Overcoming the Limitations of an Urban Setting Through Field-based Earth Systems Inquiry

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ABSTRACT

Disconnection between students and nature in an urban setting thwarts student engagement and impedes geoscience teaching and learning. Conducting field trips is one way to engage students, but the urban environment does not provide an ideal setting with respect to the availability of appropriate field sites and safety. A field-based inquiry project focusing on Earth systems and system interactions overcomes the obstacles imposed by the urban environment by permitting teachers to focus on student observations and student initiated research questions rather than solely being limited to the use of text and laboratory activities. Using a problem based learning model, students make observations in the field to compile a matrix addressing "What do I know?", "What do I need to know?", and "How or where do I get this information?" This latter question guides student activities for subsequent visits to the field. This approach is not limited to specific field sites and enables teachers to utilize local community facilities such as neighborhood parks. Qualitative data support the conclusion that a field-based Earth systems inquiry approach is a valid pedagogical strategy in an urban setting, one that engages students and instills more positive student attitudes.

INTRODUCTION

To a geoscientist and educator, it is an obvious statement that geology is everywhere; it surrounds us and influences our daily lives. However, this is not always obvious in a major urban setting such as San Antonio, Texas, where mountain vistas and dynamic scenery are absent, thus contributing to a disengaged student population that is detached from nature and the geosciences. Considering that ethnic minorities commonly populate residential urban areas, minority under representation in the geosciences may be linked to life experience dominated by urban settings.

The City of San Antonio, located in Bexar County, Texas, is the nation's eighth largest city with a population of 1,147,213 (U.S. Census Bureau, 1999a). Bexar County, the sixth largest in the nation in terms of its Hispanic population (57% Hispanic), has experienced a 32.8% increase in Hispanics between 1990 and 1999 (U.S. Census Bureau, 1999b). The University of Texas at San Antonio (UTSA), the only public institution of higher education in San Antonio offering both undergraduate and graduate degrees in the geosciences, is an Hispanic Serving Institution. Through an aggressive recruitment strategy, UTSA has grown its student body from just over 18,000 students in 1998 to almost 23,000 students in 2003, and during this period the Hispanic student enrollment increased from 42% to 46% and continues to climb. Despite this growth, too few students are selecting the geosciences as an academic major, especially among the Hispanic student population. There are many reasons for this disparity, and the faculty is implementing several strategies to attract students into the geosciences. Here I report on one programmatic effort to address this problem, a National Science Foundation funded project entitled "A Field Science Approach to Earth Systems Science: Back to Basics" (EAR-0085487), a collaborative program between the Department of Earth and Environmental Science at UTSA and the South San Antonio Independent School District (SSAISD) which largely serves a low-income urban Hispanic population. Three middle schools (sixth through eighth grade) in SSAISD are involved.

Students in these middle schools have few opportunities to study Earth systems science outside of the classroom, and few students have traveled very far from their own urban neighborhoods. This program is designed to provide students an opportunity to conduct field-based research through multiple visits to a field research locality. This field-based Earth systems approach is an attempt to overcome some of the barriers of the urban setting.

THE PROBLEM

Science attempts to describe and explain nature and natural phenomena. Historically, the sciences are rooted in field observations; the stars, the rocks and soils, the oceans, rivers, and lakes, and the fauna and flora were, and remain, important objects of observation. The laboratory is also an important venue for conducting scientific inquiry, but work conducted in the laboratory is ultimately linked to questions that derive from field observations and questions. Today's science curriculum in K-16 education is, with rare exception, restricted to a classroom format. "Hands-on" laboratory activities are important components of the curriculum, but if these are conducted out of context, with no clear link to the primary field observations that originally inspired the experiments, then the activities lose much of their potential educational value. Urban students, commonly shielded from direct contact with nature by their setting, face difficulty in finding tangible and immediate relevance of the geosciences in their lives. As a scientist working in geology, I believe that much of the excitement of our discipline derives from the experience of conducting fieldwork. The excitement and enthusiasm of fieldwork should become institutionalized in the K-16 curriculum.

In an urban setting students are far removed from field-based inquiry for many reasons, not all of which are unique to the urban setting. Kean and Enochs (2001), in summarizing the work of Mason (1980) and Anderson (1980), list many obstacles to implementing field trips in the school curriculum. Some of these obstacles include: lack of planning time, additional demands upon teachers, lack of funding, limited availability of transportation, time away from required content, difficulty in tying field trips into the curriculum, and teacher insecurity regarding content knowledge. In the urban setting of San Antonio, I would add to this list the lack of available or convenient localities to visit. In summary, the primary obstacles to incorporating a field component into secondary school science in an urban setting can be distilled to four key questions:

1. Where do I take students?
2. What do I do in the field?
3. How do I integrate field observations into an existing curriculum?
4. What preparation is required on the part of both teachers and students to make the fieldwork an enriching experience?

