

Jane Jackson's talk at the Teacher Training session: 2019 AAPT Summer Meeting in Provo, UT:

Why are you and I a physics teacher? Because we love the physical world. We enhance that love by *understanding* the physical world. Understanding requires *thinking* – thinking scientifically, based on evidence. We want to share our understanding with young people, and the best way to do that is to help them learn to *think*, as we have learned to think. That's what we do in Modeling Instruction. **The Arizona State University (ASU) Department of Physics is the birthplace of this world-renowned program in research-validated physics teaching.** It was founded 30 years ago, by ASU physics professor David Hestenes and high school teacher Malcolm Wells.

Modeling Instruction emphasizes critical and creative thinking, problem-solving, teamwork, data analysis using computers, verbal and written communication, listening skills, and self-reliance. Our national partner is the American Modeling Teachers Association (AMTA). Modeling Instruction is super-compatible with the Investigative Science Learning Environment (ISLE) and its high school component, PUM, both developed by Prof. Eugenia Etkina at Rutgers.

The ASU Modeling Instruction program holds six to eight graduate courses in physics and chemistry each summer, for 60 Arizona teachers in high school and community college, and a dozen from out-of-state. Most teachers serve low- to moderate-income students. They prepare tens of thousands of students each year for the 21st century workplace. In fall and spring semester, we have 3 Modeling Workshops that are methods of teaching physics, chemistry, and physical science courses, taken mostly by undergraduates. Since 2/3 of Arizona residents live within commuting distance of ASU, all courses are face-to-face - that is much better than online.

Modeling Workshops improve all teachers' effectiveness in STEM. Some teachers re-train (often for non-credit) to become physics or chemistry teachers, some earn graduate credits to teach dual enrollment physics or chemistry, 84 have earned a Master of Natural Science degree. Degree-seeking teachers in 15 western states get in-state tuition, a considerable saving!

Modeling Instruction corrects weaknesses of the traditional lecture-demonstration method, including fragmentation of knowledge, student passivity, and persistence of naive beliefs about the physical world. It is successful with students who do not typically do well in physics, and it improves learning of all students. Experienced modelers report increased enrollments, parental satisfaction, and enhanced achievement in college courses, across the curriculum!

THE NEED: Only 20% of Greater Phoenix high school students take physics, compared with 40% nationwide – and Arizona has only 160 certified physics teachers left who are teaching physics. Some 20% of Arizona public high schools dropped physics after the Great Recession of 2008. **Yet physics is the chief STEM pathway** to compete in the 21st century workplace, as it includes more math, technology, and engineering than any other high school course. Arizona's economic health depends on a strong K-12 education that includes robust physics courses. And the world needs thinkers. Our work is crucial.

EVIDENCE OF SUCCESS: Modeling Instruction is designated by the U.S. Department of Education as an Exemplary K-12 Science and a Promising K-12 Technology program. It received the 2014 *Excellence in Physics Education Award* of the American Physical Society. Change the Equation, a coalition of Fortune 500 companies, designated the ASU Modeling Instruction and Master of Natural Science (MNS) degree programs as *Accomplished STEM Programs*.

Modeling Instruction promotes scientific literacy. It is harmonious with new Arizona science standards, similar to the Next Generation Science Standards (NGSS). A recent nationwide survey of 700 teachers showed that "on average, high school teachers who have completed 90 hours of professional development in Modeling Instruction (a 3-week summer workshop) feel significantly more motivated and better prepared for NGSS than high school teachers who are non-Modelers." Physics professor Helen Quinn of Stanford University was chairman of the National Research Council (NRC) committee that wrote the book *A Framework for K-12 Science Education*, the research basis for NGSS. She told David Hestenes later that what was said about modeling in that book was informed by Modeling Instruction.

We rely on local corporate donations, since the demise of the Federal Title II-A 2.5% set-aside higher education grant program. We need \$80,000/year, but we get \$50,000. It is hard.

* Program support: We hire 6 to 9 expert teachers to instruct graduate Modeling Workshops. This gives them a meaningful summer job. We buy instructional materials for courses. (Long-distance teachers need \$1500 for dorm, travel, and meals, but we lack enough funds for that.)

* We give partial tuition scholarships. ASU summer tuition is \$2000 for three graduate credits.

Teacher salaries are so low that ASU tuition is unaffordable, but teachers need graduate credit to get a small raise (typically \$75/graduate credit). The 2017 Arizona Senate Bill SB1038 and 2019 SB1051, "High Quality Teacher Professional Development Pilot Program", provide \$2000 scholarships for a few dozen teachers to seek an additional certificate or credential in physics or chemistry. Many teachers need 3 to 6 times this amount for tuition in 3 summers, e.g., to earn 18 graduate credits in physics to qualify to teach dual enrollment physics.

BENEFITS: Teacher effectiveness is the chief determinant of student achievement. That is our focus! Our chief long-term measurable outcomes are improved student understanding of concepts. These outcomes are established in numerous research studies. Also, teachers report improved achievement on ACT science and AP physics tests, higher enrollment in advanced high school science electives, and more STEM majors in college.

Teachers write that Modeling Instruction "saved their career". Teachers laud our program: "ASU's summer program is a national treasure!" "This Modeling Workshop was one of the most helpful classes I have ever taken." "Modeling allows my students to be better thinkers and gives them opportunity to understand science in a way that keeps their interest."

ASU is committed to social and cultural embeddedness. Arizona communities are ultimate recipients of our program, because physics is the foundation of all sciences, engineering and technology -- so Arizona's economic health requires strong high school physics. In short, as the only program of its type in the state, **ASU Modeling Instruction contributes crucially to Arizona's economic and cultural health by strengthening the K-16 education continuum.**

Jane Jackson, Ph.D., Co-Director, Modeling Instruction Program. (jane.jackson@asu.edu)

URLs: <http://modeling.asu.edu> , <https://physics.asu.edu/content/modeling-instruction-program> ,
<https://physics.asu.edu/degrees/graduate/master-of-natural-science>