

Modeling Instruction Program _____ Founder: Prof. David Hestenes

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MEMO

To: colleagues interested in K-12 science and mathematics education
From: Jane Jackson
Subject: annual report on Modeling Workshops at ASU and nationwide

In October 2013, we were informed that High School Modeling Instruction will be recognized with the 2014 *Excellence in Physics Education Award* of the American Physical Society (APS). The APS is the largest professional organization of physicists worldwide. The Award includes \$5,000. It will be presented to David Hestenes, Jane Jackson, and Colleen Megowan at the APS April 2014 meeting in Savannah, Georgia at a Ceremonial session. Colleen Megowan is Executive Officer of the American Modeling Teachers Association. Information will be at <http://www.aps.org/units/fed/awards/education.cfm>.

I first report on Arizona, and then I summarize our activities nationwide and cumulatively.

Activities at Arizona State University in summer 2013:

In summer 2013, ~50 Arizona science and math teachers and ~20 out-of-state teachers participated in our four Modeling Workshops and two other graduate courses. Included were four physics and chemistry teachers sent by the Ministry of Education in Singapore. This brings their total to 31 teachers in seven years. Singapore students have the highest math and science scores in international tests; that is strong evidence for the high quality of Modeling Instruction.

Our courses are for lifelong learning for teachers of high school physics, chemistry, physical science and math, and grade eight science and math. They can lead to a Master of Natural Science (MNS) degree. Since inception in 2001, ~65 teachers have earned this degree. Physics professor Robert Culbertson has directed the MNS program since 2005.

Courses are content-intensive; and integration of physics, chemistry, and math is emphasized. The ultimate target is not the teachers themselves but their students. Therefore each course addresses the subject at a level that prepares them to entice and inform their students.

Modeling Workshops are peer-led. Modeling Instruction is designated by the U.S. Department of Education as an *Exemplary* K-12 science program.

We are thankful for these donors, who made our summer 2013 program possible. **For the third year in a row, the Boeing Company** contributed \$30,000 for wages of peer co-leaders/interns, instructional materials, and partial tuition scholarships for 15 teachers taking 17 courses. For the

fifth time, the **Salt River Project** contributed \$10,000, which provided partial tuition scholarships for 8 teachers who took 10 courses. (Our teachers' salaries are typically around \$36,000, and they can't afford to pay much of the ASU resident tuition of ~\$1750 for one course.) **Freepoint McMoRan, Inc.** donated \$8000 for tuition, room and board, stipend and classroom supplies for two long-distance rural Arizona teachers. The **Ronald and Ling Cheng Foundation** contributed full-tuition and half-tuition scholarships for 11 non-Arizona physics teachers who commit to leadership, thus enabling Modeling Instruction to spread nationwide.

Until 2011, we were funded for \$225,000 per year for ESEA (nicknamed No Child Left Behind) "Improving Teacher Quality" grants administered by the Arizona Board of Regents. In the impending Federal ESEA reauthorization, it appears that no funding will be provided for discipline-specific professional development for high school science teachers. This is contrary to the U.S. goal to maintain its global competitiveness, and we find it very troubling. Details are at <http://modeling.asu.edu/modeling/ConvincingDocuments.html>.

The need:

A critical need exists for content-centered professional development in the physical sciences. About three-fourths of Arizona's 280 physics teachers *don't* have a degree in physics or physics education. Half of the chemistry teachers don't have a degree in chemistry. The vast majority of 9th grade physical science teachers are out-of-field; their most prevalent degree is biology.

The shortage of qualified physics teachers is dire and worsening, due chiefly to Arizona's recent requirement of three years of high school science courses and to a Federal grant to open many new charter high schools that have rigorous curricula. Coupled with physics teacher turnover, this resulted in 60 physics job openings in fall 2011. Teachers are smart and committed, but these 60 teachers need summer professional development in content with effective teaching strategies.

For example, a Phoenix math teacher who was asked by his principal to teach physics wrote, "I'm just trying to do my best until we can find a "real" physics teacher. It seems that they are very hard to come by." Teachers from overseas (most often from Asia) are hired to teach chemistry, physics, and math in high-poverty schools that have many English language learners (especially in isolated rural schools). Although these teachers are dedicated, a language barrier exists in some cases, and stability is lacking because their visa is good for only three years.

ASU does not graduate nearly enough teachers of physics, chemistry, and physical science to satisfy the demand. Even with Noyce scholarship opportunities, few undergraduate students choose science teaching. A PhysTEC grant to the ASU Department of Physics in 2012 is slowly increasing the number of undergraduate pre-service teachers, but professional development of physics teachers already in the classroom is crucial for fast improvement of student learning.

About Modeling Instruction:

Modeling Instruction is an innovative, effective pedagogy: it is guided inquiry structured by modeling principles. It develops in students the ability to analyze data, reach a conclusion and defend it; and it emphasizes experiment design. Other 21st century skills developed include scientific use of computers and probeware, teamwork, and verbal and written communication

skills. Students become self-directed, independent learners. It is aligned with the NRC *Framework for K-12 Science Education* and the Next Generation Science Standards (NGSS).

