# A School Where STEM Is King

Members of the robotics team at Baltimore Polytechnic Institute work on a robot they are entering in a competition. Team captain Lauren LoGrande ducks as teacher Ron Hoge reaches for a drill.

—Stephanie Kuykendal for Education Week

## A selective, specialized high school in Baltimore uses an interdisciplinary approach that enables students to experience STEM as a way of life.

**By** Andrew Trotter



*Baltimore*

A visit to **Baltimore Polytechnic Institute** creates a strong impression: This is a place for doers.

Teachers and students at Poly, as it is known here, seem to gather up knowledge and information because they have a use for it. A student is doing background research for her two-year project with local scientists on cannibalism among blue crabs. A group of teenagers searches the Web for a design concept to improve a robot they are entering in a contest. And an aeronautics class discusses the afternoon's weather forecast—as measured from the roof of the school—as a factor in flying several radio-controlled model helicopters.

That focus on applied information is a clue to the bigger purpose at this public school on the northern end of the Baltimore school district: To be a caldron for the blending disciplines known as STEM—science, technology, engineering, and mathematics.



STEM "is blending practice with theory," says Barney J. Wilson, the energetic leader of the school. "Folks talk about STEM as if it were in a box, but it's a way of thinking and living. To really understand it, you have to live it."

For the past two decades, the high school—which for more than a century was organized around manual arts and, later, vocational technology—has remolded itself around STEM.

Robert Marinelli, who arrived 14 years ago and is now the head of Poly's science department, helped convert hand-drafting studios and wood, sheet-metal, hot-metal, and machine shops into computer and design labs, an aviation lab, and other modern learning spaces.

Just as important, he and other teachers developed courses that addressed the T and the E in the STEM acronym, starting with a yearlong course on the fundamentals of engineering that every Poly freshman must pass through.

Today, with STEM education on the lips of national and business leaders and a growing cadre of educators, the 1,350-student school finds itself in a position of leadership.

**Admissions Criteria**

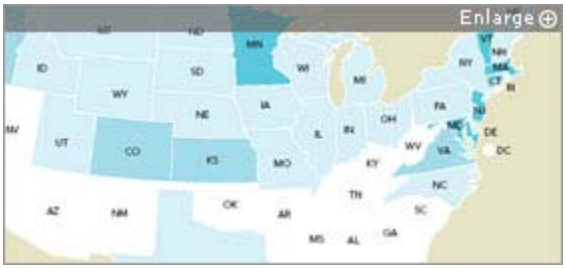
Poly is one of a handful of selective public high schools in Baltimore, with admission based on criteria favoring students with good grades and recommendations by their middle school teachers and counselors.

"We look for students who have shown aptitude in math and a love for science; also, students who are serious about school" as reflected in good attendance in middle school, Wilson says.

The school has plenty of choices of students. For the 2007-08 school year, 1,800 students from across the city applied for 430 freshman spots.

## Scoring High in Science and Math

Nationwide, just 6.6 percent of 8th graders scored at the advanced level on the 2007 National Assessment of Educational Progress in math. Massachusetts led the pack with 14.9 percent of its 8th graders scoring advanced. In science, an average of only 2.9 percent of 8th graders scored at the advanced level nationally on the 2005 NAEP. Massachusetts again ranked No.1, with 5.8 percent of its 8th graders scoring at the advanced level.




SOURCE: EPE Research Center, 2008

The current enrollment is 78 percent African-American and evenly split between boys and girls. Nearly all its students are aiming for higher education, Wilson says proudly.

He says the school's three secrets to success are a great faculty, a history of success, and great students.

But Poly has other assets to draw upon, such as the fervent loyalty of its large pool of alumni: The school's database has 20,000 individuals, including members of the city's business, higher education, and government establishment. They provide crucial contacts and give money that supplements the formula funding that the 82,000-student Baltimore district provides each of its high schools.

And some graduates have come home to Poly to teach, bringing lessons from the broader world of industry and academia.

**STEM at Poly**

Wilson, himself a Poly grad, earned undergraduate degrees in electrical engineering, economics, and math at Carnegie Mellon University before completing a master's degree in industrial administration and a doctorate in urban educational leadership.

