Using the Urban Environment to Engage Youths in Urban Ecology Field Studies

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ABSTRACT: Recent science education reform proponents explicitly put forward the idea that all students, regardless of culture, gender, race, or socioeconomic status, are capable of understanding and doing science. To address this need, the authors have developed and implemented a field-based urban ecology science program to engage traditionally underrepresented groups, such as minorities and women in real-world science. The authors describe the components of the program and discuss why the program has been successful in providing opportunities for all students to engage in and learn science. Using mixed methods to evaluate the program, they found that it improves student interest in science, supports students in developing a better understanding of scientific methodologies, and improves students' sense of environmental stewardship when compared with students experiencing traditional science instruction over the course of an academic year.

KEY WORDS: ecology, field studies, science interest, urban science education

Students often report that what they learn in science lacks relevance to their lives (Nieto, 1994). It is unfortunate that this perception is rather pronounced in the field of environmental education (EE). For example, Connell, Fien, Lee, Sykes, and Yencken (1999) found that most Australian high school students did not believe that environmental issues affected them and that there was very little they could do to improve the environmental conditions where they lived. These findings are indicative of a more generalized perception that traditional

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school science experiences do not facilitate in developing the belief that students can be caretakers of the environment (Gough, 2002; Hudson, 2001; Legault & Pelletier, 2000; Tran, Euan, & Isla, 2002; Worsley & Skrzypiec, 1998).

There has been increased interest in exploring how to engage students in science within and through interaction with their local environment. Yet, as noted by Orion and Hofstein (1994), the outdoor environment is neglected by teachers, curriculum developers, and researchers. There have been several studies (e.g., Orion, 1994) documenting that teachers tend to avoid outdoor activities because they are frequently unfamiliar with the philosophy, technique, and organization of using the outdoors as an effective medium for teaching. Yet, when leveraged appropriately, outdoor experiences appear to be fruitful because they engage students in activities situated in real-world cultural contexts that enhance their local relevance (Fusco, 2001).

In this article, we describe an urban ecology field-based studies program (UEFSP) designed to improve students' understanding of the environment and their ability to care for it. We describe the major components of the program, the successes, and the challenges so that others who have similar goals may use what we have learned to design and implement or improve their own programs.

The UEFSP

The UEFSP was developed by the Urban Ecology Institute in partnership with the Boston, Massachusetts, Public School department, local community centers, and the Boston College School of Education. The UEFSP engages students in the scientific process by combining the immediate relevancy of their own urban ecosystem with basic scientific research. Built on the educational process of inquiry, each study is framed around the following question: What is the health of Boston's urban ecosystem? By using this overarching question as the context, we developed a series of curriculum modules that participating teachers use to augment their existing science curriculum.

The primary thrust of our work is drawn from the emerging field of urban ecology. Urban ecology has been called "an important frontier for educators" because the "core skills and concepts integral to urban ecosystem education are well established in national and state science education standards" (Hollweg, Pea, & Berkowitz, 2003, p. 33). Urban ecology is a subject around which inquiry-based science activities can be built by critically examining the science standards and constructing scientific experiences that address both the content and the inquiry processes described in those standards (Bybee, 2003). Thus, urban ecology affords a thoroughly integrated curriculum that combines the power of science with the direct impact of active learning about, and in service to, the local community (Berkowitz, Nilon, & Hollweg, 2003). In short, curricula designed from an urban ecological perspective emphasize both process and content, moving away from the "survey of the sciences" approach often found in traditional classrooms and textbooks, which often saps the excitement and curiosity from many urban students (Kahle, Meece, & Scantlebury, 2000).

There are three basic elements to the program's framework: professional development, field research and curriculum materials, and the annual student research conference. To aid teachers in the implementation of these program components, the Urban Ecology Institute provides trained field assistants as well as small grants for equipment and transportation costs. The field assistants serve as liaisons between the schools and the Urban Ecology Institute and are available for field and classroom assistance, including working directly with students and consulting with teachers to prepare classroom and field lessons.

Professional Development

One of the most important components of the UEFSP is the ongoing professional development opportunities provided to educators. The Urban Ecology Institute offers a week-long institute in July for teachers, community leaders, and urban professionals to define a common forum for initiating community-based, urban research. Field visits and lectures focus on an introduction to urban ecology and study design, water quality, biodiversity, social ecology, and connecting fieldwork to the classroom and community. This orientation prepares teachers, before the school year starts, to incorporate the program into their existing curriculum. In addition, a 1-day "Fall Kick-Off Workshop" is organized for all participating educators. A central feature for these workshops is peer education, such that veteran teachers working in the program lead at least one of the sessions for their colleagues. Afternoon workshops are conducted throughout the school year, usually two per semester. These are teacher-directed forums during which information is provided, ideas are exchanged, and experiences are shared.

