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REVIEW

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Three students in Donna Irons physics class build motor-powered boats based on their research and designs.

NJEA and NJCTL opening up STEM careers in Camden

A firm belief that economically disadvantaged and underserved minority students should have equal access to careers in science, technology, engineering and mathematics (STEM) drives much of the work of the New Jersey Center for Teaching and Learning (NJCTL). NJEA created NJCTL under the leadership of NJEA President Joyce Powell in 2007. The Association remains a major sponsor of the organization.

Almost all STEM majors in higher education require students to study physics, chemistry and calculus. Students who have studied those subjects in high school have a distinct advantage in college, in the workplace and as educated members of their communities.

"The problem is that too few students enter higher education with a strong pre-school to 12th-grade STEM background, and those least likely to have that background are African-American, Hispanic and economically disadvantaged students," says Dr. Robert Goodman, NJCTL's executive director.

Goodman knows something about both teaching science and working in STEM-related occupations outside the classroom. Prior to his career as a physics teacher at Bergen County Technical High School, he spent the first 22 years of his professional life designing equipment and running several companies, including Harmon Kardon, JBL Consumer Products and Onkyo International Operations.

A major barrier for students in districts such as Camden, Trenton and Newark is lack of adequate resources. For students in Camden, that meant few teachers qualified to teach physics, chemistry and biology. It also meant a lack of materials to carry out experiments.

As a former art teacher, Nancy Holmes, an NJEA UniServ field rep in Camden, knows the value of hands-on experience for true learning.

"Tell me and I forget. Teach me and I remember. Involve me and I learn," Holmes said, recalling the adage. "Despite everything NJEA and NJCTL were doing to enroll Camden students in physics classes—including providing physics teachers—the lack of lab materials put Camden students at a serious disadvantage."

With help from her colleagues in the Region 4 UniServ office—and with a $35,000 contribution from NJEA—Holmes gathered and packaged supplies to create laboratory materials for up to 15 classes. The labs included all the materials necessary for students in Camden's public schools to become fully engaged in the city's new physics curriculum.

Physics for all

This year, Camden public schools instituted a new way to teach science that is promoted by NJCTL and NJEA. In this program, the traditional sequence of biology, chemistry and physics is reversed, with physics taught first in the ninth grade.

The program was initiated by Goodman in 1999 when he was a physics teacher at Bergen County Technical High School. It eventually became the school's pre-engineering science program and was available for all students, including general and special education students at Bergen Tech. By 2012, this school ranked first in New Jersey for the percentage of students taking and passing AP Physics B.

"The challenge in 1999 was to launch a new high school pre-engineering program with 16 students whose middle school experiences did not prepare them for such a technical major," Goodman said. "Because of our enrollees' limited algebra and physics skills, we chose to augment 40 minutes of engineering study with 40 minutes of algebra, and 40 minutes of algebra-based physics."

This then-unique physics course was designed:

- To be mathematically rigorous, using only algebra so that all the students could succeed.
- To provide motivation for learning algebra by showing its usefulness to students.
- To be the foundation for a logical flow of science from physics to chemistry and then on to molecular biology.
- To lead to AP science exams so that program graduates would have external validation of what they learned and in order to increase the likelihood that students from a new vocational high school would be accepted to high-quality colleges and universities.
- To use pedagogy that would provide a welcoming introduction

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to science and math to all students, since most of the program participants lacked prior success in traditional mathematics and science classes.

This physics course, which would become known as the Progress Science Initiative's (PSI) Algebra-Based Physics, needed to be welcoming to all students while providing access to highly rigorous mathematics and science.

To accomplish that, teachers at Bergen Tech sliced the AP Physics B curriculum in a way that was not traditional. Rather than splitting the content into two years by topic, they divided it by the level of mathematics. Since more than 80 percent of AP Physics B just requires algebra, and since most eighth and ninth grade students are working to master algebra, Bergen Tech did not use trigonometry in the first physics course.

The next step was to choose topics based on their value in preparing students for chemistry and biology, and to provide a coherent progression of learning. These included mechanics; electricity and magnetism; simple harmonic motion and waves; and quantum and nuclear physics. In that way, the course prepares students for chemistry and biology courses over the next two years, as well as the elective PSI Trigonometry-based Physics (AP Physics B).

Ninth-grader Sydney demonstrates her motor-powered boat to the class of sixth graders.

By the end of that second physics course, students have mastered exactly the same AP Physics B content that they would have if they had been required to use trigonometry in both physics courses, but by saving the use of trigonometry for the advanced elective course, the path has been opened to all students.

The pedagogical blend was as unique as the course content. It intertwined direct instruction with social constructivism. The design was geared to succeed with a wide range of students who could support one another as they sat at round tables solving problems and discussing mathematics and science.

The details of how this was accomplished are explained in "Squaring the Circle" (*http://njc.tl/wc*), in "PSI-PMI: A New Educational Paradigm" (*http://njc.tl/we*), and in Goodman's doctoral dissertation (*http://njc.tl/wd*).

Trenton leads *the way in adoption of PSI-PMI*

The Trenton Education Association (TEA) and Trenton school district administration set the pace in the 2014-15 school year when they implemented Progressive Science Initiative (PSI) and Progressive Math Initiative (PMI). The program quickly garnered national attention when TEA, district administration, and a Trenton physics teacher were invited to present an overview of their partnership to implement PSI-PMI in Trenton at the National Education Association Leadership Summit in Anaheim, Calif.

