

Fast-worsening physics teacher shortage in Greater Phoenix!

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Supplement: new data added on Oct. 24, 2017

GREATER PHOENIX:

The shortage of physics teachers is worse now. These 12 large comprehensive public high schools in Greater Phoenix (out of about 100 total) do NOT have a physics teacher in fall 2017:

- * Copper Canyon HS (Tolleson UHSD. Approx. 2300 students).
- * Sierra Linda HS (Tolleson UHSD. 1900 students).
- * Verrado HS (Agua Fria UHSD. 1900. A teacher travels from another HS, 1 period/day.)
- * North Canyon HS (Paradise Valley USD. 1900 students. They do online physics.)
- * Peoria HS [1500 students. A teacher travels from another HS, 1 period/day.]
- * Greenway HS (Glendale UHSD. 1400 students)
- * Buckeye Union HS (1375 students).
- * J. O. Combs HS (1300. The physics/biology teacher & dept. chair quit in Sept. 2017. The chemistry teacher quit earlier, & no one applied for the position, so a long-term sub was hired.)
- * Apache Junction HS (1200)
- * Cortez HS (Glendale UHSD. 1100)
- * Coolidge HS (600 students)
- * Tonopah Valley HS (near the Palo Verde nuclear power plant) (400 students)

This tiny high school in an outlying town has no physics teacher:

- * Gila Bend HS [105 students]

Small high schools CAN offer physics -- every other year, as Julia Slucas does at Salome HS (120 students). Julia re-trained in summers at ASU Modeling Instruction Program. Betty Hultin teaches physics this year at Seligman HS (~50 students in that high school). She took Modeling Workshops in physics to re-train. Physics is taught every year at Valley Union HS in Elfrida (125 students). These three examples show that small schools can have a physics teacher.

RURAL ARIZONA:

25% of rural AZ public district high schools NO LONGER have a physics teacher, as of fall 2017. Almost all of them FORMERLY OFFERED PHYSICS; I have detailed records back to 2002. (I did not include schools in my tally that are smaller than 120 students. Few exist.)

18 to 20 rural Arizona public district high schools (out of ~70, including Yuma) do NOT have a physics teacher in fall 2017. Almost all of them USED to, but they dropped physics -- mostly AFTER 2008, according to my records. The physics teacher retired or left. THE BASIC PROBLEM IS LOW SALARIES, IMHO, due to the decline in state funding for K-12 education.

Rural Arizona schools that do NOT have a physics teacher in fall 2017 are (ordered by size):

NORTHEAST TO NORTHWEST areas:

Kingman HS (approx. 900 students)

Page HS (800 students). Joshua Adams, the science dept chair, wrote, "our school wants to push Scottsdale online for physics."

Tuba City HS (700 students. No chemistry teacher, either)

Winslow HS (700). They do ONLINE physics.

Pinon HS (360. No chemistry teacher, either?)

Williams HS (230)

Hopi Sr HS?

SOUTHWEST:

Gila Ridge HS (Yuma USD. 2000 students)

Ajo HS (120 students)

SOUTHEAST:

Thatcher HS (450 students. No chemistry teacher, either.)

Willcox HS (400)

Bisbee HS (330)

San Manuel HS (230)

St David HS (125)

Fort Thomas HS (120)

EAST OF GREATER PHOENIX:

Globe HS (540 students. The chemistry teacher wants to re-train to become certified in physics.)

Santa Cruz Valley HS (450)

Miami HS (300): The physics & chemistry teacher left in May 2017. Chemistry was replaced.

Superior HS (120 students). Some students take online physics by Mesa USD distance learning. It is inferior to hands-on, minds-on experiential interactive engagement of Modeling Instruction.

Notes:

* Appendix 1 below lists the high schools that did not have a physics teacher in 2015-16.

* More evidence is at <http://modeling.asu.edu>. Scroll to the bottom of that webpage.

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July 2016 update of original document, which was posted in spring 2016

OVERVIEW:

Since 1998, ASU's Department of Physics has alleviated a chronic shortage of qualified physics teachers through the Modeling Instruction Program, which provides research-validated professional development each summer for 50 to 100 Arizona teachers of physics and chemistry. As the only program of its kind in the state, we help maintain physics education in high schools, improve its quality, and increase enrollment. Modeling Instruction began at ASU.