Field Research and Curriculum Materials

The UEFSP currently provides curriculum materials for a variety of studies, including water quality monitoring, avian diversity, and coyote, crow, and turtle ecology and behavior studies using radiotelemetry. These materials have been developed to provide teachers with (a) information on how to prepare, conduct, and analyze data; (b) a general conceptual and contextual framework for the studies; and (c) classroom and field-based activities that expand on the learning and experiences gained through the field research and connect them to the classroom curriculum and state standards.

Each school is also expected to conduct research at a local ecologically rich study site within the city. The field site is selected by the teacher in conjunction with the Urban Ecology Institute and local watershed associations and environmental agencies. Each school's study site is located near the school, ideally within walking distance, but some sites do require a short bus ride. The same sites are used each year to provide long-term, comparative data.

Annual Student Research Conference

The culminating event of the program occurs at the end of each school year when the Urban Ecology Institute organizes a large gathering of teachers, students, and invited guests, including academic professors, government agency representatives, and members of community organizations. The conference is held at Boston College and runs as a professional research conference. The conference provides a public forum for recognition and reward of school and individual student achievement. Such an event offers the students the opportunity to showcase their commitment and knowledge gained through their year-long studies.

Participant Feedback and Program Evaluation

Study Context

Students who participate in the field studies program are representative of the students that attend the Boston Public Schools (BPS). The Boston Public School District (18,400 students in Grades 9–12) is like many other urban districts that have large populations of low income and minority stu-

dents (64% of the BPS students are African American or Hispanic with 62% eligible for the free lunch program, and 9% for reduced price meals.) The district is engaged in a whole school reform process based on increasing subject literacy, pedagogical accountability, and the use of technology to improve teaching. Unfortunately, in BPS, like other urban school districts, under-prepared teachers or those teaching out of their subject area, insufficient materials and supplies, and lack of structures to support innovative teaching practices often compromises high-quality science teaching (BPS, 2004). With the goal of providing scientific experiences for students we collaborated with the BPS Science department and used the UEFSP framework to activate the Boston urban ecosystem as an instructional resource.

In this section, we present a summary of our findings during the 2 years of our program (2001–2003). Our research and evaluation program consists of a mixed methodological strategy, including survey and interview protocols. Starting in the fall of 2001 and continuing for the next 2 years, we administered a modified version of the Scientific Attitude Inventory II (Moore & Foy, 1997) to a subset of participating students. The survey was modified to meet our specific local and contextual needs. The final survey consisted of 63 questions designed to measure students' interest in science and their understanding of scientific investigative methodologies. At the beginning and end of the year, we administered the survey to a randomly selected subset of UEFSP students and to randomly selected students in a science class who had not participated in the program (comparison group). Tables 1 and 2 show the survey results for both years of the study.

In addition to the quantitative survey data, students (n = 30 each year) were interviewed at the conclusion of their participation in the UEFSP to better understand how their participation influenced their thinking. In addition, some of the participating teachers (n = 25 each year) were also interviewed to understand their perspectives regarding how participation in the UEFSP influenced their students' thinking toward the environment, their ability to conduct scientific investigations,

TABLE 1. Pretest and Posttest Scores for Students in the Urban Ecology Field-Based Studies Program (UEFSP) and Comparison Students in Traditional Science Classes in the First Year of Study

	Pretest (Fall 2001)				Posttest (2002)			
Scale/group	*n*	*M*	*SD*	*t*(328)	*n*	*M*	*SD*	*t*
I Want to Be a Scientist								
UEFSP	137	2.87	.86	–4.35*	129	3.12	.84	1.04
Comparison	193	3.28	.85		56	2.98	.65	
Science Methodology								
UEFSP	137	3.26	.39	–1.5	129	3.51	.61	1.52
Comparison	193	3. 33	.41		56	3.35	.63	
Science as an Authority								
UEFSP	137	2.68	.57	–0.73	129	2.80	.71	.11
Comparison	193	2.73	.65		56	2.79	.67	
Ecological Mindset								
UEFSP	—	—	—	—	129	3.32	.60	2.52*
Comparison	—	—	—	—	56	3.08	.54	

*$p < .05$.

and if they had observed a change in their students' interest in science. The interview protocol consisted of a set of semistructured questions designed to provide data regarding the teachers' perceptions of the strengths, weaknesses, and challenges experienced while implementing the UEFSP.