The urban setting does not, in itself, eliminate the field component from a curriculum. Some authors use building and architectural stones as their "field" examples (Hoskin, 2000; Kemp, 1992); whereas others recommend the use of local or regional parks (Manner, 1995; Schneider, 1989); and still others implement a lengthy summer field component. This latter option is most often reserved for college students (Stephens, 1987; Anderson et al., 1999) or for those unusual circumstances in which students can afford to bear the costs of the trip (Schwartz, 1988).

THE PROJECT

One major goal of this project is to apply an Earth systems approach to field-based inquiry in an effort to overcome the lack of safe, readily available access to exposed rocks in an urban setting. A second major goal is to replace the common "show and tell" field trip with a model of field-based inquiry that incorporates multiple visits to a field locality to investigate student-initiated research questions. A field-based curriculum component in which student research is self-motivated provides the opportunity to address major portions of the National Science Education Standards (National Research Council, 1996). Specifically, in addition to the discipline-based content standards, a field-based Earth systems approach addresses content standards in "History and Nature of Science" and "Science in Personal and Social Perspectives". Additionally, standards in teaching, assessment, and professional development are also addressed by this approach.

A Field-Based Approach - What Does The Research Tell Us? - Experience shows that field-based inquiry, which contributes to understanding and applying the methods of science, is an effective way to develop important critical thinking skills. Using a field-based Earth systems component in the curriculum can provide the necessary engagement to inspire students to ask meaningful questions and develop critical thinking skills.

Incorporating field trips into the curriculum enhances student learning in many ways including improving students' abilities to set goals, enhance observational and record keeping skills, formulate hypotheses, interpret data, and develop conclusions (Manner, 1995). Few studies, however, explore gains associated with longer-term field-based inquiry. Carpenter (1983), and Kern and Carpenter (1984, 1986) state that fieldtrips increase the motivation of college students studying geoscience and so should enhance learning. Folkomer (1981) reports that field trips used to illustrate specific concepts enhance junior high school students' observational skills. Wiley and Humphreys (1987) state that field trips enabled their ninth-grade students to develop abstract concepts in ways that were not possible in the classroom setting. Clearly, field-based inquiry can make a significant contribution to the curriculum by improving student attitudes and critical thinking skills.

Why An Earth Systems Approach? - Relevance!- Two major national curriculum initiatives, the National Science Education Standards developed by the National Research Council (1996), and the American Association for the Advancement of Science, Project 2061: Science for All Americans (Rutherford and Ahlgren, 1990) provide research foundations for recommending change in curriculum and practice. Using these documents as guides, the National Science Foundation Directorate for Geosciences established a Geoscience Education Working Group to explore the current state of the field of geoscience education and to make appropriate recommendations. This report, "Geoscience Education: A Recommended Strategy" (NSF 97-171), along with "Shaping the Future of Undergraduate Earth Science Education: Innovation and Change Using an Earth System Approach" (Ireton et al., 1997), provides a thorough background regarding geoscience education.

According to Ireton et al. (1997), "Reaching out to all students involves several strategies: teaching Earth and space sciences in a cultural context; providing access to field experiences and technology; and making science relevant to real life." Ireton et al. (1997) further posit: "In addition to thinking globally, Earth system science must also think locally. Earth system science principles and problem-solving methods should be placed in the context of the local environment in order for students to better comprehend the relevance of science to their lives. Earth system science should not be viewed only as the study of remote, natural environments but as the study of students' backyards." Drummond (2001, p. 420) also states "By focusing on the dynamics of natural processes, earth systems science education links facts and concepts into a meaningful whole." An Earth systems approach has the advantage of providing both intellectual challenge and relevance to student studies.

PROJECT FUNDAMENTALS

An important part of this project is to develop a structured way of thinking amongst students that is based upon problem-based learning (Delisle, 1997). To emphasize the nature of science and field-based research, students should visit the field site multiple times with the number of visits defined, at least in part, by their research questions, strategies, and needs. Students should be provided a simple form containing three columns; "What do I know?"; "What do I need to know?"; and " Where (or how) do I get this information?" During the initial field visit students must make observations to address the first column - "What do I know?" Back at their campus, under their teacher's guidance, students should use their recorded observations to formulate research questions. Examples of questions proposed by students in this project include:

Why do some rocks have holes in them and why do some rocks have more than one layer?
Why are scorpions only found under rocks?
Why do some cactus grow on rocks and others in the open and what things do they need to grow and stay alive?

