Investigating Earth Science in Urban Schoolyards

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ABSTRACT

The Urban Schoolyards project is a two year partnership with a university Earth Science Department and the surrounding urban elementary schools. The goal of the project was to develop the capacity of elementary teachers to teach earth science lessons using their schoolyards and local parks as field sites. The university personnel developed lessons and resources which were taught to the teachers during a summer institute. The teachers then implemented these lessons with their elementary classes during the following school year. It was found that 70% of the teachers who participated in the summer institutes used their schoolyards and local parks for science lessons during the following school year.

INTRODUCTION

Both authors of this paper live in the City of Syracuse. We knew of the many green spaces, parks and bodies of the water in our city and we had used them in both our own teaching and research. We also knew that in many cases they were under-utilized by the schools that were walking distance from them. To us, it seemed there was great learning potential in taking students to a local setting, even a schoolyard, and having students explore and learn about the earth science in that setting. Our plan was to develop earth science lessons for various outdoor settings and train teachers to teach them, so that the capacity for this type of learning would be built within the school system, and remain there beyond the funding we had for this project.

Donald Siegel is an Earth Science Professor at Syracuse University. Although his research is in the area of hydrology, he has taught the Introduction to Geology for non-majors for many years. Anna Endreny is a middle school science teacher who has worked as an elementary science teacher and in university outreach settings. Our backgrounds were used for creating field based earth science lessons for locations close to schools and with helping teachers learn to teach the lessons.

CHALLENGES IN URBAN SCHOOLS

Although Syracuse might be unusual in having a large number of parks and green spaces close to schools, its schools suffer the same plight of other northeastern urban school systems. In their paper on inquiry-based science and urban reform, Geier, Blumenfeld, Marx, Krajcik, Fishman, Soloway and Clay-Chambers (2008) succinctly stated the myriad of problems facing urban schools to include, "lack of resources, high levels of poverty, low student achievement, below grade level English proficiency, high student mobility, attendance problems and difficultly recruiting and retaining highly qualified teachers" (p 923). Consequently, the students in urban schools perform significantly worse on national and international science achievement tests (U.S. National Assessment of Educational Progress and TIMSS) than compared with low-poverty schools and high-poverty nonurban schools (National Center for Educational Statistics, 2004; Ruby, 2006).

This poor preparation in urban schools is one of several reasons that minorities are under-represented in science fields, particularly earth science. African Americans and Latinos make up the majority of students in urban school systems, yet they constitute only 1% of undergraduate geology majors in the U.S. (NSF, 2003). Our hope was to create a program that would interest urban students in science and build the capacity of elementary teachers to teach science. Reaching students early in their school career is imperative as many scientists attribute their career choices to positive childhood exposure to science (Louv, 2006; Nazier, 1993; NSF, 2005).

OPPORTUNITIES IN URBAN SETTINGS

Because of their green spaces and human made systems, urban settings provide an excellent venue for earth science education. They contain a vast array of opportunities such as parks, water and resource agencies and impressive examples of systems in the form of water supplies and waste processing (Barstow & Yazijian, 2004).

Teachers can use urban parks and even schoolyards to study earth science. These familiar spaces serve as an extension of students' prior experiences, and enhance meaningful learning (Novak & Gowin, 1984). Ireton, Manduca and Mogk (1997) state, "Earth System Science should not be viewed as the study of remote, natural environments but as the study of students' backyard" (p.X). By working in local natural settings students develop an emotional attachment and, in turn, realize their actions (either conserving or degrading resources) can have impact (Vaske & Corbin, 2001).

Practically speaking, when teachers can use schoolyards or parks within walking distance (typical of urban settings) many perceived obstacles to school field trips can be overcome, including time, money, and lack of connection to the curriculum (Kean & Enoch 2001). By using schoolyards and adjacent parks, students and teachers can go to the field sites multiple times to answer research questions and meet unit learning objectives (Endreny, 2007). Moreover, access to sites remains free and familiar.

Field-based research works to teach Earth System Science in urban settings because it instills positive student attitudes (Birnbaum, 2004); engages students (Harnick & Ross, 2004); improves student ability to do

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research (Manner, 1995) and helps students develop abstract concepts (Wiley & Humphreys, 1987).

THE URBAN SCHOOLYARDS PROJECT

In order to address the previously discussed concerns, we designed a university-public school partnership that would meet the following goals:

1. Prepare urban elementary teachers to teach field based earth science using their schoolyards and local parks.
2. Increase elementary student achievement in and enthusiasm for earth science.
3. Create and compile standards based earth science lessons that focus on using field research in schoolyards and parks.