Data Analysis

We analyzed the quantitative data using SPSS (Version 11) and analyzed the qualitative data using a grounded theory approach to look for commonalities across the student and teacher interviews to determine which aspects of the program were most valuable from the participants' viewpoint and which areas of the program needed improvement. For the first year of data collection (Fall 2001–Spring 2002), we conducted an initial exploratory factor analysis and identified four scales: (a) I Want to Be a Scientist, (b) Science Methodology, (c) Science as an Authority, and (d) Ecological Mindset. The first two scales both had a reliability of .74. The latter two scales' reliabilities were below .45. However, by removing the 17 questions that had a low-point biserial correlation, we reduced the scales' length and increased the reliabilities of each scale to .82, .81, .58, and .60, respectively. During the second year of data collection, we used a similar statistical approach with the improved survey. The same scales were leveraged again with reliabilities .85, .82, .67, and .76, respectively.

Using the reduced scales for both the comparison and the experimental groups, we conducted independent samples *t* tests to determine whether there were any differences between the two groups. We then conducted a more finely grained analysis by examining the differences on each question of each scale between the experimental and comparison groups and reexamined the interview data to develop a better understanding of why particular aspects of the program were more or less effective.

TABLE 2. Pretest and Posttest Scores for Students in the Urban Ecology Field-Based Studies Program (UEFSP) and Comparison Students in Traditional Science Classes in the Second Year of Study

	Pretest (Fall 2002)				Posttest (2003)			
Scale/group	*n*	*M*	*SD*	*t*(644)	*n*	*M*	*SD*	*t*
I Want to Be a Scientist								
UEFSP	418	3.16	.82	.12	355	3.10	.81	2.6*
Comparison	228	3.15	.86		184	2.88	.77	
Science Methodology								
UEFSP	418	3.82	.47	1.47	355	3.75	.55	5.9*
Comparison	228	3.76	.55		184	3.40	.77	
Science as an Authority								
UEFSP	418	2.66	.66	1.20	355	2.76	.68	.223
Comparison	228	2.60	.65		184	2.77	.64	
Ecological Mindset								
UEFSP	418	3.51	.62	.59	355	3.48	.59	4.60*
Comparison	228	3.48	.64		184	3.20	.63	

*$p < .05$.

Results

During the first year, our results indicate that, at the start of the academic year, there were no significant differences on the scales Science Methodology and Science as an Authority between the experimental and the comparison groups. The comparison group scored significantly higher on the scale "I Want to Be a Scientist" than the experimental group. At the end of the academic year, whereas the comparison group scored significantly lower on the "I Want to Be a Scientist" scale than it did in the fall, the experimental group showed significant increases in their scores on the "I Want to Be a Scientist" and the Science Methodology scales. No significant differences were observed on the Science as an Authority scale for either of the groups. In addition, on the Ecological Mindset scale, which was tested only in the spring, the experimental group showed statistically significant higher scores. The Ecological Mindset scale was only tested in the spring because our formative research suggested that participation in the Field Studies Program was affecting student sense of environmental stewardship. However, we did not have an instrument to measure the affect until the spring. The lack of a statistically significant difference in the spring between the experimental and comparison groups (Table 1) can most likely be attributed to the decrease in sample size for the spring comparison group.

In the second year of the program, our results (Table 2) indicate that, at the start of the academic year, there were no significant differences on the four scales between the experimental and comparison groups. At the end of the academic year, whereas the comparison group scored significantly lower on all of the scales, the experimental group scored higher on the "I Want to Be a Scientist" scale and Ecological Mindset scale than on the pretest. Furthermore, comparison of the group scores revealed that the experimental group significantly outperformed the comparison group on the "I Want to Be a Scientist," Scientific Methodology, and Ecological Mindset scales. There was no significant difference between the two groups on the Science as an Authority scale.

Although the experimental group outperformed the comparison group on three of the four scales, it is important to note that the experimental group posttest scores were not significantly different from the pretest scores. Therefore, we undertook a further examination to better understand our results. Specifically, we examined gender effects of our program in Year 2. This analysis revealed that boys in the experimental group significantly outperformed boys in the comparison group (n = 60) on the posttest on the Scientific Methodology scale, $t(58)$= 6.20, $p < .05$, and Ecological Mindset scale, $t(58) = 4.34$, $p < .05$. Analysis of the female responses revealed that girls in the experimental group (n = 127) significantly outperformed girls in the comparison group (n = 48) on the Scientific Methodology scale, $t(125) = 3.73$, $p < .05$, and the "I Want to Be a Scientist" scale, $t(125) = 2.10$, $p < .05$. Furthermore, analysis of the female responses showed that the experimental group improved on all four scales, whereas the comparison group's scores decreased on all four scales. Thus, participation in the UEFSP appears to maintain interest in science and improves understanding of the scientific process and sense of stewardship for boys. Participation in the UEFSP program also appears to improve understanding of the scientific process and their interest in science for girls. This latter finding is significant in that girls' interest in science typically decreases during the secondary school years (American Association of University Women, 2004).

