Connecting Urban Students with their Rivers Generates Interest and Skills in the Geosciences

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ABSTRACT

Two different enrichment programs for urban high school students from the Greater Hartford Area of Connecticut were conducted during the summer of 2002. They were designed to expose students entering the tenth grade to Earth Science as a problem solving science in a challenging and supportive atmosphere. This was done by focusing on understanding watersheds and water quality using primarily chemical techniques on samples collected from the Connecticut River, it's two Hartford area tributaries (the Hockanum and Park Rivers) and coves and ponds adjacent to or feeding into these rivers. Students worked in groups of one to three and all gave presentations of their results (data and interpretation) on the last day. Student faculty ratios that did not exceed three to one provided close supervision and individual attention.

The majority of the students found the programs a positive experience. Students stated that they had developed a greater appreciation for science, the rivers in the Hartford area, and the issue of pollution and how it relates to them. The majority indicated that the program would help them in subsequent science classes and that they would like to continue to participate in the program the following year. All of the students said they would recommend the program to another student interested in science.

INTRODUCTION

National Science Foundation (NSF) statistics in a year 2000 document on diversity in the geosciences (Prenderville and Elthon, 2000) indicate that geoscience Ph.D.s are earned by minorities at the following rate; African-Americans ~1.7%, Hispanic-Americans ~3%, and Native-Americans/Native-Alaskans ~0.5%. Thus roughly 5% of the approximately 800 Ph.D.s awarded annually in earth, atmospheric and ocean sciences are earned by minorities.

To address the lack of ethnic diversity in the geosciences, NSF provided funds to enhance minority participation through a Geodiversity Initiative, with three specific objectives.

1) Increase opportunities for geosciences research experiences for students, undergraduate and graduate, from underrepresented groups.
2) Facilitate the establishment, development and enhancement of geoscience educational research capabilities in minority serving institutions (MSIs).
3) Foster educational and research partnerships/ collaborations/exchanges between and among the following: minority serving institutions, traditional majority serving institutions, research centers, professional and industrial organizations.

Our program was developed to address the three primary objectives of this initiative. Although objectives one (research experiences) and two (research capabilities at minority serving institutions) were aimed primarily at undergraduate and graduate students, we, as others (e.g. Blackwell et al., 2003) argue that the Earth Science pipeline needs to begin before college.

High school students of all ethnic backgrounds, but especially low-income urban students, are not generally aware of the career opportunities in Earth Science and its relevance to them. For them, a connection with earth processes may seem particularly remote. Hartford, Connecticut with a poverty rate of 43% (2000 census) certainly qualifies as a low-income urban area. In addition, students attending Hartford Public schools are predominantly ethnic minorities (Table 1), and thus provide a rich opportunity to engage minority high school students in the Earth Sciences.

Our program grew out of the unique association of the Greater Hartford Academy of Math and Science (GHAMAS) and Trinity College, a small liberal arts college in Hartford. The Trinity College administration provided the impetus for the construction of GHAMAS and the two schools are located across the street from each other. GHAMAS, a magnet school that opened in 2001, draws students from Hartford and surrounding towns. Half of the students attending GHAMAS live in Hartford; the others come from the towns listed in Table 1. Students attend GHAMAS for half a day and, while there, take math and two-hours of inquiry-based science instruction. They return to their home school for social studies, humanities and arts courses. Ninth and tenth graders attend during the morning and eleventh and twelfth graders attend during the afternoon. There are no sports or other extra-curricular activities.

THE PROGRAM

Rivers have figured prominently in human history. Adrian Block sailed up the Connecticut River in 1614, six years before the Pilgrims landed at Plymouth Rock (Arnold, 1985; Perk, 1998). Mark Twain, spinner of Mississippi River tales, lived next to the Park River in Hartford and a short distance form the Connecticut River (Arnold, 1985). Today, most people along the Connecticut River do not talk about its literary qualities, especially those living in Hartford. They want to know where to fish, if they can eat the fish and if it is safe to swim in the water. We exploited these more prosaic interests to excite students to conduct research to address

Town	Amer. Indian (%)	Asian (%)	Black (%)	Hispanic (%)	White (%)
Bloomfield	0.0	1.1	83.8	4.1	10.9
Farmington	0.2	3.9	7.0	2.3	87.0
Glastonbury	0.2	4.1	4.0	4.1	87.6
Granby	0.1	0.9	3.0	1.6	94.5
Hartford	**0.1**	**2.6**	**42.1**	**51.0**	**4.6**
Manchester	0.3	2.8	15.9	9.1	72.0
New Britain	0.1	2.7	15.9	5.6	34.8
Newington	0.1	4.5	4.5	3.8	87.2
Rocky Hill	0.1	3.0	4.2	3.4	89.3
Simsbury	0.0	2.5	4.0	0.9	93.0
Wthersfield	0.2	2.3	2.8	7.8	89.9
Windsor	0.3	3.2	34.4	5.9	55.2

Table 1. Demographics of the school districs participating in the Greater Hartford Academy of Math and Science (GHAMAS). Half of the students come from Hartford, and half from the other districts.