Student achievement on tests of concept understanding is typically *double* that of traditional instruction. A modeler wrote, "One can only imagine the future of science if only we all could understand the power of modeling."

Since 1995, ~870 Arizona teachers have taken one or more 15-day Modeling Workshops. Estimating one-third retirement/relocation/advancement and 160 students per teacher, ~90,000 Arizona students each year are benefiting.

Modeling Instruction is used in most high schools in metropolitan Phoenix, notably Bioscience High School, Arizona School for the Arts, Tempe Preparatory Academy, some Great Hearts Academies, Pinnacle High School in Paradise Valley USD, Hamilton High School in Chandler USD, Red Mountain High School in Mesa USD, and Xavier Preparatory High School.

Information about our summer courses is at <http://modeling.asu.edu/MNS/MNS.html>.

Our ASU courses for teachers in summer 2013 (most are three graduate credits):

Modeling Workshop in mechanics (2 sections)

Modeling Workshop in circuit electricity

Modeling Workshops in chemistry (first and second semester)

Energy and the Environment

Matter and Light

Leadership workshop (1 credit)

The nationwide Modeling Instruction program, as of 2013:

This grassroots, teacher-led program has grown tremendously. The first two nationwide Leadership Modeling Workshops in physics were held in 1995 at ASU and the University of Illinois at Chicago. Due to teacher demand, the program expanded at ASU to physical science in 2000 and to chemistry in 2005. The first 2-week biology Modeling Workshop was held in 2010 at Shady Side Academy in Pittsburgh, Pennsylvania.

In 2013 the *American Modeling Teachers Association* (AMTA) assumed oversight of nationwide Modeling Workshops. The AMTA is a grassroots professional society focused on **effective** teaching. AMTA membership is ~1450, and the AMTA listserv has 2000 subscribers.

The number of Modeling Workshops doubled in the past five years. In summer 2013, 48 Modeling Workshops averaging 15 days were held, with ~800 participants. Five-day introductions served another 130 teachers. Sites are listed at the AMTA website: <http://modelinginstruction.org/workshops> .

Since 1995, about 5200 different high school teachers and 800 different middle school teachers have taken at least one of 440 Modeling Workshops of median duration 15 days. This includes ~3050 U.S. high school physics teachers, i.e., about 10% of the nation's 27,000 physics teachers.

Modeling Workshops have been held in 32 states and American Samoa. Workshops have been organized by science faculty at 58 universities and colleges and 30 schools/school districts, including the U.S. Department of Defense Education Agency.

The Ministry of Education in Singapore has sent 34 teachers. Four Australian teacher-leaders have participated, and teachers in Finland, Canada, Jordan, Qatar, Chile, Brazil, Mexico, and Ghana.

Modeling Instruction is taught to pre-service high school science teachers at Arizona State University, Florida International University, Brigham Young University, Illinois State University, Buffalo State College, and the University of Wisconsin at Oshkosh.

If you would like to contribute to the success of Modeling Instruction, please e-mail Jane.Jackson@asu.edu and/or Colleen Megowan (amtaexec@realstem.com).

Typical teacher comments:

"Thanks to taking physics modeling course work, I am highly qualified in physics."

"I learned a tremendous amount and am all fired up to teach physics this fall!"

"I learned more about teaching and physics this summer than in 5 years of college!"

"Great chem workshop."

"I LOVE this program!"

"It was, without a doubt, the single greatest professional development experience of my career."

A metropolitan Phoenix teacher in a high-poverty school wrote in 2008:

"I make about 38k a year. I have a degree in chemical engineering -- I should be making at least double that. This almost kept me out of teaching. But some things are more important than money.

I'm reaching the end of my fourth year teaching science and my second teaching physics. In those last two years, I've doubled the population of students registering for the general physics class at my school. I've poured enormous effort into improving the program. The reason I've been able to do this is because of what I've learned through the modeling program at ASU, both in terms of knowledge and superior teaching practices. It is by far the best science methodology out there. Unlike traditional science classroom practices, the modeling program stresses the PROCESS of science. Students not only learn the requisite science curriculum but how to design and implement experiments that will address a question, how to work well in a community of peers, how to collect and process data, how to think logically and critically - basically, how to be effective problem solvers. Not only do these skills serve to help knowledge retention and increase general interest in science but these are skills that transcend the science classroom."

MORE CUMULATIVE NATIONAL STATISTICS as of fall 2013:

* 975 teachers have taken a chemistry Modeling Workshop since the first one in 2005.

- * 1480 teachers have taken a physical science with math Modeling Workshop since the first one in 2000. (Not all are different teachers; some took two 3-week Modeling Workshops.)
- * 1400 teachers have taken a 2nd semester physics Modeling Workshop. (Some took multiple workshops: in macroscopic models of electricity, microscopic models of e&m, light, waves.)

(Participant numbers are rounded. Not counted above are 5-day summer introductions to Modeling Instruction. At least 780 teachers have participated in them.)

Content-focused modeling listservs, for year-round professional development & support:

- * physics has 3100 subscribers
- * chemistry has 1500 subscribers
- * physical science has 675 subscribers.
- * biology has 630 subscribers.
- * 9th grade physics (camod) has 550 subscribers.