Putting Physics First

An MU faculty member wins a national award for improving high school science education as she seeks to increase the pool of students pursuing STEM-related careers.

Story by Dale Smith * Photo by Nicholas Benner

† Meera Chandrasekhar instructs education majors at MU on how to teach science.

It is by definition a rare thing to win what some call the nation's most prestigious collegiate teaching honor, Baylor University's Robert Foster Cherry Award for Great Teaching. The award comes with a $250,000 prize. MU's Meera Chandrasekhar has all the qualifications one expects of a distinguished professor whose career teaching physics spans three decades. She earned a doctoral degree from a top university (Brown). She built a strong research program and published more than 100 papers to which other academic researchers refer frequently. Private-sector engineers use her findings to design semiconductors and superconductors. She has won Mizzou's top teaching honors, as well as other national honors.

"What struck me about her is that she has this calming effect," says Mike Thompson who leads the Cherry selection committee. "There are some personality types that fear physics and math, and her calming personality says, 'It's OK, this will not hurt you.' " Thing is, this sort of career and charisma are pretty much required of nominees making it to the short list, Thompson says.

What put Chandrasekhar over the top? Thompson says it's her Physics First program, whose Missouri-wide reach is changing when and how high schools teach sciences. Her approach — requiring a hands-on physics course in ninth grade, before biology and chemistry — is designed to give students a better chance of succeeding in college courses as well as careers that involve science, technology, engineering and mathematics, or STEM. Building a 21st-century economy requires these skill sets, and many STEM-related jobs pay well.

But from Chandrasekhar's point of view, the award clincher has its roots in parenthood. Her initial step toward Physics First came in 1992, though she didn't know it at the time. "I was going about my business teaching and doing my research. I had three daughters. The oldest, Tara, was in fifth grade, and the twins, Indu and Rajni, were about to enter kindergarten. So, I was trying to do science with them at home, and one day I saw a request for proposals from the National Science Foundation. The idea was to get girls interested in science. I thought, this sounds like some-

thing nice that one could do."

Chandrasekhar won the grant and worked with Columbia Public Schools to develop Exploring Physics. It was an after-school program of hands-on activities for students in grades five and six, especially girls, who often lose interest in science around middle school. Over the next few years, Chandrasekhar developed Families Exploring Science and Technology, in which students in grades six and seven built a drawbridge with their parents; Saturday Science, where students in grades eight and nine visited local industrial sites and participated in activities; and Newton Academy, a 10-day residential science and technology program for female students in grades nine to 11.

"I also soon realized that it was not possible for us at the university to conduct programs in K-12 schools with the intensity we needed. We needed a multiplier factor — the public school teachers." So, she started teacher-training programs to extend her reach beyond the university's walls. Roughly 200 teachers attended workshops from 1993 to 2004.

The most recent of the teacher-training programs is A Time for Physics First, which launched in 2006. The aim: Help students make their way into STEM professions. The challenge: Nationwide, only 36 percent of high school students take physics, though many more take chemistry (70 percent) and biology (98 percent). But in college that might not be enough. For instance, aspiring engineers and physicians must take two physics courses, and MU enrolls 1,000 students in such courses every semester. These are some of the hardest courses the students will take because the courses move quickly through material, are math-intensive, and require not only four or five hours a week in lab and lecture but also lots of study time.

"If you are part of that 64 percent who never had physics, it's a killer," Chandrasekhar says. "It's almost like 64 percent of the kids are putting themselves at a disadvantage for getting into any STEM program. But if they've had physics in high school, they have a much better idea of what they are in for. They know the logic and have some idea of concepts. Research shows that if ninth-graders do well in a physics course like the one we developed, they are better prepared to take not just physics but also chemistry and biology."

But that ninth-grade course cannot be "a lecture from your book," Chandrasekhar says. "It needs to be experiential. We found that the ninth-grade teachers needed a well laid out curriculum, so we ended up writing the curriculum with a modeling-based pedagogy and based on activities I'd done for earlier programs." The two Physics First professional development programs (2006–08 and 2009–14) have allowed 124 teachers from 53 Missouri districts to complete their training.

† Chandrasekhar leads an after-school Exploring Physics program in 1993 for elementary-age girls.

1993 PHOTO: PUBLICATIONS FILE PHOTO

Kory Kaufman, BS FW '83, M Ed '87, a physics teacher at Rock Bridge High School in Columbia, was an early convert to Physics First. He became a student again as he attended three-week summer sessions for three years beginning in 2006. Instructors taught the new curriculum to Kaufman and his colleagues just as they would later teach it in their own classrooms.

Physics First teachers begin by asking students what they know, Kaufman says. "There are a lot of misconceptions in physics. For example, a lot of people — and I was one of them — believe that gravity affects all objects the same. But in order for heavier objects to fall at the same rate as lighter objects, the force of gravity has to be different."

Depending on the misconceptions and the topic at hand, teachers assign experiments. "We used to give students an equation and tell them, 'Go use this.' " Kaufman says. "But now, a lot of what we do is problem-solving. Students develop ideas and then discover answers for themselves. There's a lot of experimentation. Students buy into it. They feel more engaged, more ownership, like they have done something to gain their knowledge. As teachers, we guide them through the discovery.

Nationwide, only 36 percent of high school students take physics, though many more take chemistry (70 percent) and biology (98 percent).

Kaufman says other high school teachers noticed the difference right away. "They tell us that kids coming to their classes are much better at solving problems." He says teachers of those classes adapted their curriculum to build more quickly on the Physics First foundation.

The first group of students trained this way entered college in fall 2013, so no data exist to document a payoff at the college level. But it's already clear that the program's reach is long, Chandrasekhar says. In 2013, the most recent year for which data are available, about 84,000 ninth-graders took physics nationwide. Missouri students accounted for about 13,000 of them, of whom more than 10,000 were students in districts enrolled in MU's Physics First project. **M**