Association Report: $2YC_3$

edited by
Ann Cartwright
San Jacinto College, Central Campus
Division of Science & Mathematics
Pasadena, TX 77501-2007

Using Technology to Create a Scientific Learning Community

by Ray Turner

Roxbury Community College (RCC) is an urban, multicultural, two-year college in Boston with a large population of African-American and Hispanic students. Most of the entering students fail to meet minimal levels on standardized math and science tests.[1] These tests were developed for the state of Massachusetts and the state set the minimal standards. Figure 1 shows that in 1999, a representative year, students from five Boston high schools[2] specifically served by RCC performed at a lower level than students from the entire state and all students from all Boston Public Schools (BPS).

RCC has been involved in science and math education reform for more than ten years, in part because these standardized test results for incoming students indicate a lack of proficiency in science and math. The reform has taken two major approaches. The first was the introduction of a course in general science; the second was the introduction of undergraduate research.

Nontraditional General Science Course

The general science course that was developed uses a nontraditional format aimed at improving the skills of entry-level students. This led two RCC faculty to write a textbook for that course, which outlines and illustrates this nontraditional format (*1*).

Another influence on the general science course will be RCC's recent funding to become a Technology Hub that will eventually link more than 30 community technology centers and public schools.[3] The Technology Hub was made possible with support from the Timothy Smith Trust Fund from the city of Boston.[4] It will fund the purchase of hardware, software, and furniture for the 30 sites and the Hub and will upgrade all sites every third year until the year 2019. At the end of 2019, the remaining endowment will be divided among the sites. The funding presents an unprecedented opportunity for RCC not only to be the Hub for this project but also to become the principal provider of educational resources and to be able to create innovative learning communities for the neighborhood. The first use of this funding in the general science course will be for the development of interactive CD-ROM material to accompany the previously developed text (*1*).

Undergraduate Research

The second approach for RCC is introducing undergraduate research to upper-level students. Two new courses were developed and have become a part of the standard curriculum: Research Techniques in Science I & II. When these courses started, there were partnerships with Tufts University and MIT for transfer-degree-seeking students to conduct research in the biomedical sciences. Increasing numbers of students from RCC began pursuing science-related careers, but few were chemistry majors. Although there are more than 100 students in the general chemistry courses each semester,

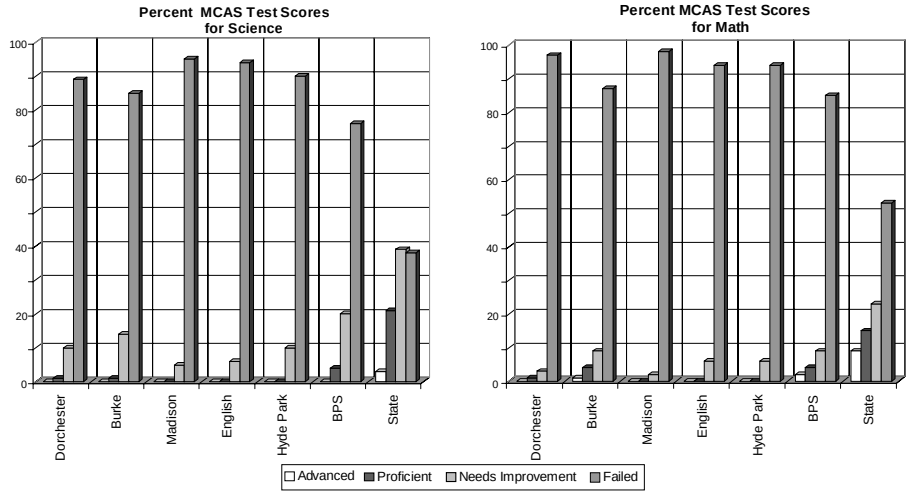

Figure 1. Students from Boston Public Schools (BPS) and from the state as a whole perform better on the Massachusetts standardized tests in science and mathematics than do the students from the five Boston schools specifically served by Roxbury Community College. Graphs were calculated from data of the Massachusetts Comprehensive Assessment System at *http://www.doe.mass.edu/mcas/results.html*.

Sample Experiment: Electrical Stimulation as a Means to Enhance the Uptake of Lead in Plant Roots

The high level of heavy metal contamination in the soil of many inner-city neighborhoods makes the challenge of finding a technological solution to the removal of the contamination especially appealing to nontraditional students from those areas. Many students are attracted by the possibility of harnessing science to serve their communities.

Plants are relatively inexpensive, and it has been shown that they can be used to recover heavy metals found in low concentration from various contaminated sites. This ability of plants to remediate or remove toxic materials from soil is called phytoremediation. Our experiment investigates applying alternating current to soil–soil solutions to see if it increases uptake of lead or other metals into corn, and comparing these data with data gathered from applying direct current.

Students who participated in the initial studies worked at the MIT Materials Chemistry Laboratory and at the Roxbury Community College greenhouse (Fig. 2). The experiment was run at a constant rms current of 7 mA at 25 °C, and the growing seedlings received normal daylight with approximately five hours of direct sunlight per day. There was no attempt to regulate or quantify the amount of light in this preliminary experiment. EDTA was added to half of the samples at a level of 1 g/kg dry soil and the Pb^{2+} concentration in soil was 1.5 g/kg soil. XRF measurements were made on plants parts (root, shoots, and stems) only after they were dried in an oven for approximately 36 hours at 95 °C until completely dehydrated. The dried plant parts were weighed, pulverized, and made into pellets. The pellets were used for XRF measurements. Plant parts were harvested and prepared for measurement with X-ray fluorescence after several days of passing either ac or dc through them. The students used an XRF spectrometer to obtain data. Changes were found in biomass and uptake of lead and copper as a function of current type. See Table 1 for preliminary results.