Based on analysis of individual questions and the interview data, we found that students participating in the program began to change their perspectives regarding stewardship of their local environment, as noted by a Boston public high school teacher during an interview, "They [the students] have a heightened sensitivity to trash on "their" field site once it becomes theirs. They start

to think about it proactively, even asking on their own if we could bring out materials to do a clean-up."

Most urban students do not see science as relevant to their daily lives for myriad reasons (Fusco, 2001); however, through participation in the UEFSP, many students commented that they recognized science as a tool that they can use to understand the world around them. One inner-city student noted the following:

> I'd like to do some science work but the Neponset River was kind of dry. . . . This is a question I'd like to ask: Why weren't there a lot of creatures out there . . . no nothing . . . it was just dry. . . it was just water. I'd like to know what's up with that.

Teachers also observed that students' self-confidence in science increased as a result of participating in the program. A Boston public high school science teacher stated the following:

> One day they were all walking out to the field with the testing equipment, and the students were bragging to other students in the hallway that they were going to do 'real science' outside. Students are usually excited to go out to the field site.

The participating teachers were also excited that, over time, their students succeeded and collected significant amounts of data, analyzed the data, and presented their work at the year-end conference. One teacher commented, "A lot of people said inner city kids can't do science and they proved them wrong. Our kids enjoy being out in the environment and I hope next year we'll get more opportunities to do that."

Perhaps most important was that science became accessible to urban youth through observations, discussion about real-world problems affecting their neighborhoods, and sustained involvement in locally relevant scientific investigations throughout the year. It is not surprising that such experiences were seen as having little in common with school science, as noted by one student, "We had a better learning experience out there doing science rather than inside hoping to see it!"

In short, participation in the field-based program provided students with one of their few scientific laboratory experiences (many schools in the city do not have laboratories or equipment) and exposure and the opportunity to learn (Tate, 2001), both of which are critical for students to better understand their role in shaping and caring for their local environment.

Implementation of the UEFSP

We encountered numerous challenges that affected implementation of the UEFSP. In this section, we summarize those challenges and the strategies we used to overcome them.

In the current age of district and state standardized examinations, teachers have less and less freedom regarding the material they are expected to cover. Thus, it has become critical for us to develop strategies that integrate the UEFSP into existing curricula. To achieve this goal, we have relied on providing a structure for supporting field study and on teacher professional judgment and expertise.

Providing Supports for the Field Studies

Early obstacles in our work included transportation to the field sites and supporting teachers in the field. Given that our program works primarily within an urban school system, most schools have

little to no funding for buses to transport students to the ecologically interesting field sites. However, using external funding, we were able to provide transportation to field sites. Unfortunately, that funding was not sustained. As a result, we developed additional curriculum materials so that students could explore ecosystems on a smaller scale, such as their schoolyard.

We also found that many teachers were hesitant to take their classes out of the classroom. The reasons for this varied, but the most prominent was behavioral management. To support the teachers during the early stages of implementing our curriculum materials, we decided to provide a field assistant who understood the science and the scientific procedures. This assistant modeled how to conduct an outdoor scientific investigation not only for the students but for the teachers as well. As the teacher became more comfortable with the materials and the science, we slowly scaled back the assistance until the teacher was self-sufficient and could serve as a mentor to other beginning teachers.

Trusting and Leveraging Teacher Professional Judgment

We found that teachers themselves are in an ideal position to adapt our curriculum materials to their students' needs and day-to-day realities of their particular school and classroom. Most teachers have valued our support of their innovations, as noted in the following interview excerpt:

> I think the thing that I like about the program is that I have the freedom to play with the curriculum in ways that meet my and my students' needs. The materials are already very good, plus I have a lot of support, but it is nice to know that I can add this or that and that such input is valued.

> We also established a teacher advisory board to maintain a strong connection to the classroom and focus on the development of a flexible curriculum rather than creating a "teacher-proof curriculum." To support this process, we have found that the regular professional development workshops and summer institutes are invaluable. However, this model does have its limits and, to further expand our work, we are developing a technology-based support system as additional teachers begin to participate in our program.

Conclusion

Implicit in current state and national environmental science education reform policies and practices is the assumption that students need real-world scientific experiences that engage and support them in learning about the process of science and how to become caretakers for their environment. It is unfortunate that given the recent research on student attitudes toward the environment, we, as an educational community, are not achieving these goals as more and more students underperform on national tests and do not enter scientific fields after graduation. As a result, there is a critical need for programs that support students in conducting authentic scientific investigations that motivate and increase their interest in science. The UEFSP described here attempts to achieve that elusive goal of building a program that fits within existing urban school district structures while providing the opportunity for every student to learn and engage in science and to become caretakers for their local environment.

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