allowed to move through the sand, gravel and clay layers powered by a pump or by gravity. Colored dye is added to the water at key points to allow visual inspection of the water movement. Transparent tubes into the aquifers represent wells at which the modeler can inject water or remove it. There is a "lake" and a "landfill" in the model where dye representing pollution may be injected into the groundwater system.

The groundwater model has been used in many other outreach and education programs and may be adapted to all age levels including adults. For instance, young students appear fascinated by the ability to pollute the system themselves by injecting water colored with dye into the system. Students are receptive to the idea that groundwater resources must be kept clean. Secondary students and adults are also able to utilize the vocabulary of groundwater systems. They are also better able to understand the physics behind groundwater movement. However, older students have a much harder time overcoming their embarrassment at "playing" with the groundwater model

A website is maintained to support teachers in their efforts to effectively teach geologic principles to their students. This website contains descriptions of the demonstrations including the objective of the demonstration, the activity, the materials required, and age appropriate variations. The website also lists commercial sources of geologic demonstration and activity materials and equipment. A list of recommended books on geologic topics is included. It is hoped that this book list will eventually include books of interest to K-12 students. This website is an evolving resource that includes many resources desired by classroom teachers.

RESULTS

During the past fourteen months EIU students have been invited to give presentations in 57 classrooms and one science workshop for middle school girls. They talked with an estimated 1240 students. Overwhelming teacher response indicates there is a need for geologic outreach in east central Illinois.

The number of demonstrations requested by teachers in each grade level during the spring is shown in Figure 1. Figure 1 shows that the most requested topic is minerals and the least requested topic is groundwater. As teachers become more familiar with all the demonstrations, it is expected that all topics will be requested equally. Figure 1 also indicates that teachers of grades 4-6 are most likely to request demonstrations through a geologic outreach program.

Success of the outreach program is demonstrated by continuing teacher requests for demonstrations. In Fall, 2000 three EIU students were available for presentations. In the first two weeks of September, twenty-three requests for presentations by EIU undergraduates were made. More requests were made later during fall semester. Again, there were not enough EIU students available to fill the requests for geologic demonstrations. The demand for presentations indicates that teachers are very satisfied with the outreach program.

Comments from classroom teachers on the evaluation form are generally extremely favorable. Quotes from teachers include:

> Excellent! Scott's presentation was right on target for this age group. He allowed them to see and even feel the fossils. He answered every question on a level we could understand. Thank you for this opportunity!

> Scott did an excellent job keeping the presentation at a level where students could understand. Lots of hands on and participation by students. Great job motivating children. Several came in the following day with their rock collections. This was a very beneficial presentation to give students some insight into their upcoming unit on geography/geology.

Some of the comments offer specific suggestions for improvement such as writing vocabulary words on the board for the students, using more hands-on activities, or using lower level vocabulary.

CONCLUSION

I initiated a geologic outreach program in the Geology/Geography Department of Eastern Illinois University (EIU) located in Charleston Illinois. Geologic demonstrations are presented by EIU undergraduates to area classrooms in elementary, middle, and secondary schools. The K-12 students participating in the presentations actively learn about geologic principals, which they may apply in their life. The K-12 students are exposed to enthusiastic EIU students, which may increase the students' aesthetic appreciation of the study of geology and of the world around them. Classroom teachers are exposed to a variety of geologic presentations.

The demonstration are available on a website available to teachers so teachers can give the demonstrations themselves if no outside presenter is available. The website also contains other teacher resources of interest to teachers.

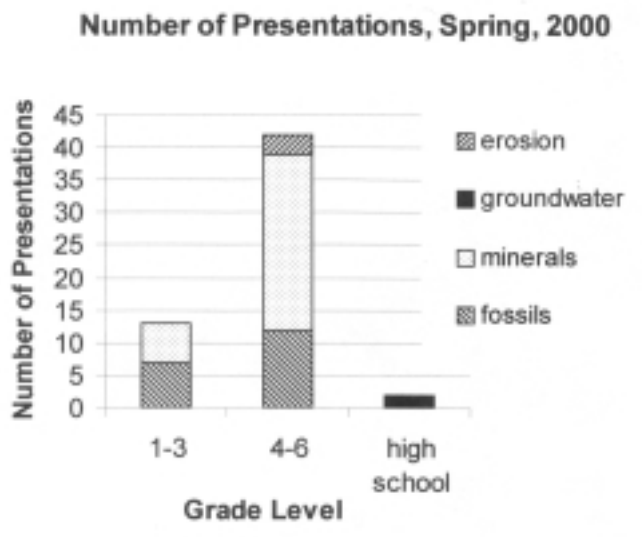

Figure 1. Presentations of each topic grades 1-3, 4-6, and high school during the first fourteen months of the outreach program.

The program has been well received by area teachers — demonstrations are in demand. EIU undergraduates are benefiting from presenting to classrooms by increased confidence and knowledge. They also benefit by learning how exciting and important education is; a benefit that may encourage them to be educationally active throughout their careers; whether they work in education, government, consulting, or industry.

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