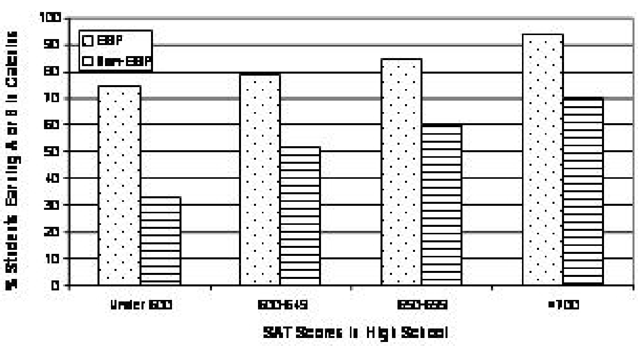

Figure 1. Honor grades (A and B) received in Introductory Calculus at the University of Texas, Austin. Those students participating in the Emerging Scholars Program (ESP) outperformed non-ESP students. The differences are most pronounced in students with lower math SAT scores. ESP is not a remedial program. Participants are given additional, accelerated, calculus work and support to successfully complete the work. (Treisman, 1992).

these very questions. During the program, students were acquainted with basic scientific procedures (observation, collection, and interpretation of data) as they learned Earth Science principles. They also had the opportunity to work with scientists and present the results of their research at a formal symposium. The program described herein is the first part of a two-year effort.

On a broader scale, this program was designed, 1) to set high academic standards, 2) to build upon existing academic skills and 3) to nurture a supportive relationship among the students. Studies of college students have shown that programs with these three qualities lead to academic success in math and science (Treisman, 1992; Asera and Treisman, 1995; Steele, 1992), (Figure 1).

STUDENT RECRUITMENT AND DEVELOPMENT OF TWO DIFFERENT SUMMER SESSIONS

The initial plan was to organize two separate two-week programs during the first summer. Each program would have about fifteen students and three teachers (two science and one history/language arts). The target audience was ninth graders, as these students were likely to have finished a year of earth or physical science and would also most likely be too young to be able to work at paying jobs. These students would be encouraged to continue to participate in the full two-year program.

Session 1 Recruitment - Recruitment of GHAMAS students was difficult. We recruited only nine students (six from GHAMAS, one from a parochial school and two from other non-Hartford Public Schools). This despite:

- Attending all six ninth and tenth grade classes and describing the program,
- Sending a brochure describing the program to science teachers and guidance counselors at school districts participating in GHAMAS,
- Sending a brochure describing the program to families at participating schools who had previously shown interest in enrichment programs,
- Attending and recruiting at parents meetings,
- Attending and recruiting at the "graduation" of students from the "Saturday Academy", a weekend math and science enrichment program for middle school students, and
- Expanding the grade range of students to those entering ninth through twelfth grades.

Of these, eight students enrolled. There were five female and three males. One of the male students, the only Caucasian in the program voluntarily left after the first week with no explanation.

Session Two Recruitment - During the development of the program we had forged relationships with two other

	July Session 1	August Session 2
Day 1	Introduction games Overview of program Preprogram assessment Connecticut geology Distrube maps Vist three places on Trout Brook and Park River to see rapid changes in physical environment Human history of Hartford and the CT River	Introductions Program overview - Projects - Maps Introduction to history of Park River Vist three places on Trout Brook and Park River to see rapid changes in physical environment Summary
Day 2	Water chemistry and measurements Topographic maps Introduction to Vermier probes - Temperature measurements - Time -temperature graph - pH measurements, 2-point calibration - ph measurements of different liquids Discuss papers and presentations	Water chemistry and measurements Brainstorming Introduction to Vermier probes - Temperature measurements - Time -temperature graph - pH measurements, 2-point calibration - ph measurements of different liquids Discuss papers and presentations
Day 3	River Flow - why and how Hockanum River Gaging Station, flow measurements, collect water samples USGS field van - sampling for water quality (bacteria, chemistry, flow)	Water chemistry, titration for dissolved O_2 Bushnell Park Mark Twain House
Day 4	Turbidity)what it is, how it's measured) Boats on CT River, Water sample collection, *in situ* Temperature, pH and flow - surface & depth at three stations at Charter Oak and Railroad Bridges	Split, 3 groups, rotate over next 3 days Group 1 - Trout Brook Group 2 - CT River on boat Group 3 - GHAMAS analyses, colometry (nitrate and phosphate)
Day 5	Introductions to spreadsheet methods (Hockanum River data) - entering data - entering formulas - graphing - simple statistics How to measure Nitrate (NO_3--) - measure NO_3-- on CT River samples	Introduction to spreadsheet method (water chemistry data) - entering data - entering formula - graphing - simple statistics Projects - online time
Weekend		
Day 6	Week one evaluation Measuring dissolved Oxygen Trout Brook and Beechland Park - measure dissolved Oxygen, Temperature and pH - collect samples for NO_3-- - measure flow and x-section profiles	Measurements at the Hockanum River
Day 7	Data collection	Analyses - Park River
Day 8	Boating all day - Bottom sampling - Transects of water samples and data	Groups boat and walking sampling
Day 9	Analyze Data/Prepare Presentations - Planning for fall and next summer - Evaluation	Analyze Data/Prepare Presentations - Planning for fall and next summer - Evaluation
Day 10	Analyze Data/ Prepare Presentations - 1:00 Presentations, Conclusions	Analyze Data/Prepare Presentations - 1:00 Presentations, Conclusions