The physics teacher shortage in Greater Phoenix has worsened drastically in the last few years, since our Federal "Improving Teacher Quality" grants ended in 2010! **Nine of the 100 comprehensive public high schools in Maricopa and western Pinal Counties (within commuting distance of ASU) HAD NO PHYSICS TEACHER in 2015-2016. Another 13**

schools (at least!) “made do” (with retirees or overloads or teachers uncertified in physics – and/or the school cancelled sections of physics). These 100 schools serve 85% of Greater Phoenix high school students. (See Appendix I.)

One of these overworked teachers, an engineering teacher who is also teaching physics because the physics teacher quit, wrote, *“I have not had a prep in 4 years. ... [Next year] I will be teaching a 0 hr and have no prep plus possibly giving up my lunch time. I struggle, as this is my retirement job and the added pressure may break me soon, it is starting to impact my health.”*

(The numbers above do NOT include the many teachers who have huge classes, like Adrian Boyarsky, the sole physics teacher at Desert Vista High School. In 2014-2015 he had class sizes of 40 students, and taught 5 sections of physics: nearly 200 students per day. He re-trained from biology in our Federal ESEA Title II-A “Improving Teacher Quality” ITQ grants at ASU, which ended in 2010. Most physics teachers report class sizes of 30 or more students.)

Although about 350 teachers in Arizona teach some physics, only half of them are certified in physics, as of 2015. Three-fourths of the 350 physics teachers did not major in physics nor in physics education. Most district high schools have only ONE physics teacher. (Exceptions are 5 high schools with 9th grade physics.) **Only 30% of Greater Phoenix physics teachers are fully utilized;** i.e, teach physics full-time -- most teach only one or two sections.

8 PHYSICS TEACHERS IN GREATER PHOENIX RETIRED OR LEFT TEACHING:

FIVE local physics teachers fully retired in May 2016 (not counting the retirees already mentioned above). **And at least 3 left physics teaching in the Valley** for a different profession, different region, or to earn a doctorate. So that’s 8 more, added to the 22 above. In sum: **ONE-THIRD of the 100 district high schools in Greater Phoenix must hire a new physics teacher, or “make do” again, or go without physics.**

We know of 25 physics teaching openings in Greater Phoenix in spring 2016 (and 10 more elsewhere in Arizona). Some schools aren’t even trying any more). ASU’s 3 universities graduate only a half-dozen physics teachers yearly. 6 new teachers for 35 openings!

COMPARISON WITH THE NATION:

Only 20% of high school students in Greater Phoenix took physics in 2014-15. This is HALF the percentage nationwide, where almost 40% of high school students take physics. Physics is declining here. It should be growing, to meet 21st century STEM workforce needs.

WHY DOES HIGH SCHOOL PHYSICS MATTER? Two main reasons:

1) **Physics is the chief STEM pathway,** essential for almost all STEM careers.

The loss of physics is harmful for the future STEM workforce in Arizona, because physics is prerequisite for almost all STEM careers. Research shows that **high school physics is the chief STEM pathway.** A college student who has taken high school physics using a hands-on, minds-on approach such as Modeling Instruction, is three times more likely to earn a STEM degree than a student whose last high school science course was just chemistry. (Endnote 1 and Appendix II.)

Two sophomore engineering majors at ASU in 2016, awardees in the “Earn to Learn” program, wrote in March 2016 about how important high school physics is.

* Saul Lopez took physics at Mesa High School, from Liz Fife. Liz uses Modeling Instruction. Saul wrote, *“Taking physics with Ms. Fife is the best decision I ever made.”*

* Michaela Starkey did not take physics at Westwood High School in Mesa. Instead, she took Anatomy and Physiology. She wrote, *“I wish I had the opportunity to take physics in high school because it would have helped me in college.”*

2) **Physics is essential for college and career readiness for all:** scientific & math literacy. Thus regular physics courses are needed – not just honors, AP, and Dual Enrollment (DE). In Greater Phoenix in 1998, 70% of physics courses were regular/core, and 30% were honors or AP. In 2015, the situation is reversed: only 30% of physics courses are regular/core, and 70% are honors/AP/DE. (Nationwide, about 35% of physics courses are honors/AP/second year.)