TEA president Naomi Lafleur, then-Trenton Chief Academic Officer Dr. Kendra Johnson and physics teacher Nicole Hamlet described the challenges and positive impact their partnership is having on Trenton students.

During that first year, the district enrolled 17 teachers in NJCTL's physics endorsement program, changed the science sequence to physics-chemistry-biology, and scheduled incoming freshman to take physics during the 2014-15 school year. In addition, TEA secured an NEA grant for NJCTL to do in-class training with teachers. TEA also used grant funds to support training of all math and science middle school teachers in PSI-PMI.

TEA was critical to assuring a long-term commitment to the program. This year, with the support of the interim Superintendent Lucy Feria and STEM supervisor Mike Tofte, the school district is funding five teachers to participate in NJCTL's chemistry endorsement program, making it possible for sophomores to take chemistry this year.

"Anything goes after graduation," Chavarria said. "Any career they want to aim for, I try to encourage them, and our whole staff here is like that. A lot of these kids have it rough, so we try to get them away from the streets and encourage them to do whatever they can academically to be successful in life."

Increasing the number of physics teachers in Camden

This year Camden, with NJEA and NJCTL support, is following in Trenton's footsteps.

Thirteen Camden educators, some who were already teaching science and some who came from other assignments in the district, are now teaching physics in the city's public schools. Some of them are working toward an endorsement to teach physics while others are already certified.

The PSI physics teacher endorsement program is for current teachers in any subject area seeking to add a physics endorsement to their basic certification. The program includes more than 300 hours of instruction by certified physics teachers. Each cohort of teachers meets one night a week and every third Saturday to learn algebra-based physics, advanced physics and physics pedagogy. NJCTL visits teachers in their classrooms to support them as they teach physics for the first time.

NJCTL is the number one producer of new physics teachers in the United States.

Two of those teachers are Chris Chavarria, who teaches in the Camelot program at Camden High School, and Donna Irons, who teaches at the Creative Arts Morgan Village Academy, a district-run magnet school serving students in grades 7 to 12.

Chavarria had been a biology teacher.

"Our principal asked me last year if I wanted to become a physics teacher," Chavarria recalled. "She said there was a shortage of physics and chemistry teachers in the Camden school district and that they were sending any teacher back to school for free. Free school? I was all on board with it."

Chavarria's first courses focused on how to teach algebra-based physics. He is now in the second part of the program, which prepares educators for the trigonometry-based program.

In addition to the lab materials supplied through NJEA, Chavarria makes connections everywhere he can for his students.

After having taken a course at Chestnut Hill Academy in Philadelphia, he worked with the head of the science department to acquire supply donations. The physics certification courses for the Camden teachers are hosted at Gateway Regional High School in Woodbury Heights, where Chavarria has developed an exchange with physics teacher Brian Dericks who shares lab materials and other resources with him for his students.

"At Gateway High School, Brian's class skyped with NASA and he said next time they link up with NASA he's going to link them up with us in Camden," Chavarria said.

Chavarria believes that NJCTL's PMI and PSI program will prepare his students for whatever testing regimen the state creates, but he has bigger dreams for them.

"Anything goes after graduation," he said. "Any career they want to aim for, I try to encourage them, and our whole staff here is like that. A lot of these kids have it rough, so we try to get them away from the streets and encourage them to do whatever they can academically to

Ninth-graders Teseanna (r) and Alexiara demonstrate the electrostatic spinning tower.

Camden science teacher Chris Chavarria, who works in the district's Camelot program, builds a strong rapport with his students as he implements the NJCTL algebra-based physics program.

be successful in life. And this new curriculum will give them some shots towards science too."

Like many participants in the NJCTL program, Irons' path to the classroom was not direct. Her undergraduate degree was in nursing, a program she completed while raising a family.

"However, I think I was always meant to be a teacher," Irons said. "One of the things I love about teaching here is that I feel can relate to what my students are going through. I know what it feels like to be close, but not close enough. I know what it is like to have a yearning for physics, but lack the acumen to apply it. With the support of PSI, I can teach toward true mastery."

Irons explained that prior to receiving the NJEA-funded physics lab materials she did "a lot of kitchen science" that did not provide the depth of accuracy needed to demonstrate key concepts.

"Because the products are specifically designed for the learning objectives, it gives the students a more accurate picture," Irons explained. "The 'kitchen science' depended on how much time I had to cut-and-paste things together."

The homemade and dollar-store materials, Irons said, didn't yield the accurate measurements her students can record now that they have the right tools.

"When my students set up experiments to measure speed with the dollar store stopwatches, for example, they all got the same imprecise result: two meters per second," she said. "The materials we now have from NJEA will really make a difference in what we can do and in what we will learn."

NJCTL Executive Director Dr. Robert Goodman contributed to this article. He can be reached at bob@njctl.org.

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NJCTL works closely with the teachers in Camden's public schools who are implementing its science courses. In addition to coursework, the teachers attend NJCTL professional development programs, including this one at the NJEA UniServ Region 4 office in Camden.