Table 2. Two week schedule for each of the sessions. Session 1 schedule is on the left and Session 2 schedule is on the right.

community organizations, the Hartford Courant Foundation and Riverfront Recapture. Riverfront Recapture is an organization with a focus on the revitalization of the Connecticut River in the Hartford area. Its staff had organized summer programs for students in previous years. Through Riverfront Recapture, we met with administrators from the Hartford Public Schools. The result was a second program organized through Bulkeley High School, one of the Hartford Public Schools. These students came from a wide variety of academic backgrounds. This second program ran for six-weeks. Students in this program received one high school science credit and a stipend of $20/day. The first four weeks were organized by high school teachers with guidance from us and based out of Bulkeley High School. The last two weeks were based at GHAMAS and taught by us in conjunction with the high school teachers. Fifteen students (seven males and eight females) completed the program. Two male students who began the program were asked to leave for disciplinary reasons.

CURRICULUM

The program was designed with a classroom and field component, stressed working together as research teams (collaboration), and problem solving (Table 2). Educational studies (focusing on calculus) have shown that students who work together at problem solving and receive additional challenges are able to build a strong support system, developing self-confidence and skills that make them more likely to succeed (Treisman, 1992; Asera and Treisman, 1995). Our goal was to translate this mathematical education model to the Earth Sciences.

We focused on water quality testing to answer the questions, "Is the water safe for swimming?" and

Test	Units	Results from Station 5	Q-Value	Weighting factor	Subtotal
Temperature	°C	24.4			
Temp. Change	°C	0.3	90	0.11	9.9
pH	pH units	6.58	78	0.11	8.6
Turbidity	NTU	2	96	0.08	7.7
Dissolved Oxygen	% saturation	98	100	0.17	17.0
Dissolved Oxygen	mg/L	0.84			
Total Phosphate	mg/L PO4	1.66	52	0.10	5.2
Nitrates	mg/L NO3	yes	89	0.10	8.9
Fecal Coliform	20/100 mL yes or no	N.A.			
Fecal Coliform	CFU/100 mL	N.A		0.16	
Total Solids	mg/L	N.A.		0.07	
5-Day Biological Oxygen Demand	mg/L	N.A.		0.11	
WQI					**57.3**

Table 3. Calculated Water Quality Index (WQI) for measurements at Station 5 (USGS gaging station at Hockanunm River. The WQI value of 57 is out of a possible total of 67, indicating "Very Good Water Quality." WQI is from Mitchell et al., 2000. Q-values are determined by finding the measured value along the x-axis and reading the Q-value off of the y-axis.

"Where do fish live?" This allowed students to learn about Hartford's history and the importance of the river, use maps, collect and interpret data, and develop computer and writing skills. To measure water quality we used six of the nine basic water quality parameters that define the Water Quality Index (WQI). (Mitchell et al., 2000; River Watch Manual, 1995). This is a standard index developed in 1970 through the National Sanitation Foundation. With it, a unitless number (Q value) ranging from 1 to 100 is generated. A higher number is indicative of better water quality. The measurements we made were: temperature, pH, turbidity, dissolved oxygen, nitrate, and phosphate (Table 3). (This table and information about the WQI is also available at the NSF International website: http://www.nsf.org/consumer/earth_day/wqi.asp) Two additional measures, which we did not make, are total dissolved solids and biological oxygen demand. We also only used the presence or absence of coliform (20/100 mL) and did not culture and count bacteria. We limited ourselves to these six measurements so that students would become comfortable with the measurement procedures and have time to design a project, collect and interpret the data.

Using the WQI allowed us to show the students the different types of techniques for measuring water quality and why they are important. Each type of measurement was learned in the classroom and then carried out in the field. For each parameter we discussed why it was important and how it was measured. Since the WQI has weighting factors we were able to use this to show the students why one parameter, e.g., dissolved oxygen, is more important than another (e.g., turbidity) in defining water quality. In addition, students in the six-week program were also shown how to use benthic marcroinvertebrates to measure water quality (Beauchene, M., no date).

For many parameters, we were able to show that more than one method could be used to make the measurement and the use would depend upon accuracy, availability of equipment and funding. We began with temperature measurements using both thermometers and Vernier probes attached to TI-83 graphing calculators. This was used as an introduction to probe measurements and also allowed us to introduce the concept of rate of change. Students next learned how to measure pH, using both pH paper and Vernier probes. The probes needed to be calibrated before use, so students were introduced to two-point calibration procedures.

With these two parameters mastered and with maps in hand, students were taken to areas of the river to make measurements. We continued the procedure of learning in the classroom followed by field experience for the other parameters. Students learned how to measure dissolved oxygen (dO) using a prepackaged Hach azide kit, a modification of the Winkler Titration Method. Later we showed them how dO could also be measured by using an electric probe with a special permeable membrane. They were pleased when both measurements gave the same results. Nutrients (nitrate and phosphate) were measured with a simple colorimeter. We explained the chemistry behind the color changes for both colorimetric and titration techniques, well as the importance of the measurements. All data were stored in a master spreadsheet. The data were entered by us after double checking the values with the students.

