Innovation by Example

In a fun, hands-on way, the Whiting School leads the vital effort to engage young students in exploring engineering.

THE CHALLENGES OF THE 21ST CENTURY—developing alternative energy sources, promoting sustainable development, managing threats to the environment, defeating human diseases, to name a few—will be solved by innovators, inventors, and creators. In short, it is the future generations of engineers and scientists who will lead the way.

Many experts predict, however, that the United States' ability to meet these challenges will be crippled in the next 10 to 20 years by a shortage of workers skilled in science, technology, engineering, and mathematics (STEM). "The United States has already begun to experience an alarming rise in the outsourcing of STEM jobs to foreign firms," observes Leigh Abts, deputy director of the Whiting School of Engineering's Center for Educational Outreach (CEO).

While Abts and other educators at the Whiting School—and across the country—have been concerned about this for years, the issue took on national prominence in January when President George W. Bush recognized in his State of the Union speech that America's economic future depends on investment in science and technology research and education.

Although President Bush's goal to increase Advanced Placement offerings in high school science is admirable, educators at the Whiting School are convinced that to affect real change, the interest of even younger students must be cultivated—and quickly. With this objective in mind, the CEO in July launched the first phase of Engineering Innovation. This bold and original three-course sequential program, geared to students in middle school through high school, will be implemented in Maryland, Washington, D.C., and California this year, and in states across the country in the summer of 2007.

Working with faculty accredited by the Whiting School, more than 80 Maryland high school juniors and seniors participating in Engineering Innovation will complete "What is Engineering?," a four-week course. Much more than lectures, it will feature virtual and hands-on laboratories, oral presentations, and testing structures the students have built. The fun course captures some of the amazing ways engineering touches daily life. It's an introduction "to the entire field of engineering from the usual disciplines like structural and chemical, to the daily activities of an engineer," says Abts. In teams of 18 to 22, students will explore the analytic tools and techniques and the basics of the engineering process. They'll get to actually build a better mousetrap, experiment with chemical processes, and construct a bridge using spaghetti and epoxy. Students who earn an "A" or "B" will receive three college credits transferable to Hopkins.

The "What Is Engineering?" course will be offered in three locations in the Baltimore-Washington area, including on the Homewood campus. In California, the University of California's Mathematics, Engineering Science Achievement (MESA) program will offer it to about 110 students in July, taught by faculty trained at Hopkins. Locations include California State universities in Fullerton, Long Beach, and the Channel Islands, as well as the University of California Santa Barbara and the University of the Pacific.

In the summer of 2007, the curriculum will be expanded to include "The Way Things Work" for rising eighth graders and "Evolution of Technology" for rising ninth and tenth graders. Educators in Texas and Pennsylvania have already expressed interest in offering the three courses.

The curriculum emphasizes creativity and innovation. The "What is Engineering?" course is based on an earlier one developed by Michael Karweit, a research professor in the Whiting School's Department of Chemical and Biomolecular Engineering.

"While many educators are studying the shortage of young people studying science, technology, engineering, and mathematics, Johns Hopkins is actually doing something about it," says Marc Donohue, associate dean for research at the Whiting School and director of the CEO. The program "has the potential to increase dramatically the number of young scholars studying technical disciplines in the next decade," he adds. "We've had a terrific response and are confident that Engineering Innovation can create a nationwide pipeline of innovative and creative thinkers who will lead us through the century."

Local corporations and government grants are helping to underwrite Engineering Innovation and provide scholarships for students who could not otherwise attend.

— Abby Lattes

For more information about Engineering Innovation or to sponsor a student, visit engineering-innovation.jhu.edu.

Sophisticated Science in a Schoolyard

Grad student Sam Small deploys a remote sensing project at Poly to give high school students in-depth experience with environmental monitoring.

"GET STUDENTS INVOLVED in novel science, math, and technology experiences in the K-12 classroom, and they'll be interested in studying engineering when they go to college," explains Sam Small, a third-year PhD student in the Whiting School of Engineering's Department of Computer Science. "Give them the chance to conduct research and understand its real-world applications, and they'll be engaged and will want to do more." That's exactly his plan for students at Poly (Baltimore Polytechnic Institute).