We designed this project to serve as a template for other similar projects elsewhere. In this paper we will describe how we established a partnership with the teachers, developed lessons for their local resources (objective three) and prepared teachers to teach these lessons (objective one).

CONTEXT

Within the Syracuse City Schools, the majority of the students receive free or reduced lunch and are African American (NYSED, 2006). The students involved in this project ranged from Kindergarten to sixth grade. They were involved because their teachers took workshops taught by the authors of this paper. There were at total of 34 teachers from 17 different elementary schools involved in this project. All the teachers were certified elementary teachers, and one was a certified science teacher. They ranged in teaching experience from 2 to 35 years. Three of the teachers were males and the rest were females. Most of these teachers had limited university coursework in science (one or two courses for non-majors).

LESSON AND PARTNERSHIP DEVELOPMENT

The first step for this project was to develop and pilot-test lessons that would use the green spaces close to Syracuse City Schools. In order to do this, we met with the District's Science and Math Curriculum Coordinator to figure out how to recruit teachers that would be willing to meet with Dr. Endreny, have her develop lessons for their school's resources and have her teach the lessons in their classrooms. The curriculum coordinator advertised this opportunity to all the elementary principals in the district and a letter was sent to all 22 elementary schools in the district. Dr. Endreny followed up with a phone call to each principal to see if they had gotten the letter and if they would advertise this to their teachers.

A total of three principals responded and three teachers from three different schools were excited to work with Dr. Endreny. It should be noted that at this point, the teachers received no compensation for their involvement in the project, they simply were taking advantage of an opportunity to get new ideas about teaching science. Also, the poor initial response could be attributed to several factors:

1. The project was completely new and had no reputation.
2. The district is involved in numerous initiatives so teachers and administrators become overwhelmed.
3. Lastly, many of these schools were under pressure to improve their New York State test scores on Math and English Language Arts. Students' performance on the New York State Science Test had little influence on a school's status. Thus, science was a subject that some schools did not prioritize and that some teachers did not even teach.

Although only three teachers began working with Dr. Endreny, these three teachers recruited 10 different teachers within four different schools who were interested in having her develop and pilot urban schoolyard lessons in their classrooms. The first step in developing lessons was to discover the earth science resources that were close to the school. Since many of the teachers did not live in the city, they often could not identify the resources themselves. Dr. Siegel and Dr. Endreny would look for all the earth science learning opportunities close to the school and Dr. Endreny would translate these into inquiry-oriented lessons for elementary students.

Two schools were walking distance from creeks and brooks. One of these schools had a very large creek running behind the school. The other of these two schools was located three blocks from a walking trail around a brook and wetland. For these schools Dr. Endreny developed and pilot-tested lessons related to watersheds.

The school that was located close to the walking trail, also had community gardens behind their playground area. For this school, lessons on gardening, soil, seasons and plants were developed. One school was located walking distance from a historical cemetery that is often used for university field trips because of its diversity of tree species. The sculptures, headstones and buildings in this cemetery are made of either granite, gneiss, marble or limestone. Thus, this cemetery was used for lessons on the rock cycle and rock types. The last school was not walking distance to any green spaces and had a tiny play area. So, we used its parking lot for studying snow.

Once we brainstormed ideas for topics that could be covered by the resources around the school, Dr. Endreny used a variety of resources such as the Digital Library for Earth System Education (http://www.dlese.org/library/index.jsp), project GLOBE, Journey North and Helen Russell Ross's book *Ten Minute Field Trips* to develop the lessons. Dr. Endreny taught these lessons, while the classroom teacher was involved in a supporting role. The students kept science journals and these were used to assess student learning and the success of the lesson. In addition Dr. Endreny regularly met and communicated with the teachers to get feedback on the success of the lessons. The lessons developed from this pilot phase will be described in the next section. These lessons are posted in more detail on the project website (www.urbanschoolyards.org).

LESSON DESCRIPTIONS

Watershed Science

Shepardson and others (2007) aligned the study of watersheds with the *National Science Education Standards*. We modified and used their ideas as learning standards for our lessons on watersheds. These standards include:

- Watersheds are defined by elevation and relief.
- Watersheds have a structure that includes running water and still water.
- Watersheds consist of biological and physical components.
- Watersheds are changed by natural processes and human activity.
- Watersheds function to transport water and materials, store water and cycle water.
- Watersheds are polluted by point sources and non - point sources.

The unit on watersheds began with students learning how to make field observations and keep a field journal. The students recorded observations of plants, animals, rocks, soil, water and weather and wrote down any questions that they had about the watershed. A discussion of the questions at the beginning of the unit helped create guiding questions for the entire unit.