Students were also shown how to measure river flow rates, generate a river cross-sectional profile and calculate the volume of flow. The place where these measurements were made is also a U.S. Geological Survey (USGS) gaging station so they could compare their values against the "official" measurements as well as each other. This provided an opportunity to discuss river measurements throughout the country and their importance, plus the importance of floodplains and wetlands.

In addition to the water measurements students were also taught how to record data, how to use a spreadsheet (inputting data, using formulas and graphing), how to use presentation software, and how to search for information in books and on the Web.

Students also kept daily journals of their activities, which were reviewed for spelling, grammar, and content. For their presentations, students separated into

Session	Presentation Titles
1	A Waterway to NO3-
1	Cross-River Flow Velocity Using Visual Analysis of Grain Size
1	Nitrate Progression in the River & the Tributaries
1	Comparison of Dissolved Oxygen & Phosphate in the Park River & Trout Brook
2	Fecal Coliform
2	Dissolved Oxygen
2	Nitrate
2	pH Water Quality
2	Temperature and Water Quality
2	Phosphates

Table 4. Final presentation titles for both sessions.

groups of one to three and each focused on a single parameter (Table 4). At the presentation, they were responsible for describing the significance of their parameter and the measurements that were collected. Family and friends were invited to the presentations and reception that followed. At the reception, students were awarded certificates and a river book to further encourage them to continue their scientific interests.

SAMPLE LOCATIONS

We chose sampling areas that were safely accessible a relatively short ride from campus and that would allow the students to see variations in the parameters they were measuring. Thus, all of the sampling areas had an urban component. On foot we sampled at three locations along the Trout Brook- Park River system and one location along the Hockanum River (Figure 2). These are both tributaries to the Connecticut River. We were also able to use a boat to sample several places in the Connecticut River. In the Connecticut River we collected water samples from both the surface and at depth and sampled near bridges and at the confluence of the Park River (Station 4, Figure 2). The bridge sites were sampled because they provided shelter from the hot sun and there are continuous monitoring probes on several of the bridges that would allow us to compare our data with those being continuously recorded. Unfortunately, the continuous bridge data were not available. A transect of sediment grab samples were also taken in the Connecticut River to show the bottom composition and how it varied across the river.

There were three sampling stations along the Trout Brook-Park River system (Figure 2). The first was a park, with both a tree-covered brook and an open treeless pond with many ducks. This was an ideal site to make measurements and show that the river water, despite some garbage and partially rip-rapped banks, could support life. We also compared measurements from the moving, tree-covered brook with those from the still, treeless pond (Station 1, Figure 2). Over a short distance (a few kilometers) from this park the river undergoes dramatic changes. It meanders through increasingly developed urban areas with shopping cart islands, then through a steep-walled culvert, and then goes underground, re-emerging through a giant tunnel into the Connecticut River. The second station contained considerably more garbage and shopping cart islands and the third station was where the river flows about 200 meters in a treeless cement culvert, before going into the tunnel (Figure 3). We also sampled the river as it flowed out of the tunnel and mixed with the Connecticut River.

Only one place was sampled along the Hockanum River. This was at the USGS gaging station. We had planned to sample the mouth of the river at the confluence of the Connecticut River, too, but it took too long to get there by boat. For session one students, we were able to schedule our trip to coincide with the USGS water-quality sampling. They sampled for dissolved oxygen (dO), temperature, coliform, and for trace metals samples. The first three analyses were done on site, while samples for metal analysis were sent to the USGS Denver facility. Students saw the elaborate measures that are taken to insure a well-mixed and uncontaminated sample and they had the opportunity to examine the geo-van where initial sample processing is conducted.

SELECTED STUDENT RESPONSES (FROM SUMMARY JOURNALS)

Written statements from student journals in the second program showed an increased interest in science and an enhanced sense of ability to do science. Students also expressed an increased awareness of environmental issues and the steps that could be taken to preserve the environment. Samples of statements from eight different students in Session 2 are given in Table 5.

ASSESSMENT - RESULTS SUMMATIVE INTERVIEWS

A summative survey consisting of an eleven-question interview for Session 1, and a fourteen-question interview for Session 2 was conducted by Joseph D. Ortiz on the second to last day of each program session. The survey for Session 2 included additional questions to assess the impact of the pre-program and the impact that payment and high school science credit had on the students' motivation within the course. Summaries of assessment responses from both groups are given in Table 6.

DISCUSSION

The "Connecting with the River" progrTam seems to have been very effective in stimulating interest in the river and developing scientific skills. The majority of the students involved with the program indicate that it was a positive experience. They developed a greater appreciation for science, the rivers in the Hartford area, and the issue of pollution and it how it relates to them. The vast majority of students indicate that they would like to continue to participate in the program during the following year, and all of the students would recommend the program to another student interested in science.

