

HOW & WHY TO INCREASE HIGH SCHOOL PHYSICS IN MARICOPA COUNTY **By Jane Jackson, with help from Earl Barrett and Larry Dukerich (AZ-AAPT 9-2015)**

In Zachary Kovach's talk today, he downplayed the role of physics content. Yet his students have high learning gains, as measured by the Force Concept Inventory. He implements Modeling Instruction fully. In fact, he has such a deep understanding of Modeling Instruction, and is so effective in using it, that ASU hires him each summer to co-lead the mechanics Modeling Workshop.

Zak Kovach and Melissa Girmsheid show us what can and should be, in Arizona physics. Both of them use Modeling Instruction; both of them have greatly increased their physics enrollment, while being very effective in improving student learning. Their students understand and remember, rather than memorize and forget. (Their strategies and more are in your handouts.ⁱ)

Why is this important? Physics is everywhere! Physics is STEM— science, technology, engineering, and mathematics. High school physics incorporates all elements of STEM better than any other course. Physics is the foundational science upon which all other sciences, engineering, and technology build. Thus an AAPT goal is **Physics for All**.ⁱⁱ

I organized these three talks today, on increasing physics enrollment, because Arizona is doing very poorly compared to the rest of the nation. **My survey in 2015 shows that in Maricopa County, only 20% of high school students take physics, while the nationwide average is ~40%.**ⁱⁱⁱ Furthermore, honors and advanced placement physics classes comprise 2/3 of physics courses in Maricopa County – as opposed to nationwide, where 2/3 of the physics courses are regular/core/standard.

It used to be the other way around in Arizona; in the late 1990s, I documented that 2/3 of the physics courses were regular/core/standard, and only 1/3 were honors and AP.^{iv} (20% of high school students took physics then. So the percentage has not grown; Arizona is stagnant.)

The push in Arizona, in the last decade, to promote AP courses has had an unintended, troubling effect: high schools replaced regular/core physics with honors or AP physics, thus making physics a course for only the mathematically adept. This hinders all but the top students from pursuing STEM majors and STEM careers. Disadvantaged minorities and girls are left out, because they tend to have a weaker background in math (through no fault of theirs). Physics is the ideal course to make algebra I and pre-algebra make sense; and the disappearance of regular/core physics closes doors in careers and higher education for the middle half of students.

Arizona's mandate of three years of lab science for graduation has not increased the number of students who enroll in physics. Instead, more students are taking advanced life sciences as their 3rd science course. Research shows that taking advanced life science courses instead of physics holds students back from pursuing STEM majors in college, including health & medical majors.^v

Research shows that a student who takes high school physics is 2 to 3 times as likely to earn a STEM degree than a student whose last high school science course was chemistry.^{vi} Thus Arizona's stagnancy is a danger sign, because high school physics is crucial for Arizona's

economic health. Data from the U.S. Bureau of Labor Statistics predict that U.S. employment in STEM occupations will grow to more than 9 million between 2012 and 2022. That's an increase of about 1 million jobs in 10 years. If the middle half of high school students don't take physics, Arizona will suffer.

To prepare our students for Arizona's share of these 9 million jobs, we should do all we can to interest the middle half of high school students in physics, while developing a world-class group of physics teachers. We should expand physics enrollment with our current staff, and retrain teachers of other sciences who show an interest in becoming a physics teacher.

Maricopa County has 125 physics teachers employed in the 90 school district high schools that offer physics. Only 30% of these teachers are fully utilized; i.e., teach physics full-time. So we can easily expand physics enrollment with current staff, in the short-term.

As for retraining out-of-field teachers, ASU has prepared dozens of physics teachers from other sciences, usually biology and chemistry, in 3-week summer Modeling Workshops. Five such workshops have been developed in physics.^{vii} Teachers say they are the BEST preparation.

Modeling Instruction is the pedagogy that has shown the most success in actively engaging students of all abilities in high school physics. Modeling Instruction began at Arizona State University in 1985, in a partnership between a physics professor and a physics teacher at Marcos De Niza High School in Tempe. It is designated as an *Exemplary K-12 science program* and a *Promising Educational Technology Program* by the U.S. Department of Education. The American Physical Society recognized it with the *2014 Excellence in Physics Education Award*, and Change the Equation rates it an *Accomplished STEM Program*.^{viii} Most physics teachers in Maricopa County have attended one or more 3-week intensive summer Modeling Workshops. The Boeing Company and Salt River Project fund the program, and 70 teachers participate each summer in 4 Modeling Workshops and advanced courses that can lead to an MNS degree in physics.^{ix} ASU has prepared many physics teachers from 2nd career teachers, too.

Who will advocate for increased high school physics enrollment in Arizona, focusing on regular/core physics? I hope that the AZ-AAPT section will, and that others will join us. We love physics, for the joy of understanding our world and the delight in thinking and reasoning. Physics is essential for a 21st century educated citizenry and for meeting our huge societal challenges and thriving economically. Let's turn this sorry situation around, now, before it's too late. Head toward **Physics for All!**

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Zachary Kovach's powerpoint (September 2015), Melissa Girmscheid's statement, and this report are at <http://www.azaapt.org/Fall 2015.html>

ⁱ See <http://modeling.asu.edu/Projects-Resources/BarrettE-IncreaseEnroll.pdf> and <http://modeling.asu.edu/Projects-Resources/PhysicsIncrease-How.htm> Several related articles on **how to increase physics enrollment in high school** are in the section by that name, at <http://modeling.asu.edu/Projects-Resources.html> (Scroll to the bottom of that webpage.)

ⁱⁱ <http://www.aapt.org/Resources/policy/> (see Physics First, and Statement on Diversity)

ⁱⁱⁱ <http://www.aip.org/statistics> (Click on high school.)

^{iv} See reports of Eisenhower grants at ASU for physics Modeling Workshops in 1998 to 2000, at <http://modeling.asu.edu/Evaluations/Evaluations.html>

^v Philip M. Sadler et al. (2014). *Science Educator*, Vol.23, No.1, pp. 1-13. Fig. 3 shows that ONE year of high school physics is more strongly correlated with STEM career interest, than ANY other science course. http://nsela.org/images/stories/scienceeducator/Summer2014/Sadler_231.pdf

^{vi} References are at <http://modeling.asu.edu/modeling/STEMpathways-PhysicsAZ.htm>

^{vii} <http://modeling.asu.edu/MNS/MNS.html> (See links on that webpage.)

^{viii} <http://modeling.asu.edu> (See links on that webpage.)

^{ix} <https://physics.asu.edu/graduate/mns>