The students used field guides to identify the animals and plants in their watersheds and eventually created a field guide to their own watershed. The students also conducted a macroinvertebrate sample to learn about new types of animals and monitor pollution. In addition to learning about biological factors in a watershed, students made soil, rock and weather observations to learn about the physical factors.

To learn about water pollution the students conducted simple water pollution tests using a kit for Dissolved Oxygen, pH, Phosphate, Nitrate and Turbidity. The students read about water pollution from several websites and wrote a report on the water quality of their watershed.

The students learned about the water cycle by making observations of how the water level and water speed changed throughout the seasons. They also completed an activity where they poured water on different surfaces within the watershed and observed and compared whether the water infiltrated into the ground or ran off the surface. A demonstration was also conducted where the student poured muddy water through a column of sand and soil and observed clean water come out the end of the column. This demonstrated the filtering capacity of soil.

To learn about the topography of watersheds, students looked at different maps of the watershed including topographic maps. They also walked around the watershed with the maps and compared the physical features in real life to those on the maps. The students used these observations to make a model of their watersheds using playdough. Non-point source pollution was modeled by pouring powdered kool-aid on the model and then spraying the model with water to simulate rain. The students could visually see from this demonstration how pollution on land could run-off into bodies of water.

Rock Types in Cemeteries

We used a field trip to a historical cemetery to teach students about the characteristics and uses of three different rock types and how they weather. On the first trip to the cemetery students were shown the different rock samples that they would see in the cemetery. These included granite for newer gravestones and marble for older gravestones. Also, there were many monuments made out of limestone. There were even a few gravestones made out of gneiss, limestone and sandstone. The students were also shown weathered gravestones. The most weathered gravestones were either marble or sandstone. By the end of this first trip the students were able to identify the igneous, metamorphic and sedimentary rock types in the cemetery.

For the second trip to the cemetery the class was divided into groups and each group was assigned a different small section in the cemetery. The groups had to record data on rock type and date of death for each gravestone. Through pooling and analyzing their data these students discovered that sedimentary rock was used for the oldest gravestones (pre-mid 1800s) and then marble was used and granite was used for the 20th Century headstones. Back in the classroom the students then read about rocks using various library books. They filled out a graphic organizer to learn more information about the different rock's characteristics and uses.

Gardens, Seasons and Soil

One of the participating schools was located next to a community garden. For this school we worked with the Kindergarten students and their parents to plant a garden in one of the plots. Through this experience we wanted the Kindergarteners to learn how to prepare the soil and how a garden changes throughout the seasons. The Kindergartners and their parents prepared the soil in the garden with compost and manure and then planted, from seed, plants that would be harvested in the fall such as pumpkins, sunflowers and corn. Over the summer various families from the school maintained the garden. Then, in the fall, when the students were in first grade, they harvested the vegetables from the garden.

At other schools there were small planting beds that were available because of the landscaping around the schools. In these beds, we planted tulips in order to participate in the citizen science project, Journey North (www.learner.org/jnorth/). In the Journey North gardens, classes planted tulips in the fall and recorded observations about their emergence in the Spring. Observations were submitted on-line where data from Journey North gardens around the world were pooled onto an interactive map. Students were able observe the different times that spring and fall indicators arrived in different locations. In addition to the gardening experience students participated in lessons that explained the "reasons for the seasons". These lessons often took place outside so that students could record how the position of the sun and earth changed throughout the day and seasons. These lessons are all available on the Journey North website.

Because we knew that many schools may not have bodies of water, gardens or cemeteries close by, we created lessons on soil as it is an earth material that would be present at all schools. For these soil lessons we wanted the students to understand that soil has many different parts to it (organic material, weathered rocks) and soil from different areas would be different.

First, the students were asked to dig up soil from different locations around the schoolyards. They had to record their observations about where they were digging (i.e. under a tree, a place where a lot of students walked) and then had to record their observations about what the soil was like as they were digging it up. The students then separated their soil using different sized screen sieves. They learned from this activity that small organisms, decaying matter, rocks are the largest pieces of matter in soil. They were also able to see that sand was the smallest component of soil that could be separated using the screens that we had.

The students further separated the soil by creating "mudshakes". In this activity the students half way filled an empty water bottle with soil and then filled the rest with water. They capped the water bottle and shook it. The water bottle was then left to settle for several days. The students noticed that the soil separated into layers of sand, silt and clay. After these observations were made for individual soil samples, the students then reported and compared their observations with their classmates' soil samples from different locations. The students then read two books: *Dirt* by Steve Tomecek and *A Handful of Dirt* by Raymond Bial to learn about how soil is formed and what soil contains.