TWO POLICY STATEMENTS that recommend high school physics as a **core** course are:

a) The ACT policy platform: K-12 (2013) states:

“ACT research has demonstrated the benefits to student academic performance of a **minimum core curriculum that includes the following: ... Three years of science, including rigorous courses in Biology, Chemistry, and PHYSICS [MY CAPS] ...**”

<http://www.act.org/content/dam/act/unsecured/documents/Policy-Platforms-k-12-online.pdf> p.8

b) Position Statement of the National Alliance of Black School Educators (2012):

<http://vector.nsbp.org/2012/03/16/national-alliance-of-black-school-educators-endorses-physics-first/>

“**Physics is a gateway course** for post-secondary study in science, medicine, and engineering, as well as an essential component in the formation of students’ scientific literacy. Physics classes hone thinking skills. An understanding of physics leads to a better understanding of other science disciplines. Physics classes help polish the skills needed to score well on the SAT and ACT. College recruiters recognize the value of taking high school physics. College success for virtually all science, computing, engineering, and premedical majors depends in part on passing physics. The job market for people with skills in physics is strong. Knowledge of physics is helpful for understanding the arts, politics, history, and culture.

Currently only 25% of Black and Hispanic high school students take any course in physics. Thus **many do not even get to the gateway. ...**”

A SOLUTION IS ALREADY IN THE HIGH SCHOOLS:

A partial solution exists, and it is already in these high schools. Experienced biology, earth science, and chemistry teachers can be prepared at ASU to teach physics. An overabundance of biology and earth science teachers exists. Schools should ask out-of-field teachers to re-train in Modeling Instruction in the ASU Department of Physics. Our program prepared many out-of-field teachers until 2010, and they wrote statements such as, *“Thanks to taking ASU physics modeling course work, I am highly qualified in physics.”* *“ASU Modeling Workshops are the BEST preparation to pass the AEPA content test.”* (See endnote 2.)

Biology, chemistry, and earth/space science teachers need financial incentives of \$2000 each summer for free ASU tuition, to entice them to prepare to teach physics by taking ASU summer Modeling Workshops. (Physics and chemistry are like hand and glove. Physics is the hand.)

We have proven success. **From 2006 to 2011 we helped 70 out-of-field teachers to become Highly Qualified in physics, chemistry, or high school general science**, in our Federal ESEA “Improving Teacher Quality” grants. ASU tuition was FREE; that was key to success. Three ASU 3-week summer Modeling Workshops usually suffice to prepare for NES content test

The main problem in Arizona is low salaries for newer teachers. Teaching is a calling. Yet when salaries are too low to support a family, teachers are forced to leave. Many people who have the potential to teach physics avoid the teaching profession. The economic recovery is providing high-paying opportunities for physics-trained people in the private sector – but teacher salaries are low and stagnant. Thus teachers leave, or never start to teach. It is a terrible loss of talent. Teaching physics is joyful and rewarding – and crucial for Arizona’s economic health.

WHAT THE BUSINESS COMMUNITY CAN DO:

It will take an effort led by the Greater Phoenix business community to convince the state legislature to increase STEM teachers’ salaries, and to appropriate more state funds to public district high schools. (Appendix III discusses causes of the crisis.) Businesses care! In the survey commissioned by Jim Lundy, CEO of Alliance Bank of Arizona (in Nov. 2015) of 400 Arizona business executives, 61% wrote that their top choice to have a positive impact on Arizona business is increasing the flow of graduates with STEM backgrounds. Jim Lundy said that a better skill set is needed in the workforce, specifically QUANTITATIVE & PROBLEM-SOLVING abilities. (See <http://azc.cc/1TqGlq5> and <http://azbigmedia.com/ab/economy/ceos-say-education-is-arizonas-no-1-business-challenge>.)

Until 2018, local businesses need to support teachers financially for professional development at ASU to train in physics. We at ASU are asking local STEM-related companies for donations; it is a slow process, and contributions as of June 2016 are relatively small. By 2018 we expect that Federal funds will again be available, due to the ESEA re-authorization. For longterm stability, a state appropriation and/or endowment is needed for teacher re-training in physics and chemistry.