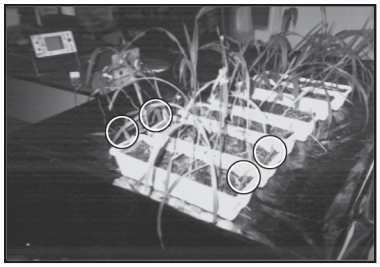

Figure 2. The corn plants in this photograph have matured from seedlings and are ready for harvesting. The clips are attached to electrodes (circled) embedded in the soil. Steel electrodes obtained from a neighborhood junkyard were used. The dc supply seen in the background provided the steady current source.

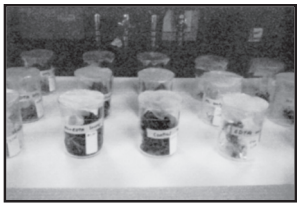

Figure 3. Harvested plant roots, shoots, and leaves.

Table 1. Preliminary Results, Phytoremediation Experiments

Conditions	Concentration/(μg/g) dry weight of plant material	
	Pb	Cu
Control, no current		
$Pb(NO_3)_2$ only	82	262
$Pb(NO_3)_2$ + EDTA	303	150
Alternating current		
ac without EDTA	48	33
ac with EDTA	565	98
Direct current		
dc without EDTA	74	45
dc with EDTA	60	1265

Preliminary results from experiments performed at Roxbury Community College, with results measured at MIT using an X-ray fluorescence spectrophotometer. All the samples were tested in a soil–soil solution containing $Pb(NO_3)_2$. The plants were separated into roots, leaves, and shoots.

few continue in chemistry. The basic problem appears to be the students' perception of chemistry as irrelevant. In an attempt to attract more students to chemistry, particularly minority students, the college is now using low-cost "culturally relevant" undergraduate research projects in chemistry. See Table 1. Since the college is the Technology Hub, it will be possible to have a powerful multimedia component. Part of our plan is to use the resources made available through multi-institutional collaboration to create "virtual laboratory bench spaces" at many of the sites.

The virtual lab bench will allow multiple levels of participation by RCE students (depending on their grade level and abilities) and faculty. The coupling of scientifically sound research projects with multimedia technology will give students the advantage of hands-on experience while participating in a learning community with extended resources. The exploration will use a "What's in my backyard?" approach. One example is to use plants grown in soil with possible lead contamination. Here the effects of alternating current (ac) and direct current (dc) on lead uptake into plants was studied.[5] In the near future, participants from linked sites will be able to function as members of an expanded research group and share electronic data and experiences, advantages that are traditionally reserved for very exclusive research groups. Everyone in the learning community will be able to contribute to the results.

These two approaches, a general science course for the under-prepared entering students accompanied by relevant undergraduate research for upper-level students, just might be the "magic bullets" needed to increase participation and inspire students to continue and earn undergraduate degrees in chemistry.[6]

Representative Research Projects Performed by Roxbury Community College Students at MIT or Tufts University

Development of a Novel Solid State Battery

Environmentally Safe Procedure for Human Tissue Regeneration

Mapping the Housatonic River: A Toxic Waste Site

Locating and Eliminating Toxic Waste Sites

Biodegradable Polymers for Drug Release Technology

Computer Program for Toxic Waste Analysis

Notes

1. The tests used are the *Massachusetts Comprehensive Assessment System* (MCAS), which are the only standard tests recognized by the Commonwealth of Massachusetts. By the year 2003, students who do not pass these exams will not graduate from the Boston Public Schools.

2. The five Boston high schools are Dorchester, Burke, Madison, English, and Hyde Park.

3. The Hub will be the principal provider of educational resources and will create innovative learning centers. The Hub will develop a Virtual Scientific Learning Community. It will also address the low test scores of local high school students in science and math and provide K–12 outreach programs. K–12 students will be a part of the proposed Virtual Scientific Learning Community.

4. The Timothy Smith Trust Fund was set up more than a hundred years ago by a Roxbury merchant to be used after his death for the benefit of the citizens of Roxbury. Since the fund has accumulated so much interest, the city decided to use the monies for technology.

5. A search of the literature found that only dc had been used previously for this type of study. In the preliminary experiments ac and dc were used simultaneously to see if ac or dc would give higher uptake of lead into plants. The root mean square value of the alternating current was always made to equal the rms value of the direct current.

6. The National Institutes of Health has recently funded the Advanced Training Opportunities for Minorities in Science (A.T.O.M.S.) at RCC. This ensures that students will be able to participate in culturally relevant research such as phytoremediation.

Literature Cited

1. Turner, R.; Russakovsky, V. *Developing Concepts in Science Throughout the 21*st *Century*; Kendall/Hunt: Dubuque, IA, 2000.
2. Sadoway, D. R.; Amini, A. *Industry Collegium Rep.* **2000**, *17* (2), 8; Massachusetts Institute of Technology Materials Processing Center: Boston, MA.

Ray Turner is the Executive Dean of Information Technologies at Roxbury Community College, 1234 Columbus Avenue, Boston, MA 02120; commander@alum.poly.edu*. He is also a Visiting Scholar in the Department of Environmental Health and Occupational Safety at Harvard School of Public Health, Boston, MA.*