From Carnegie Mellon, Wilson brought a belief in an interdisciplinary approach to creativity and problem-solving that the university calls the "Da Vinci effect." It means that students should have an education that is interdisciplinary, that uses both sides of the brain, that includes a deep understanding of art "almost to the point of being connoisseurs," and that gives them leadership roles, Wilson says.

The school advertises the concept well. A portrait of Leonardo da Vinci, the quintessential Renaissance man, gazes down from a wall in the school's media lab.

Students arriving at the sprawling school as freshmen quickly learn what STEM stands for, and the four letters are splashed across a couple of huge bulletin boards in the corridors.

Other banners trumpet the school's latest scores on the Maryland high school science assessment—a 93.4 percent passing rate on the biology assessment: "Let's be the first to 100 percent," it urges—and publicize the Siemens Competition in Math, Science, & Technology and the Intel Science Talent Search, two of the most prominent national contests in the STEM disciplines.

## Program Aims to Build 'Ingenuity'

It can be a tall order for many schools to help students excel in stem subjects. But the Baltimore district has gotten a hand from a foundation-led initiative aimed at doing just that.

The $1 million-per-year **Ingenuity Project**, begun in 1992 and led by the locally based Abell Foundation, supports about 500 selected students in grades 6-12 at two middle schools and a high school. Goals include succeeding on Advanced Placement tests and excelling in elite national competitions in mathematics, science, engineering, technology, and related fields.

Students apply to take part in middle school; all must reapply for 9th grade. Students are grouped together for science and math, but are blended into regular classes for other subjects.

At Baltimore Polytechnic Institute, a stem-focused high school that draws students from across the city, Ingenuity students in grades 9-12 take part in independent research projects in science lasting two or three school years, including work in the summers.

"They can dig into something, learning things not in a textbook but on the cutting edge," says Dolores Costello, the executive director of the Ingenuity Project.

David Nelson, the research director at Poly, whose position is funded by the project, helps students find their research topics and a Baltimore-area scientists to mentor them at an outside facility.

"We try to give students as much autonomy and responsibility to make their own decision to define their own interests," Nelson says. "It is valuable for the student to go through that process."

**—Andrew Trotter**

Glass-covered bulletin boards also recount the triumphs of the school's "Research Superstars"—three top-10 national finishers in the Intel contest over the past three school years—just a few steps from a display of interscholastic sports trophies.

The school's commitment to STEM is also built into the curriculum, starting with a course required for all 9th graders, called Foundations of Technology (Fundamentals of Engineering). The course gets students to consider technology as more than iPods or flat-screen TVs; they study the history of technology and explore its relationship to engineering, as well as to science and math.

"Technology is the application, or the fulfillment, of engineering," explains Michael J. Scott, one of the teachers of the course. "Engineering is the application of math and science and technical principles."

Scott, who goes by "Mick," teaches concepts, practice, and application in nine core areas of technology—such as electrical, electronic, structural, and fluid—or as many areas as he can get to before the year runs out.

His spacious classroom is in a former sheet-metal shop, with the conversion still incomplete, where students work on plywood sheets laid across old metal cabinets—but with airy, high ceilings, natural lighting, and an old maple floor.

The nine personal computers at one end of the room are more than 8 years old, which requires that they use an old edition of AutoCAD design software; Scott plans to install an Internet connection in the classroom this summer so his students can conveniently use the Web for research rather than having to schedule time in one of the school's computer labs.

But the classroom also has a cluster of band saws and drill presses so students can learn to make working models of technological designs. Scott shows off one model his students designed and constructed—a dialysis machine, made of plywood, plastic tubing, and an assortment of plastic bags. "I was shocked at how well it worked," in separating yellow and red from orange dye, Scott says.

One change of pace that 9th graders enjoy during the technology and engineering course is a two-week stint in Poly's aeronautics lab. Tucked away in a corner of the

school is a collection of 14 flight simulators—desktop computers equipped with authentic flight-steering harnesses, foot pedals, and simulation software.

The lab also has a life-size mock-up of the nose assembly of an aircraft and real runway signs donated by a local airport. It is equipped for model rocketry, radio-controlled model planes and helicopters, and access to real-time meteorological data from the weather station on the school roof.

Though the 9th graders get only a taste of the science of flying, students in Poly's Air Force Junior ROTC program take a full-year flying course, covering the ground training needed to qualify for a pilot's license, says the teacher, Air Force Maj. Roger Gauert.

