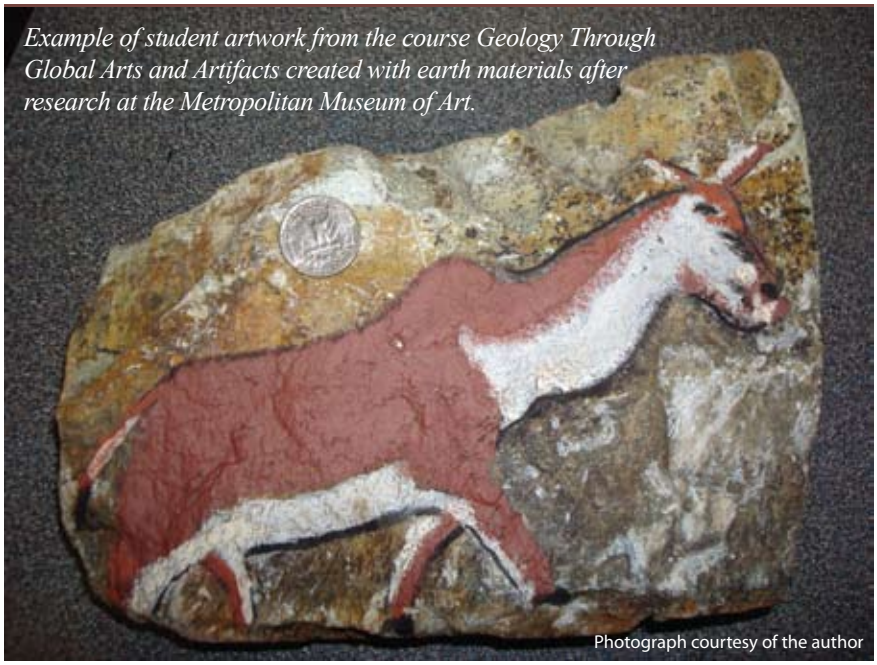
Science and the City: Community Cultural and Natural Resources at the Core of a Place-Based, Science Teacher Preparation Program

By Eleanor A. Miele and Wayne G. Powell



Example of student artwork from the course Geology Through Global Arts and Artifacts created with earth materials after research at the Metropolitan Museum of Art.

Photograph courtesy of the author

The departments of Geology and Education at Brooklyn College collaborated with five informal educational institutions in the development of a place-based graduate program for Earth science teachers. The team used "backward design" to develop a program of courses that are thematically structured and use a city-as-lab approach that places community resources at the core of instruction. The program design team was composed of higher education faculty in geology and education, high school science teachers, public school administrators, and informal science educators. The program aims to produce graduates who are prepared to integrate the resources of the city into their teaching.

We collaborated with five informal educational organizations/institutions and the Department of Education of the City of New York to create an entirely new approach to science teacher preparation focusing on local cultural and natural resources. The community partner organizations include the American Museum of Natural History, the Metropolitan Museum of Art, the Central Park Conservancy, the Prospect Park Alliance and Prospect Park Audubon Center, and the National Parks of New York Harbor. Our goal was to use a city-as-lab approach to develop a new program in Earth science education that systematically utilizes the resources of the city to produce graduates who are able to integrate these resources into their teaching. Community partner organizations were essential to provide the field environments, collections of artifacts and objects, exhibit halls, off-campus classroom facilities, and the expert knowledge of how to use them to enable us to meet this goal. We believe that science teachers prepared with this city-as-lab approach will be better prepared to teach science in urban classrooms. Lessons learned from a prior collaboration (Teacher Renewal for Urban Science Teachers [TRUST]) between the American Museum of Natural History and Brooklyn and Lehman Colleges of the City University of New York (Dhingra et al. 2001, 2006; MacDonald et al. 2008) were seminal to the Science and the City project, which includes four new informal partners.

Science and the City developed a new 30-credit master of arts in teaching program for Earth science teachers. This program includes 24 credits in geology that model active learning pedagogies. At the core of the program are four new courses developed in collaboration with our informal partners that center on the collections and field locations of local museums and parks (see Figure 1). The courses use a thematic approach to instruction that focuses on big ideas like global cataclysms or the built environment, rather than on traditional geology course topics such as sedimentology and petrology. The courses also emphasize science as inquiry and unifying concepts and principals of science that transcend disciplinary boundaries.