THE BOTTOM LINE:

Physics is the #1 shortage area of K-12 teachers – and has the highest turnover because of strains in the system and higher wages in the private sector. The teacher shortage is fast-worsening, in part due to insufficient funding to prepare out-of-field teachers at ASU.

Greater Phoenix faces a crisis: unless our ASU summer program continues to prepare out-of-field “cross-over” teachers, more high schools in Greater Phoenix will stop offering physics, the quality of instruction will deteriorate due to poorly prepared teachers, and the number of students who learn physics will dwindle. This will harm the economic health of Arizona, which depends on a strong K-12 education that includes robust physics courses.

WHAT OTHER STATES ARE DOING:

* The state legislature in Indiana has appropriated \$9,700,000 per year since 2013 for STEM teacher re-training and initial training. (Endnote 4)

* The governor of New Hampshire created a task force in 2013, which resulted in a White Paper that includes recommendations for higher salaries for physics and chemistry teachers. Businesses have recently come forth with funding to re-train teachers. (Endnote 5)

THE SURVEY: HOW I LEARNED OF THIS CRISIS:

I discovered the depth of the crisis in February 2016. I e-mailed a short survey to the 125 physics teachers in the 90 comprehensive local public high schools, including those in the western half of Pinal County, which is within commuting distance of ASU. The initial response rate was 1/3 (40/125). I emailed the survey to the other 85 teachers again on March 1. 30 teachers replied, bringing the response rate to 55%. The situation is rapidly deteriorating, the survey revealed!

ENDNOTES:

1. Evidence is from large studies at Harvard-Smithsonian, University of Southern Florida, ACT, and TIMSS. References are at <http://modeling.asu.edu/modeling/STEMpathways-PhysicsAZ.htm>.
2. In fall 2008, we conducted a survey of Arizona certification in physics of 54 metropolitan Phoenix physics teachers who had taught for six years or fewer. Twenty-six of them took a Modeling Workshop(s) before becoming certified and/or Highly Qualified (NCLB), and ALL of these teachers wrote that it was the *most important* preparation. A document is at <http://modeling.asu.edu/MNS/MNS.html>.
3. A professional learning community (PLC) in physics was started in the early 2000's by Andrew Chapman, now the physics teacher at Metro Tech. He secured district support for, organized, and led the PLC of physics teachers. He leads it now. Russ Shaffer, recently-retired science specialist at PUHSD, was very supportive of Physics modeling and PLC work both as a teacher and when he later served as district science specialist. He started chemistry PLCs.
4. News articles on Indiana legislature's \$9.7 million/year appropriation for STEM teacher training (in-service and pre-service): Dec. 15, 2015: [http://www.usi.edu/news/releases/2015/12/pott-college-awarded-more-than-\\$700,000-in-grants-from-indiana-commission-for-higher-education](http://www.usi.edu/news/releases/2015/12/pott-college-awarded-more-than-$700,000-in-grants-from-indiana-commission-for-higher-education)
Jan. 6, 2016: http://www.in.gov/che/files/160106_PressRelease_STEMteacherGrantWinners.pdf
http://www.in.gov/che/files/150106_GrantSummaries_STEMteacherGrantWinners.pdf
List of press releases: <http://www.in.gov/che/>
5. New Hampshire Governor's Task Force on K-12 STEM education, and outcomes.\$300,000 corporate grant: <http://www.unh.edu/news/releases/2015/09/em23albany.cfm> July 7, 2015 press release: <http://governor.nh.gov/media/news/2015/pr-2015-07-15-stem.htm>
<http://governor.nh.gov/commissions-task-forces/stem/documents/stem-01-2015-final-report.pdf>
The report states, "We are training virtually no teachers at all in physics and the physical sciences, and fewer than half the teachers we need in math."

APPENDIX I: examples of shortage of physics teachers in Greater Phoenix.

These 9 large comprehensive public high schools did NOT have a physics teacher in 2015-'16:

- * Willow Canyon HS (Dysart USD. 2100 students). The salary they offered was so low that the lone candidate rejected it. [July 2016 update: a section of physics will be held in 2016-17, because an experienced chemistry teacher re-trained in an ASU mechanics Modeling Workshop.]
- * Sierra Linda HS (Tolleson UHSD. 1940 students).
- * Queen Creek HS [1815 students]
- * Agua Fria HS (Agua Fria UHSD. 1725 students). The new physics teacher quit after one semester, in fall 2015.