Student research questions provide the basis for completing the second column "What do I need to know?" Again under the guidance of their teachers, students should analyze their recorded observations to determine, not only the relevant information they possess that addresses their question(s), but also what information is missing. The missing information is an important component of the process because it enables students to develop follow-up material for the last column, "Where (or how) do I get this information?" It is at this point that students should define their research needs for a follow-up field trip so that they can return to the field with greater focus and specific objectives. A brief example conducted by a group of eighth grade students illustrating an Earth-systems interaction follows.

In their reconnaissance of an assigned field area students noted large rocks lying on the surface. Turning over rocks revealed the presence of scorpions under some, but not all of the rocks (column one of the table - what do I know?). Students hypothesized that the distribution of scorpions under the rocks was controlled by temperature or moisture; this identified what they needed to know (column two of the table). On a subsequent visit to the field site students used a pace and compass method to prepare a perimeter map; within this perimeter they recorded the location of rocks and boulders lying on the surface. They systematically overturned rocks to record the presence or absence of scorpions. Soil temperature and moisture were recorded using an inexpensive soil thermometer and moisture probe. Samples of the soil were collected for laboratory analysis to obtain details about the soils such as grain size, water retention capacity, density, color, and composition (column three of the table - where (how) do I get this information?). The representation of results on maps required mathematical analysis; for example, representation of grain size data required both statistical and graphical analysis prior to plotting on maps. With this background data, students attempted to correlate scorpion distribution with physical properties of the soils. Questions asked included:

Are scorpions associated with specific soil types?

If so, what soil properties control the association?

Do scorpions spend all their time under rocks or do they leave for food?

If they leave, do they return to the same rock?

Although students were unable to address all of these questions, they were able to propose strategies for doing so (column three of their table).

CONCLUSIONS

How does this field-based Earth systems approach help students learn about the geosciences in an urban setting? The primary obstacle to engaging students in the geosciences here in San Antonio, as well as in many urban settings, is the lack of scenic grandeur. Because of this, students are more isolated from nature. As a result, they have little or no first hand experience in addressing questions that deal with nature. By incorporating an Earth systems approach to field-based inquiry into their curriculum, students can address questions they find personally interesting and engaging. Once the student is engaged, teachers can build upon student interest and expand student horizons.

Does it work? Quantitative data are currently being compiled for this project. However, there is ample qualitative data to indicate that students are more enthusiastic and engaged when involved in field-based Earth systems inquiry. In addition, students do develop interesting and, at times, sophisticated questions based upon their observations.

Teachers involved in the project are required to keep a journal and students complete survey-style forms after their visits to the field. These documents provide interesting insights into the nature of the project. Some teacher and student comments include:

> "This field trip was a great experience. The students were engaged, they asked intelligent and pertinent questions. Their observations were specific, detailed, and often related to the abiotic factors present at the site." *Margaret G , teacher*

> "Some [students] were so excited that they even wanted a chance to work on their projects during the summer." *Elsa G, teacher*

> " I now believe maybe my expectations may be too low, for my students performed much better than I expected." *Donnie N, teacher*

> "I want to keep investigating rocks and how many types of rocks there are in the whole world? Also I want to see if I can make a sandstone myself and also erode a rock and see how fast they erode and what shape they come out." *Javier C., 7th grade student*

> "I would like to know why the first time we came, it was different from the second time. And why there was no water in the bed stream we were studying." *Erica P., 6th grade student*

However, not every aspect of the project runs smoothly. The primary difficulties faced fall into two categories: teacher involvement and logistics.

Teachers are the pivotal component of this, or any proposed curriculum change. However, discussions with teachers reveal what many already know; the public school curriculum is crowded and introducing new material is a challenge. In addition Texas, as with many states, has mandates for high stakes testing resulting in a 'top down' curriculum dictated at the State and school district level; this often produces a 'lock-step' curriculum where everyone is doing the same thing. As a result the teacher's professionalism is threatened by the loss of some of their autonomy, at times translating into significant turnover rates and loss of teachers from the profession. During the three years of this project, not one teacher continued throughout owing to school district reassignments, leaving the school district, or leaving the profession. The State mandated testing also dictates the timing of fieldwork as school administrators refuse to allow off campus activities until after testing is completed. This compresses the time available for field research and strains resources. State mandated testing will not go away, but improving communication between administrators and teachers regarding the nature of field inquiry, and better integration of field research into the State standards, may help to solve this problem.

The main logistical difficulty is providing adequate adult supervision. When outdoors, unconstrained by classroom walls, such supervision is critical for student safety. When available, preservice teachers and geology students from UTSA assisted in the field, but adequate adult supervision remains an obstacle to success.

Despite these difficulties, this field-based Earth systems inquiry approach holds specific merits in the urban setting. Teachers can guide students conducting field-based inquiry in their neighborhood, a local city park, or, as in this project, a local state park. Even in the absence of rock exposures, students are able to investigate interesting aspects of Earth systems research.

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