Design philosophy

As design team leaders, we chose to use "backward design" to create the curriculum for this new master's program and to invite informal educators and school teachers to participate as team members. With backward design, one first identifies the essential learning outcomes and major program goals. The specific "content" that will be taught is identified last. The goals, or desired outcomes, determine the curriculum, not tables of contents in textbooks (Wiggins and McTighe 2000). All course activities and assignments are designed to provide the structured experiences and practice needed to develop the skills and knowledge required to meet the program goals. We used backward design to plan the entire program curriculum, from course themes and sequences to individual course syllabi.

The design team for Science and the City included faculty in geology and education and delegates from each of our partner organizations. Each organization sent one or more educators, curators, or park rangers. Educational professionals employed by these "informal" institutions are skilled in the teaching applications of their facilities. In order to ensure that our program would meet the needs of teachers and schools, the team included three accredited classroom Earth science teachers and two senior administrators of science curriculum from the New York City Department of Education (NYCDOE). We also sought input from students in the design process. The participating Earth science teachers in the design team were all former or current Brooklyn College graduate students and therefore familiar with the strengths and weaknesses of our existing courses. As leaders of the design team, we emphasized that the input of all team members was equally valued and that all team members contributed essential expertise.

The design principles

Because our primary goal was to systematically integrate the city's natural and cultural resources in an innovative master of arts in teaching program, the overarching design principle was that community resources would be integral to instruction. The team's primary task was to define a set of themes that would place the city-as-lab at the core of all program coursework. We asked the team to consider the following question at all times: Is this truly a place-based course? or Could this course be taught anywhere?

A second fundamental principle was that the new program must address all content concepts and skills required for certification to teach Earth science. Our core content and skills were defined for us by the state-mandated middle school and secondary Earth science curricula. Our goal was to prepare Earth science teachers who would be successful teaching to New York City students. The participation of senior administrators of science curriculum from the Department of Education was especially helpful in keeping us focused on the needs of city teachers.

The third principle was that we would use a thematic "essential questions" approach to course development, based on our success with this approach in the TRUST project (MacDonald et al. 2008).

The fourth principle was that the individual learning objectives for all courses would be student-centered, concrete, and measurable and would develop higher-order thinking skills. These learning objectives would be stated in terms of what teachers would be able to do as a result of skills and knowledge gained through course activities, not in terms of what they would "know." Bloom's taxonomy of educational objectives was used as a resource for the design team (Bloom 1956). Course activities and assignments must develop higher-order skills such as evaluation, synthesis, and analysis as appropriate to the course content and themes.

The final principle was that the program should have multiple points of entry, including multiple foundational courses as well as more advanced coursework that would build on skills and knowledge gained in entry-level courses. We hoped to recruit program participants from among students who

FIGURE 1

Course bulletin descriptions.

Geology 640: Geology Through Global Arts and Artifacts

Inquiry approach to formation and properties of minerals, rocks, and metals; Metropolitan Museum of Art and other New York City collections or data sources for investigating real-world applications of Earth materials; a minimum of three weekend field trips as labs to New York City cultural institutions.

Geology 641: New York City Water Sources and Cycles

Principles of hydrology and hydrogeology with emphasis on the New York City region; history of the New York City water supply; water quality; water treatment; water budgets and cycles; precipitation and storms; several weekend field trips required, including Prospect Park and Jamaica Bay.

Geology 642: Geology of New York State

Field-based approach to geological history of New York State; Grenville Orogeny, Lower Paleozoic strata and the Taconic Orogeny, Catskill delta and the Acadian Orogeny, Mesozoic rift basins; six days of field trips across New York State, including overnights.

Geology 644: Global Catastrophes

Exploration of Earth dynamism and evolution; case histories of major events that changed the course of Earth history such as atmospheric oxygenation, snowball Earth, Cambrian radiation, Cretaceous-Tertiary mass extinction, Central American land-bridge, and anthropogenic catastrophes; several weekend field trips required, including the American Museum of Natural History and beaches of Coney Island and/or Jamaica Bay.

may take introductory-level courses as electives in other teacher preparation programs.

The design team also reviewed two new place-based Earth science courses that we had developed as part of the TRUST program as model place-based courses created by using backward-design principles. The team was asked to consider these courses for possible inclusion in the master's program.

Then the team broke into four concurrent brainstorming sessions with at least one teacher, one college faculty member, and two park or museum staff members in each group. Each group was asked to identify thematic questions that could be productively explored using the partner resources or other resources in the city with which they were familiar that could realistically be used by teachers. We wanted all place-based learning activities to be directly applicable to K–12 teaching. We also asked each group to identify key learning goals from the state curriculum for each theme. At the end of the brainstorming sessions, the group met to review ideas and reach consensus on the themes to be further developed. We were pleased to find that there was considerable overlap in the themes identified in the four brainstorming groups. We also reviewed the state-mandated content to make sure that all content required for New York State certification was addressed by the proposed course learning goals. Only a few required concepts had not been identified as relevant to at least one proposed thematic course, and we found appropriate courses for each. At the end of the brainstorming sessions we were able to reach consensus among all stakeholders on themes, content, and resources for the program courses.