- * Buckeye Union HS (Buckeye UHSD. 1375 students). [July 2016 update: A science teacher wants to re-train to become Highly Qualified in physics.]
- * Cactus HS (Peoria USD. 1300 students). The physics teacher at Ironwood HS drives there daily, to teach 1 section of physics. Their principal wrote me in 2015, "We share a physics teacher with another school so we are good right now."
- * Fountain Hills HS. [620 students] They could not find a 9th grade physics teacher, so all 9th graders took environmental science instead of physics. Teacher salaries were low. [July 2016 update: Base salaries have risen to more competitive rates, and physics will be offered in 2016.]
- * Coolidge HS [600 students]
- * Tonopah Valley HS (near the Palo Verde nuclear power plant) [380 students]

These 2 small high schools in outlying towns do not offer physics:

- * Superior HS (120 students). Several students take online physics by Mesa USD distance learning -- inferior to face-to-face, hands-on, minds-on team learning of Modeling Instruction.
- * Gila Bend HS [105 students]

These high schools are among those that are 'making do':

- * Mountain View HS (Mesa USD: 3100 students!) could not find a physics teacher to replace a retiree, so they consolidated their AP physics classes to be over-full. Also, *"Students who were originally enrolled in two General Physics section are being RE-ROUTED TO OTHER CONTENT AREAS [my caps]. Two other sections were saved by shifting a chemistry teacher..."* (Their salary offer was too low for the lone candidate, a retiree.)

- * Pinnacle HS (upper-middle class, in Paradise Valley USD. 2400 students) had no candidates for TWO full-time physics positions, so they hired
 - a STUDENT teacher for 5 sections of 9th grade physics, and
 - a BIOLOGY teacher for 5 sections. She became certified in physics in Feb. 2016. She wrote, "all of my classes are over 30 students, I have 39 in my largest class."
 [July 2016 update: the biology teacher strengthened her physics understanding and pedagogy by taking a 3-week mechanics Modeling Workshop at ASU in June. The student teacher moved to middle school science teaching, and an experienced physics teacher was hired to replace her.]

- * Peoria HS (Peoria USD. 1500 students) has a BAND/ORCHESTRA teacher teaching 2 sections of physics, from the goodness of his heart, because the long-time physics teacher, David Hill, retired and they could not find a replacement. They used to have 5 sections of physics. The band/orchestra teacher has a degree in physics. He wrote, *"If I didn't teach Physics at our school, we wouldn't have it, but I really think the Physics person should be full-time science and not splitting with music. I am only teaching Physics here as I am Highly Qualified and I think Physics should be taught at the High School level. I would like to teach full time music."*

- * Poston Butte HS (Florence USD. 1800 students) lost their physics teacher to the private sector. The engineering teacher added physics as an overload.

[etc. I do not have permission of other individual teachers to document their situations publicly.]

APPENDIX II: Modeling Instruction is Effective.

The ASU Modeling Instruction Program is the only program of its kind in Arizona. It is appropriately geographically located because 2/3 of Arizona physics and chemistry teachers live within commuting distance of ASU.

Teacher effectiveness is the chief determinant of student achievement. That is the focus of the ASU Modeling Instruction Program, and we have well-documented success in preparing students for the 21st century scientific and technical workforce and in scientific literacy.

Modeling Instruction is an innovative, effective hands-on pedagogy: **it re-creates what scientists and engineers do.** It is guided inquiry structured by modeling principles. It develops in students the ability to design experiments, analyze data, then reach and defend conclusions. Other 21st century workforce skills developed are scientific use of computers and probeware, teamwork, and verbal and written communication skills. Students become self-directed, independent learners. Modeling Instruction is aligned with the National Research Council (NRC)'s *Framework for K-12 Science Education*, the research basis for the Next Generation Science Standards (NGSS).

Modeling Instruction is designated as an Exemplary K-12 science program and a Promising technology program by the U.S. Department of Education. It was recognized with the 2014 *Excellence in Physics Education Award* of the American Physical Society (APS). In 2015, the ASU Modeling Instruction and Master of Natural Science (MNS) degree programs were designated "Accomplished STEM Programs" and added to the online STEMworks Database at <http://changetheequation.org/stemworks>, after a rigorous review. STEMworks is sponsored by Change the Equation, a coalition of CEOs of Fortune 500 companies.