However, organizing this sort of program is not for the faint hearted. There were unexpected challenges from the beginning and they continue. Flexibility is crucial. Surprisingly, for the most part, meeting these challenges led to better outcomes than may have been achieved had we continued with out original plan. The challenge requiring the most change was the lack of GHAMAS students. We do not know why recruitment was so difficult. From the beginning, the director of

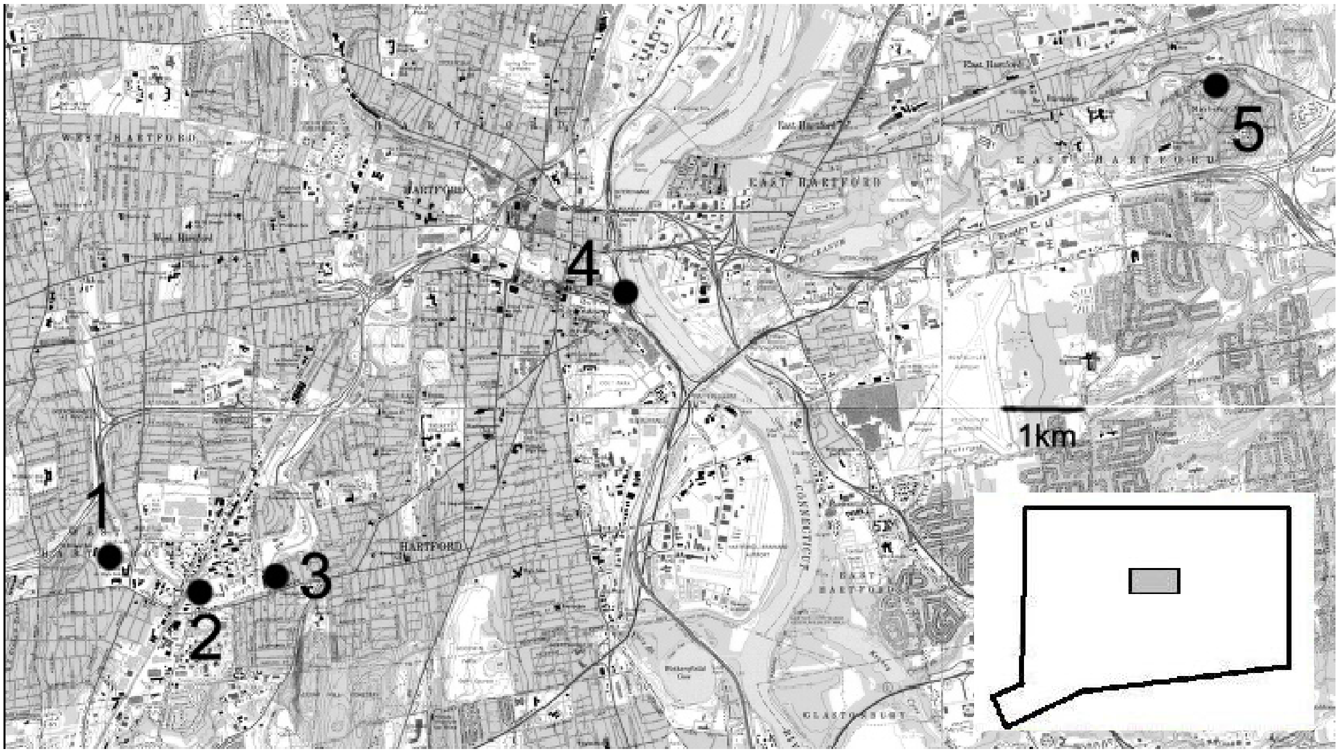

Figure 2. Map of sampling locations along the Park and Hockanunm Rivers. Station 4 is in the Connecticut River at mouth of the Park River. Base map USGS quadrangle maps for Hartford North, Hartford South, Manchester and Glastonbury. Insert shows location of study area within the state of Connecticut.

GHAMAS not was optimistic about recruitment of this age student. The one student who applied and did not enroll was unable to do so because she had to take care of a sister and a sister's new baby. Another family, whose daughter did enroll, did so even though the family had to reschedule their vacation plans.

As a group, the students in Session 1 had stronger science backgrounds. The four who came from GHAMAS had had two years of high school science and where attending GHAMAS because of their interest in pursuing science. They were also more familiar with an inquiry-based approach to learning and took the well-equipped GHAMAS facilities for granted. Their level of sophistication is suggested by both their more elaborate project titles (Table 4) and the quality of their responses to the evaluator's questions (Table 6). The students in Session 1 were better able to articulate what they had learned than the students in Session 2. Consider for example, that in response to Question 1, 71% of the Session 1 students linked the measurements they had conducted to the objective of testing water quality, while only 27% of the Session 2 students provide such a conceptual response. There was also a difference in parental involvement between the two groups. Five of the seven students in Session 1 had one or more parent attend the final presentations. In contrast, no Session 2 student had family members attend the final presentations.

Despite these differences it seems likely that the program had a bigger academic impact on the students of Session 2. This is probably because they were exposed to many new concepts for the first time, and because the program provided them with a type of academic opportunity to which they had never had access before.

Table 5. (Left) Selected student responses from summary jounrals during Session 2.