Design products

The project team identified the following thematic courses and essential questions that together would address all required content areas and essential skills required for teaching Earth science to New York City students:

- Geology in World Cultures: How do the arts and artifacts of global civilizations reflect global geology? (introductory)
- New York City Water: Where does it come from and where does it go? (introductory)
- What Is a Planet? What are the properties of objects found in the solar system and beyond? (introductory)
- New York State Geology: How does the geology of New York State reflect the major concepts of plate tectonics? (advanced)
- Global Cataclysms: What is the geological evidence of global cataclysmic events that have impacted the evolution of life on Earth? (advanced)

One common goal was identified by the design team for all courses in the program. Teachers completing these courses will be able to create interdisciplinary, age-appropriate learning activities for students that utilize New York cultural resources, focusing on a core set of specific state-mandated Earth science concepts. Learning goals for all courses also include working collaboratively, developing geoscience inquiry skills and content knowledge and the use of computer-based media to convey text and graphic information.

During the subsequent design team meeting, we asked each group to work backward from the learning goals identified in the first session to identify specific learning activities and assignments utilizing the resources of the partners. As a final step in initial course development, small groups of science teachers, informal educators, and college faculty met in interest groups to fine-tune course content and assignments. We agreed to begin with development of the first two themes and to follow up with the others over the course of the two-year collaboration.

The design team ultimately developed four new geology courses that strategically utilize local resources to teach Earth science concepts. For example, students in Geology through Global Arts and Artifacts analyze artifacts from world cultures at the American Museum of Natural History and the Metropolitan Museum of Art. They also explore a local mining museum to learn about the history and technology of mining. Students in New York City Water: Sources and Cycles travel to the Old Croton Aqueduct and Croton Gorge Dam and analyze the water quality of city tap water, the Lake in Prospect Park, and the coastal estuaries of the National Seashore at Jamaica Bay. The team also decided to incorporate one previously developed course in the program:

- Earth Science and the New York City Urban Environment: On what and of what is the city built? How has the city environment changed over time? (introductory)

The syllabi for these courses, with detailed activities and assignments, are posted on the Geology Department website.

Course revision

We designed a student-centered course revision process into the Science and the City project. Each course underwent a multiphase process of development. This process included the initial pilot teaching of the course, ongoing evaluation throughout the semester, final course evaluations, and an end-of-semester focus-group at which course completers were invited to recommend specific revisions to activities and assignments. To get timely feedback and opportunities for midcourse corrections, we encouraged students to provide anonymous comments throughout the semester via a "Comments" link to a course e-mail box embedded in the online course syllabus. Following the pilot course evaluation, the courses were revised in small team meetings that included teachers and faculty in geology and education. The revised courses were then retaught and reevaluated.

One of our working assumptions was that students of education are well-qualified to judge and articulate the value of their educational experiences. As stakeholders in the process of science teacher training, our teacher-participants provided insight into the effectiveness of assignments, teaching strategies, and evaluation tools and offered suggestions for new approaches. Our initial experience with this approach to formative assessment of course offerings suggests that inclusion of student stakeholders in course and program revision is more effective than standard faculty-driven redesign strategies (Powell et al. 2007).

Challenges

We have learned that successful partnerships between higher education institutions and informal partners are dependent on having significant institutional and programmatic goals in common. For example, one anticipated new partner organization declined to participate because we had not adequately considered its institutional priorities and limitations. Prior collaborations with other partner organizations had enabled us to develop insight into their missions and institutional cultures. Preliminary meetings with representatives of community resources can help to identify common goals and needs that will provide a solid foundation for partnership as well as indicate potential pitfalls.

Maintaining the collaboration with institutional partners on this project throughout the full two-year design and revision process presented an unexpected challenge. For instance, intensively scheduled programming and limited resources prevented participating organizations from releasing personnel from programmatic obligations after the initial planning phase. Participation in later stages of the planning process would have been facilitated if we had funding to compensate the institutional partners for their time. In today's economic climate, financial considerations will present an even greater challenge to collaboration with nonprofit organizations.