**Getting on Track**

Poly gives students chances to explore a wide range of subjects in grades 9 and 10, but by junior year they must select one of two tracks: science or engineering. From that point, the program is highly scripted.

The science track, however, includes the option of a research "practicum," an opportunity to conduct research for up to two years under the mentorship of a professional scientist in the area; students often enter their research projects in high school contests that can give them an edge, and possibly scholarship money, when they apply to colleges.

Both tracks, however, aim to mold students to think scientifically, to put things in perspective, and to solve problems—and to be more than ready for postsecondary studies, Wilson says.

"Our students have a good shot at making a 4.0 in their first year of college," he boasts.

The science track is "pretty much nose to the grindstone," says Lissa R. Rotundo, a science teacher, who teaches courses in genetics and Advanced Placement biology.

Her classroom, a bright, spacious hall next door to Mick Scott's, is another former machine shop that was fully renovated a few years ago with a state grant. It has

distinct zones for lecture, reference books, laboratory activities, and Web research on new-looking iMac computers.

But Rotundo, who has taught at Poly for 23 years and wears a beaded necklace shaped like a double-helix strand of DNA, also directs a forensic-science class for 12th graders—an elective class that gives hardworking seniors a respite by requiring no outside homework. But the class is firmly grounded in the STEM philosophy, Rotundo notes, because it pulls together so many disciplines.

“They come in here and say ‘Oh, you really can use that,’ ” she says of student’s reaction. “They take the course because they think it’s ‘CSI,’ ” Rotundo says, referring to the popular television drama on crime-scene investigation. But as they learn and practice chromatography, fiber analysis, hair analysis, blood-spatter analysis, and DNA fingerprinting, their knowledge and techniques from chemistry and genetics come into play.

The evident success of Poly, an elite school with talented students, raises the issue of whether “cream skimming,” especially in an urban environment, benefits the school district and Baltimore’s student population as a whole.

To that question, Marinelli, the science department head, responds that if the resources and students assembled at Poly and the other specialty schools were dispersed among all the city’s high schools, some families would vote with their feet and move to suburban Baltimore County or enroll their children in private schools if they could afford it.

“We’d lose something really valuable, and we’d never get it back,” he says.

Of Poly students who are juniors this year, 100 percent have passed state’s high school science exam, either their first time or after a dose of remediation, according to school officials.

**Real-World Experiences**

It is important to Marinelli that people realize that Poly students have authentic experiences in science. “They are active scientists, not science students,” he declares, of the science practicum. “People think they’re washing glassware.”

Yet another technology teacher at Poly, Fred Nastvogel, an architect by training, says today's students are less well equipped to handle the real-world, physical aspects of their studies, compared with students a couple of decades ago.

"Many youngsters don't do chores anymore; they don't learn to repair or build things with their hands. Kids have never had the experience of grabbing stuff and making something happen," Nastvogel says. The lack of such experiences, he adds, limits their understanding of how "things go round and round in the universe" and concepts such as how nanoparticles work.

Essential to what he calls the "primitive STEM experience" that high schools should offer, he says, is giving students plenty of experience working with modeling and materials.

Poly is in the midst of planning an engineering-research practicum that will resemble the science-research practicum, Marinelli says. It would provide coursework in advanced engineering for 11th and 12th graders, plus field experiences with professional engineers.

Such a program would likely spur more student projects in engineering, such as an invention by Poly senior Michelle Jones that is meant to help prevent drivers from falling asleep at the wheel. She has designed a dashboard-mounted video camera that monitors a driver's eyes and triggers an alarm if the blink-rate slows or speeds up significantly.

Innovation, of course, is meant to be one of the main fruits of a rich STEM curriculum, yet that term is not well understood, and often confused with invention, teachers at Poly say.

"Bill Gates invented, but that is a rarity," Marinelli says of the Microsoft co-founder, who developed the world's most widely used computer operating software and office software suite. "Certainly, I'm telling students that most of the technology you are going to use in your lifetime has already been invented. You are going to make it better—you are efficiency experts."

Whatever the label given to the product of focused creativity in STEM, school leaders say Poly students are so well prepared that their success after school is virtually

assured. “I could grab any three students here and start a business—and in 10 years we’d be a Fortune 500,” Director Wilson says.