Modeling Workshops have been held in some 35 states. In 2013 our scale-up partner, the American Modeling Teachers Association (AMTA), assumed oversight of nationwide Modeling Workshops. AMTA is a grassroots professional society of, by, and for teachers who use Modeling Instruction. Sixty multi-week Modeling Workshops were held in 2015. The AMTA website is <http://modelinginstruction.org>.

APPENDIX III: Causes. WHY THE PHYSICS TEACHER SHORTAGE:

Low salaries and poor benefits are chief reasons, especially as STEM job opportunities proliferate in the private sector. New teachers cannot afford to teach, due to the need to support their families and pay off student loans. For example: *"I do not teach any longer. I am getting an AAS in engineering technology and will be looking for a job in industry this summer."*

Phoenix Union High School District demonstrates that physics instruction benefits from higher teacher salaries. It has the highest teacher salaries in the state. It is fully staffed in physics, with multiple sections in each of its 10 schools. Physics teacher turnover is low. It has a thriving physics teacher professional learning community. (See endnote 3)

Its clientele are 90% underserved minorities, and all of its schools are Title I. You might think that would be a detriment; but it isn't. Almost all physics teachers have taken ASU Modeling Workshops. They use Modeling Instruction, and it works. The district fully supports Modeling Instruction by reimbursing ASU tuition, using Federal Title II funds.

(I learned in March 2016 that some physics teachers were looking for jobs in other districts, due to threatened loss of desegregation funds, which account for 10% of the district's income. Loss of desegregation funds would reduce their salaries and benefits. Luckily, it didn't happen. Job stability is crucial for teachers, and higher salaries mean more job stability.)

WHY THE LOW NUMBER OF PHYSICS COURSES:

The dearth of physics teachers is a very recent phenomenon, occurring only in the past few years, thanks to our 12 years of grants up to 2010 that included free ASU tuition.

On the other hand, the 20% enrollment in physics is long-term; that 20% percent enrollment was the same, 15 years ago. What happened is, the push in Arizona in the last decade, to promote AP courses and increase the graduation rate with very limited financial resources in schools, had an unintended, destructive effect: high schools replaced regular/core physics with honors and AP physics, instead of adding them to regular/core physics-- thus giving physics *the appearance* of being a course for only students who are mathematically advanced. This hinders all but top students in math from pursuing STEM majors and STEM careers. Disadvantaged minorities and girls are left out, because they tend to have a weaker background in math. **Physics is the ideal course to make algebra make sense**; the disappearance of regular/core physics closes doors in careers and higher education for the middle half of students.

In other words, for a decade or longer, schools have lacked funds to hire teachers, so they eliminated regular/core physics, and increased class sizes to up to 40, to save money.

REFERENCES:

* ACT (2006): Developing the STEM Education Pipeline, page 2 & 3.

Download at <http://files.eric.ed.gov/fulltext/ED493179.pdf>

* Will Tyson, Reginald Lee, Kathryn M. Borman and Mary Ann Hanson (2007). Science, Technology, Engineering, and Mathematics (STEM) Pathways: High School Science and Math Coursework and Postsecondary Degree Attainment, Journal of Education for Students Placed at Risk, Vol. 12, No. 3, pp. 243-270. (Tyson was at the University of South Florida.)

* TIMSS Physics Achievement Comparison Study, by Eugenio Gonzalez (April 2000). Conducted for the National Science Foundation by TIMSS International Study Center, Boston College, Chestnut Hill. For science & math literacy, see Table A1: just after page 35.

http://modeling.asu.edu/Evaluations/TIMSS_NSFphysicsStudy99.pdf

* Philip M. Sadler et al. (2014). Science Educator, Vol.23, No.1, pp. 1-13. See Fig. 3.

http://nsela.org/images/stories/scienceeducator/Summer2014/Sadler_231.pdf

* High School Physics Courses & Enrollments, American Institute of Physics (June 2014).

<http://www.aip.org/statistics/reports/high-school-physics-courses-enrollments-0>

* More evidence at <http://modeling.asu.edu>. Questions? Jane.Jackson@asu.edu