1. "…This was one of the best educational experiences I had so far…I think the overall success of this program would be pretty high, because many of us knew nothing about water testing procedures and now we can discuss things about it, which *is amazing*."
2. ". … Before this program I really didn't care as much as I do now about nature. This program made me think about it more. Before this program I didn't care, but after going to different sites such as the Park River, it made me think that we are destroying our own environment."
3. "… Completing the program did change everything I feel about rivers, ponds and lakes. I feel that this city needs to try to clean out these bodies of waters. If we do not start now we would not have fresh water to drink or to swim in. Water is very important to us but also to the animals on land and in water. We should stand up to our government to help clean up lakes, rivers and ponds."
4. "I also learned that you should not always judge the water by the way I looks. You have to test it first. "
5. "Well this program gives me a new perspective on how I see science. It helps me understand science better. I never knew what dissolved oxygen was until I came to this program. Now I am an expert on it!"
6. "I think the way people treat the different sites we visited was pitiful. I do not think we, as a community, should treat this beautiful land that has been provided for us like a garbage field. Before I was in this program I really didn't take notice of these water sites. Now I take notice and I want to help take better care of the environment."
7. "I enjoyed being a part of this program for many different reasons. The most important reason is that I learned so many new things about science that will help me to get a good grade when I take biology next year. For example, I never knew how to test water for nitrate. I actually had never heard of nitrate before this program, but now I can do these tests without even reading instructions. …. I hope that this program will continue next year and if it does, I would love to be part of it. I learned so much, that I would be able to help newcomers next year."
8. "What I learned about rivers, lakes, ponds and brooks were that they all have good things and bad things. All rivers have different features. For instance, ponds get a lot of movement so they do not get a lot of oxygen. I learned that streams move fast and pick up a lot of oxygen from the air. Also rivers have a lot of oxygen and fishes and other creatures."

Session 1 Responses	Session 2 Responses
1 Can you tell me what you did suring this program?	
All of the students who completed the program were able to list the types of measurements and describe the fieldwork that they conducted. Five of the seven students (71%) went on to note that these measurements were conducted to assess the water quality of the rivers that they studied. One of the students commented that the data they collected would help them to address hypotheses that they had formulated. Another noted that the data they collected was graphed so that they could try to understand the trends they plotted.	All of the fifteen students interviewed were able to list the types of measurements and describe some aspects of the fieldwork that they conducted during the program. Four of the fifteen students (27%) noted that these measurements were conducted to assess the water quality of the rivers that they studied. Two of the fifteen (13%) noted that they used computers, six (40%) mentioned their visit to the Project Oceanology research vessel, three (20%) commented on their crabbing and fishing trips during the pre-program and two of the fifteen (13%) noted that they had fun.
2. Was this what you expected from the program?	
Three of the seven students (43%) found that the program was what they had expected. Two noted specifically that they had studied local rivers in detail as promised. One of these three however, also commented that they had expected to learn more about animals. Three of the remaining students (43%) said that the program was not what they had expected. One thought the program was more fun than they had expected. Another expected to learn more about animals. The third had expected more chemistry and had hoped that the course would relate more to her intended career choice (forensic science). One student (14%) said that he had had no initial expectations regarding the program.	Six of the students (40%) felt that the program had provided what they had expected. One (7%) felt that it had provided "pretty much" what was expected (they had anticipated more classroom lecture experiences). Five of the fifteen (33%) felt that the program was different from their expectation. As with the single student previously mentioned, four had expected more lecture. Three of the five were surprised by the hands-on lab work, the complexity of the analysis and the ease with which they were able to learn the methods. Two of these five had expected the program to be boring and were pleased that it was in fact interesting. The remaining three students (20%) had no expectations.
3. Has your view of science changed?	
Students had diverse responses to this question and six answered with two responses, so the total number of comments exceeds seven. One student's response was neutral, six were positive. Two of seven students (29%) made each of the following statements: a) they now felt science was more fun than they did before participating in the program, b) they enjoyed the exciting, hands on nature of the program, c) they had a better understanding of pollution and water related issues, d) they had a better understanding of scientific concepts such as nutrient cycling, or how different variables were linked through processes such as decomposition, e) the program had helped them to sharpen their scientific curiosity (e.g. by encouraging them to ask questions), and f) the program made science more accessible, or helped them to develop more confidence in their scientific abilities. The student with a neutral response stated that he had not changed her interest or opinion, but added that her interest was high to begin with and that she remained excited about science.	Fourteen (93%) students commented that the program had left them with a significantly improved view of science. One student (7%) felt that his/her view of science was unchanged. None of the students expressed a negative view of science after completing the program.
4a. Will you take an science classes next year?	
One (14%) will take chemistry, two (28%) will take biology and four (57%) will take both biology and chemistry next year.	Eleven (73%) will take biology, three (20%) were unsure what science course they would take next year and one (7%) intended to take a sports medicine class.
4b. How do you think your experience here will have an impact on that course?	
The majority of students felt this course would have a positive impact on the science courses they would take in the future. This was particularly true of the students who planned to take chemistry. Four (57%) felt that having participated in this program would help them when they enrolled in chemistry. Three students (43%) felt that this program would give them a head start in their next science course. One felt that the program had boosted her scientific confidence. Another noted that the program was fun and that the one-on-one interactions during experiments were very positive. One of the two students who would take biology in the next year felt that this program would not help them much in their biology class that but that it would be helpful when they enrolled in chemistry.	Thirteen students (87%) felt that participating in the program would benefit them in their next science course. Nine of these students (60%) commented that they felt they would be able to draw directly on this experience to help with their next class. One of these students commented that they "will pay attention better because [they] will understand more". Four of the students (27%) felt that this course would give then a competitive advantage over their peers in their next science class. Two (13%) were unsure, but one cited potential positive impacts that the program might have.
5. What is the most surprising thing that you learned or did?	
Three of students were most surprised with pH measurements, but for different reasons. One was impressed with the instrument and measurement process, as she did not have access to a similar pH probe at her school. A second found the pH measurement methods initially complicated, and was surprised that she could master them. The third had expected worse water quality conditions (e.g. lower pH) than was observed. Of the remaining students, one student was surprised to learn how much the grain size of sediment within the rivers could vary with location. One student was surprised to learn of the Park River, which flows in part beneath Hartford as a channeled conduit. One student was surprised at the interactions between the variables that they studied and the processes that linked them. Several students were surprised with various aspects of the measurements they conducted. One was impressed with the complexity of the nitrogen measurements. Another was impressed with the turbidity measurements and the fact that samples could be collected from the river bottom.	This question elicited a wide variety of responses drawing from the activities during the session II and during the four-week pre-session program. Eight students (53%) were most surprised by some aspect of their time on the river. These responses included three who were most surprised by the Connecticut River, two who were most surprised by the Park River, two who were most surprised by the Hockanum River, and one who was most surprised by their visit to a river after heavy rains. Three of the students (20%) were most surprised by the instrumentation and lab work. Two (13%) were most surprised by what they learned about the quality of local waters. Other comments dealt with aspects of the pre-session program including Project Oceanology and marine life on the Long Island Sound (2 responses), the ropes challenge course (6 responses), and crabbing (1 response).