Snow

Syracuse is one of the snowiest cities in the United States (NOAA,2007). Snow covers the ground much of the school year. Because it was a resource available at every school we developed a series of activities which used snow to teach the water cycle. Some of the activities dealt with the water cycle. These included observing how fast snow melted on different colored surfaces; observing how icicles got longer with melting and freezing and observing snow on the roofs of buildings. Students observed how the snow accumulation, steepness and color of the roofs differed and then drew inferences about these differences.

The second activity involved digging into large snow banks so that students could observe a cross section of the snow bank. They observed how the snow and plowed material was more compressed at the bottom of the bank and how snow could easily be moved off the top of the bank. This was used as a model for geologic processes of sedimentation, structural deformation and metamorphism. Making snowballs also modeled metamorphism as the students observed how heat and pressure compacted the snow. The students also took the temperature at various snow depths to learn how snow acts as an insulator and that greater depths have hotter temperatures.

SUMMER INSTITUTE

After the lessons were developed and pilot-tested during the first school year of the project, a summer institute was planned so that these lessons could be taught to teachers in the school district. The first summer the institute ran for four full days and 20 teachers attended. The second summer the institute ran for five full days and 14 teachers attended. Teachers were paid a stipend for their participation in the institute and were required to teach lessons to their classrooms based upon the summer institute experience.

During both summer institutes teachers were taught by both authors of this paper as well as other scientists from both Syracuse University and SUNY-ESF (State Univerisity of New York-Environmental, Science and Forestry). The topics and lessons covered in the workshop included creating and using field guides; watersheds, water quality monitoring and testing, water cycle experiments and stream restoration; soil experiments and lastly, changing shadows experiments. In addition there were pedagogical lessons on using science tradebooks and notebooks to integrate literacy with science and using guiding questions and inquiry to set up experiments.

For both summer institutes, 100% of the teachers responded in their evaluations that they had increased their understanding of how to involve students in outdoor science investigations. 95% of the teachers felt that going outside and carrying out the investigations was the strongest part of the workshop. The teachers described the weakest part of the workshop as the "college type lectures" that the scientists presented.

The evaluation data from the summer institutes indicated that teachers felt prepared to teach the lessons. However, as part of receiving their complete stipend we required that the teachers actually teach a short unit on an earth science topic using a schoolyard or local green space. We required that they use student assessments for the unit and report on their experience at two follow up meetings during the school year. At the meetings they filled out evaluation surveys and we collected their unit lesson plans to evaluate. In addition to these meetings, Dr. Endreny observed the teachers from the first summer institute teach at least one outdoor lesson during the school year. Participation both years at the follow up meetings exceeded 70% of the teachers who took the summer workshops.

All of the teachers attending the follow up meetings took their students out to a schoolyard or local green space at least once during the school year. Most teachers took their students outside three to six times during the school year. Following the first summer institute, most teachers focused on teaching the rock cycle or the water cycle, but three teachers actually taught life science topics instead of earth science topics. After the first summer, we found that seven teachers used guided inquiry, six teachers used hands-on activities but these activities were not driven by student questions and one teacher had the students filling out a worksheet. Although we were successful in getting the teachers to use resources that had never been used before, for some teachers, their science teaching was weaker than expected.

We modified the second summer institute based upon our evaluation data. It was clear to us that the elementary teachers needed much more basic support and modeling than we offered the first year. In addition, the participating scientists needed clearer expectations. They could not merely lecture to the teachers as if they were science graduate students. Elementary teachers had different backgrounds and needed different information.

Thus, in the second summer, we significantly decreased the amount of lecturing done by professors and spent more time having teachers participate in the same lessons that we had done with the students, thus, modeling the process of guided inquiry. In addition, we extended the workshop by one day so that the teachers would have time to plan a unit that they would do with their students and we gave them feedback on these lessons. With this guidance, the teachers only planned earth science lessons that required more than one visit to a field site. Our follow up data from the second summer indicates that 100% of the teachers interviewed (we have not yet met with three of the teachers) are teaching earth science lessons that involve guided inquiry.

LESSONS LEARNED

100% of the teachers who participated in the summer institutes felt prepared to use their local parks and schoolyards to teach earth science. Of this group, 70% actually taught the lessons, wrote out unit plans and student assessments and participated in school year evaluations and follow up meetings. Thus, we feel that we were successful in our objective of preparing the teachers to use their local green spaces for teaching earth science.