WILL KIRK

At Baltimore Polytechnic Institute, Sam Small (right) launches a network of 20 wireless environmental sensors to be used by students. On the left is their A.P. Environmental Science teacher, Robert Marinelli.

When Small was a high school student in northern Virginia, he knew he wanted to study computer science in college. "I took an A.P. [Advanced Placement] computer science class and interned at technology companies while in high school," he explains. At The College of William & Mary, he never questioned what his major would be—until the second semester of his senior year, when he took a biology class to fulfill a science requirement. "Until then, I never realized science and technology could be so closely related," he says. "I think if I'd discovered that earlier, there's a good chance I might not have majored in computer science—or I would have combined it with a science degree."

This spring, through participating in BIGSTEP (Broader Impact for Graduate Students Transferring Engineering Principles), Small is combining his desire to share his interests—including the connections between computer science and biology—with his research. He is exploring wireless sensor networks with his adviser, Andreas Terzis, assistant professor of Computer Science. BIGSTEP, an initiative to reach K-12 students, is part of the Whiting School's Center for Educational Outreach and is funded by the National Science Foundation. (See "One Giant Step Reaches Out to Schools" in the Fall 2005 *Johns Hopkins Engineer*.)

A Spring Planting of Sensors

On the grounds of Poly, a public high school known for its science and engineering curriculum, Small in March installed a network of 20 wireless environmental sensors. Students in Poly's A.P. Environmental Science class helped deploy the sensors and will use them for research.

Poly's wireless sensor system is similar to a network that Small, Terzis, and faculty from two Krieger School of Arts and Sciences departments (the Morton K. Blaustein Department of Earth and Planetary Sciences and the Henry A. Rowland Department of Physics and Astronomy) have deployed in the woods near the Homewood campus. "We've developed a network to monitor soil properties—moisture and temperature—using custom electronic components and software we've designed," Small explains. "The data is collected automatically and is available to us on the web."

Potential applications for this type of sensor are numerous, according to Small. They include structural monitoring that could provide an early warning system in unstable environments or environmental monitoring in numerous locations.

Analysis That Drives Inquiry

Traditionally, schoolyard ecology might involve a group of students monitoring soil temperature at one site, once a week, Small explains. The project at Poly, however, is unique in the sophistication of the tools the students are using and the depth of data they are gathering. The wireless sensors provide far more data—gathered from multiple locations and at multiple times. The data then are made available for analysis on the Internet through graphic simulations created by graduate students at California State University, Los Angeles.

This research opportunity, according to Small, provides high school students with far more than information about the ambient light levels, soil water pressure, and soil temperature in north Baltimore. "The project motivates science-based inquiry," Small says. "When we're dealing with data gathered at a finer granularity, it forces students to ask more questions and think about more nuanced topics than are usually introduced at the high school level—how to collect data, calibration, what is a 'good' measurement and what is not, and where bias might enter the picture. Analyzing the data provides real-world calculus problems for students to solve, bringing greater relevance and meaningful issues into their curriculum."

Robert Marinelli, who teaches the A.P. class and heads Poly's Science and Engineering Department, agrees. "This project gives kids the rare opportunity to do hard environmental science," he explains. "Environmental science is usually observational at the high school level, but we're generating real, quantifiable data." Even more important, Marinelli states, is that, "Because of the way Sam has structured the class, asking the students what they want to study and giving them a say in the investigation, the kids are gaining experience as practicing scientists and they have real ownership of the project."

Small's work at Poly represents the first phase of a project that will eventually include California State University, Los Angeles; Tufts University; and Native American schools in Minnesota. This summer, Small will travel to Minnesota to help set up additional wireless sensor networks for high school students.

The remote sensing project, Small believes, could also help students better understand the connections between technology and science and could provide them with a broader range of options from which to choose when they begin college. "I think it can demonstrate to science students that there may be a place for them in technology," he explains. "My hope is that the experience opens new doors for them."

— Abby Lattes

For project updates, visit the Poly Deployment blog at hinrg.cs.jhu.edu/poly/