<table>
<tr><td colspan="2">6. What was the most interesting thing that you learned or did?</td></tr>
<tr><td>Students had varied responses to which aspect of the program was most interesting. Two students found the dissolved oxygen titrations most interesting (e.g. “Watching the color change from blue to clear was cool”). One student was most interested in seeing scientists such as the USGS staff and the instructors in action. One student found everything interesting but in particular the interconnections of the processes they studied. One student was most interested in learning about pollution. Another student was most interested in the depth soundings and grab sampling. The final student was intrigued with learning that temperature can vary within the river on a meter-by-meter basis.</td><td>Responses to this question were varied. As with the previous question, some of these responses were for activities from the four-week pre-course. Eight students (53%) were impressed with Project Oceanology and the water quality testing that they conducted. Three (20%) were most interested in everything or a lot of what they did. Other comments included catching aquatic insects, the Park River, the Ropes course, the Hockanum River at high water, dissecting a squid and fishing.</td></tr>
<tr><td colspan="2">7. What was the least interesting thing that you learned or did?</td></tr>
<tr><td>Two students (29%) eventually responded that they had no least interesting aspect of the course. Two other students (29%) felt that the lectures were sometimes long or repetitive, and commented that they preferred the hands-on experiences in the program. One student was not particularly interested in learning about temperature as she felt that she already understood this concept. One student was uninterested in the instrumental dissolved oxygen (DO) measurements, finding the DO titrations more interesting. The final student found most of the measurements other than nitrogen to be uninteresting (due to their simplicity when compared with the nitrogen measurement method).</td><td>Six students (40%) eventually responded that they had no least interesting aspect of the course. Four of the students (27%) did not find catching aquatic insects interesting, two (13%) did not find the water testing interesting, one did not find the journal writing interesting, and one did not like the food.</td></tr>
<tr><td colspan="2">8. Will you participate in this program next year? If so, why?</td></tr>
<tr><td>Only one student (14%) indicated that they would probably not participate again next year, as the program had not been particularly interesting to them. It is noteworthy that this response came from the individual who had expressed the least initial interest or expectation in the program as described on the response to question 2 of the survey. Five students (71%) indicated that they would like to participate in the program next year. One student would participate again if the program did not conflict with family vacation plans. All but two of the students commented on why they would like to participate again. Some students gave more than one reason. Two students felt the project was interesting. One commented that the program was fun, one felt that it would help with her schoolwork. Another felt that repeating the project would give her the opportunity to serve as a role model to students who were just starting the project in the first year. One student felt it would give here the opportunity to get more familiar with the river.</td><td>Nine students (60%) said yes, they would participate in the program next year. Three (20%) indicated that they would like to participate again next year, but were not sure that they would be selected (1 response), or thought that they would be out of town (2 responses). Three students (20%) indicated that they would probably not participate again due to work plans. The students provided a variety of reasons why they would like to participate in the next year. The most common was that the program provided them with an opportunity to improve their abilities or learn (7 responses, 47%). Three students commented positively regarding the science credit, while two commented positively on the program stipend. Three noted that the program was fun. One stated that they appreciated the opportunity. And one enjoyed the opportunity to work with water.</td></tr>
<tr><td colspan="2">9. Would you recommend this program to a friend (or another student)? If so, why?</td></tr>
<tr><td colspan="2">(NOTE: During Session 1, Question 9 was modified slightly. The intent was to determine if the course provided a sufficiently positive experience that participants would recommend it to their peers. However, the use of the phrase “to a friend” (as opposed to a classmate or another student) caused the students to consider the merits of the program vis-à-vis the interests of their specific social group of friends. This became apparent in the follow up response of “If so, why?”. Accordingly, the question was modified to retain its original intent as well as the student’s interpretation. The participant’s response to the question with respect to both peer groups was recorded (i.e. other students in general and the subset of students composed of their friends in particular). The revised question was used in the Session 2 interviews.</td></tr>
<tr><td>All of the students who were in the program would recommend participation to others. Two (29%) would recommend the project unconditionally. The remaining five students (71%) noted that the program was intensive and that they would recommend the project only to friends who were interested in science. Students commented that the program would help you to, “… learn about science, biology and the world around you.” Another noted that, “It would be interesting to kids that like to see stuff happen.” Others felt that the program would help with chemistry in the future.</td><td>Fourteen students (93%) would recommend participation to others. The remaining student (7%) said that he would probably recommend the program. None of the students said that they would not recommend the program. Interestingly, the students in the second session did not make any distinction between their friends or another student, as had been the case in the first session. The students provided a number of reasons regarding why they would recommend the program. Twelve students (80%) commented that it provided many new learning experiences. Four (27%) commented that the program was fun or interesting. Three (20%) commented favorably regarding the school credit, two (13%) regarding the stipend, two (13%) said it provided you with an opportunity to learn how a scientist works, and two (13%) felt that the program kept you busy. One student felt it provided students with the opportunity to be professional, and one commented that it provided an opportunity to make new friends.</td></tr>
<tr><td colspan="2">10/14. Do you have any other comments you would like to include? (Last question in both sessions. Session 2 had three additional questions comparing the first four and last two weeks.</td></tr>
<tr><td>The free response question generated diverse responses. One student commented that they were surprised to learn that a river flows under Hartford. Three students commented that they wanted more hands on experiments, more one-on-one interactions or more fieldwork. Two students wanted less lecture time. One student would like to see the program shifted to the fall to avoid the heat when in the field, but also commented that the facilities available for the program were great. One student wanted higher enrollment and another wished the program could have been longer.</td><td>Nine of the fifteen students (60%) choose not to respond to the free response question. Five students (33%) noted that they were glad to have participated. Three (20%) commented that they learned about water, the environment, science and not to pollute. Two commented that they met nice people and made friends. One wanted the program to be longer and another wanted an opportunity to camp.</td></tr>
</table>