We continue to struggle with developing instructional relationships with scientists and educators at partner institutions. Our objective is to collaborate with institutions, not individuals. The need to compensate institutions rather than individuals complicates meeting this goal of the project. We are making some progress on this front by enlisting the cooperation of our institutional financial officers. We were able to recently work out an inter-institutional agreement that allows us to offer a new online course, the Solar System, offered by the American Museum of Natural History as the What Is a Planet themed course for the new master of arts in teaching program.

We anticipated some resistance at the college to the adoption of thematic courses and the backward-design approach. Our prior participation in the On the Cutting Edge faculty development workshops was especially helpful in preparing us to lead the Science and the City design team and to shepherd the new courses through college governance. Faculty from other science disciplines, including biology and general science, have also participated in On the Cutting Edge faculty development and have found the process helpful in creating innovative courses that integrate best practices in college science teaching in their respective disciplines. An online Course Design Tutorial is available to help science faculty identify core goals for curriculum development initiatives (Tewksbury and Macdonald 2005). We also anticipated that there might be difficulty reaching consensus with design team members as varied as current students, senior and junior faculty, public school educators and administrators and informal educators; however, the group was able to recognize the contributions and viewpoints of each constituency. Perhaps the diversity of representation prevented any single constituency from feeling uniquely privileged.

Successes

Science and the City succeeded in integrating use of community cultural and natural resources in formal coursework at the college. The design team was able to meet the curriculum design goals in two days of intensive planning. They identified essential questions and themes that addressed all required content and created innovative courses that interest students. They identified relevant local natural and cultural resources for creating authentic field-based learning experiences that meet the learning objectives of each thematic course. Course bulletin descriptions enforce the centrality of these resources to each course.

The project increased our level of collaboration with key partners, and we have embarked on several new proposals and projects. Both the NYCDOE and the New York State Education Department have subsidized the tuition of Earth science teachers at the college as a direct result of the development of these innovative courses.

The collaboration has also resulted in institutional changes in the Geology Department. Teacher preparation has assumed a more prominent role in the department, with involvement of both senior and junior faculty. A novel instructional policy has been implemented. Each of these new 4.5-hour courses is team taught by one of the geology faculty and a certified Earth science teacher. Geology faculty teach 3 hours and Earth science teachers teach 1.5 hours of the course load. Because we are a public institution, the added tuition cost to students for the additional hours is minimal. In many cases, the collaborating faculty members have elected to participate in each others' sessions with benefit to both. This creates a culture of inclusion.

Since we began offering these new thematic place-based courses, enrollment in geology courses has risen dramatically, with courses regularly filled to capacity. The number of courses offered has been limited by faculty availability and the departmental budget, not by student enrollments. The college has developed a reputation as a school that emphasizes place-based learning. New faculty have joined the department with backgrounds in place-based instruction.

The Geology Department has institutionalized the core principles of the Science and the City project by adopting the following departmental goals for all teacher-education courses. Graduates of our teacher-based programs will

- be highly effective in New York City Earth science classrooms,
- be able to integrate New York's natural and cultural resources into their Earth science classrooms and recognize the connections between Earth sciences and the lives of the people of New York,
- be familiar with technology commonly used by geoscientists, and
- be part of a supportive and cooperative network of educators (teachers and informal-education professionals) and geoscientists.

Student feedback tells us that we are on track to produce graduates who are able to integrate the resources of the city into their teaching. We could see this when all survey respondents at the end of one course strongly agreed with the statement, "I look at the city differently as a result of taking this course." All students also either agreed, or strongly agreed, with the following statements:

- I have learned how to use the city, museums, and other informal resources in teaching science from taking this course.
- I feel more confident and prepared to integrate aspects of geology into my teaching in other subjects.

Of these respondents, 87% reported that they had taken their students outside the classroom for instruction. This population includes a high proportion of teachers of grades K–6 who are more able to organize field trips than teachers of grades 5–9 or 7–12. Teachers of grades 7–12 report that they assign field-based individual assignments rather than whole-class field trips and incorporate virtual field trips on the basis of their own PowerPoint media files of their expeditions in the city, state, and nation. We are continuing to follow program participants to determine the extent to which they integrate community resources in their classroom instruction.

Science and the City has transformed the education of Earth science teachers at our institution and reinvigorated our graduate programs for high school science teachers and our Geology Department. But most important, this program will produce a new cadre of science teachers who are able to use local cultural and natural resources to enrich their instruction. ■

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Eleanor A. Miele (emiele@brooklyn.cuny.edu) *is an associate professor and program head of science education in the School of Education and* ***Wayne G. Powell*** *is an associate professor and chair in the Department of Geology, both at Brooklyn College, City University of New York, in Brooklyn, New York.*