Upon reflection, much of the success of the summer institutes occurred because of our initial work with teachers and city school students in their classrooms to develop lessons that we knew would work with urban elementary students in our particular setting. The strongest aspects of the summer institute involved modeling these lessons. We learned through our evaluation to focus more on this modeling and less on university level lectures.

We also feel that the follow up support and "pressure" was crucial to having teachers try these lessons in their classrooms. It is a lot of extra work to teach science outdoors especially in urban elementary schools where there is pressure to teach literacy and math over science. However, for the teachers that did engage their students in these lessons, 100% reported that their students were enthusiastic and excited about the lessons. Comments such as, "students are asking for more outside environmental field trips" were written on the evaluations.

Although student learning was difficult to evaluate due to the varying nature of grade levels and lessons, we feel that the quality of earth science teaching within the Syracuse City School System has improved for the elementary teachers involved in this project. In addition, teachers have started using previously underused local resources. This project has built the capacity of elementary teachers in an urban school system to take advantage of the many science learning opportunities outside of their backdoor. It is our hope that these opportunities will motivate more students to pursue science careers and to have a greater sense of stewardship for their local community.

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REFERENCES

Barstow, D., and Yazijian, H., 2004, Placing urban schools as the forefront of the revolution in Earth Science Education: Journal of Geoscience Education, v.52, n.5, p.416-419.

Bial, R. A handful of dirt. Walker and Company Press.

Birnbaum, Stuart., 2004, Overcoming the limitations of an urban setting through field-based earth systems inquiry: Journal of Geoscience Education , v. 52, n.5, p. 407-410.

Endreny, A., 2007, Watershed seasons: Science and Children, v. 44, n.9, p. 20-25.

Geier, R., Blumenfield, P.C., Marx, R.W., Krajcik, J.S., Fishman, B., Soloway, E., Clay-Chambers, J., 2008, Standardized test outcomes for students engaged in inquiry-based science curricula in the context of urban reform: Journal of Research in Science Teaching, v. 45, n.8, p. 922-939.

Harnick and Ross, 2004, Models of inquiry-based science outreach to urban schools: Journal of Geoscience Education, v.52, n. 5, p. 420-428.

Ireton, F., Manduca, C., and Mogk, D., 1997, Shaping the future of undergraduate earth science education: Innovation and change using and earth system approach, Workshop proceedings, American Geophysical Union, 61p., available at http://earth.agu.org/sci_soc/spheres/

Kean, W.F., and Enochs, L.G., 2001, Urban field geology for K-8 teachers: Journal of Geoscience Education,v.49, p.358-363.

Louv, R., 2006, Last Child in the Woods: Saving our Children from Nature Deficit Disorder. Chapel Hill, NC; Algonquin Books.

Manner, B.M. , 1995, Field studies benefit students and teachers: Journal of Geoscience Education, v. 43, p.128-131.

NOAA , 2007, Extreme Climates in the U.S. http://www.ncdc.noaa.gov/oa/climate/research/2007/dec/extreme-cities.html.

National Center for Educational Statistics, 2004, The Nation's Report Card. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

National Science Foundation, 2003, Statistics on characteristics of the U.S. population, education, and Ph.D. employment by racial/enthic group, http://www.geo.nsf.gov/geo/diversity (30 April 2003).

National Science Foundation, 2005, Geoscience Education: A Recommended Strategy. NSF 97-171.

Nazier, G., 1993, Science and engineering professors: Why did they choose science as a career?: School Science and Mathematics, v. 93, p.321-324.

New York State Education Department, 2006, New York State School Report Card. http://www.emsc.nysed.gov/irts/reportcard/2006/home.shtml

Novak, J. and Gowin, 1984, Learning how to learn. New York: Cambridge University Press.

Ross, H.R., 2001, Ten minute field trips. Arlington, VA: NSTA Press.

Ruby, A. , 2006, Improving science achievement at high-poverty urban middle schools: Science Education, v. 90, n. 6, p. 1005 -1027.

Shepardson, D.P., Wee, B., Priddy, M., Schellenberger,L., and Harbor, J., 2007, What is a watershed? Implications of student conceptions for environmental science education and the National Science Education Standards: Science Education, v. 91, n. 4, p. 554-578.

Tomecek, S. Dirt. National Geographic Press.

Vaske, J. and Korbin, K, 2001, Place attachment and environmentally responsible behavior: The Journal of Environmental Education, v. 32, n. 4, p. 16-21.

Wiley, D. and Humphreys, D.W., 1985, The geology field trip in ninth-grade earth science: Journal of Geoscience Education, v. 43, p.128-131.