The next three questions were only asked of Session 2 students.
10. Why did you enroll in this program?
Eight (53%) indicated the program was recommended to them by an administrator, a counselor, or a teacher. Three (20%) were attracted by the school credit, while one (7%) was attracted by the stipend. One learned of the program through their community center while a parent encouraged another. Three stated that they wanted to learn about science, animals, water or the environment, while one felt the program seemed interesting. Finally, one student commented that before this class they did not like science, but had learned a lot and met nice people.
11. Would you do this without pay?
Twelve students (80%) stated that they would have participated in the project without a stipend. Three (20%) stated that they probably would not have. Two of these students stated that they needed the money and would have to work without the stipend, thus they would only participate if the time were available.
12. Would you do this without getting school credit?
Eight students (53%) said that they would participate without school credit. One said that they would probably participate. Three students (20%) would not participate without school credit, and three were unsure.
13. How would you compare the first four weeks of the program with the last two?
Seven students (47%) commented that the first four weeks were different and that they spent more time outdoors. Six students (40%) felt that the first four weeks helped to prepare them for the last two weeks of the program. Six students felt the first four weeks were easier or less writing intensive. Three students (20%) felt the first four weeks were more difficult due to lack of experience and the new social situation. In contrast, one student enjoyed meeting new people in the first four weeks. Three students (20%) found the two programs "pretty much the same". One of these commented that they conducted the same types of water tests with kits in weeks one-four, but that they used instruments in weeks five and six.

Table 6. Qualitative assesement results for the two sessions. Questions 1-10 were given to both groups. Session 1 responses are in the left column and Session 2 responses are in the right column. Questions 11-14 were only given to Session 1 participants and responses extend for two columns.

This type of program may be important in involving at-risk students from underrepresented minority groups in the Earth Sciences. The problem then becomes one of continued academic support. Will it be possible, in more traditional classroom situations to provide the support that will allow these students to succeed academically and to pursue Earth Science careers?

SUMMARY/CONCLUSIONS

Positive Outcomes

1) On the basis of the assessments mentioned above, we met our primary goals of introducing these students to Earth Science in a positive and problem solving environment.
2) The existence of our proposed program and our willingness to partner with other Hartford Public Schools helped Bulkeley High School to receive the funding to run a high school summer course to which we contributed. It became our second program.
3) Teacher development. We found that at least two of the teachers who participated in the program, found it to be an enriching experience. One, a middle school English and history teacher developed a new appreciation for and understanding of science, and learned new computer skills which she will bring to her classrooms. The other was a new biology teacher. This program expanded her experience in and understanding of Earth Science in general and watershed science in particular.
4) Community support, especially that provided by Riverfront Recapture, proved to be invaluable in our ability to run the program.

RECOMMENDATIONS FOR SIMILAR PROGRAMS

1) Focus on one or two community organizations and schools for partnering.
2) Small student groups and direct student contact are important to the success of the program.
3) Get help with logistics – parents, partner schools, and funds to hire people to transport students, purchase supplies and food.
4) Keep expectations and plans reasonable.
5) Program stability. For a program like this to grow, we think it is necessary to continue it over several summers so that word-of-mouth from student "alums" can help with successful recruitment of future students.

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