

The State of Physics First

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ABSTRACT: My teaching career underwent a major change when Paul Hewitt introduced me to teaching physics to ninth graders (“Physics First”) in 1989. I will relate how my teaching Physics First has evolved since and what I have learned about other ways other people are teaching it. If you are interested in implementing Physics First at your school, I have some comments on that, too.

I was first introduced to the idea of “Physics First” at the Physics Teaching Resource Agent (PTRA) Training Institute prior to the 1989 summer meeting of AAPT in San Luis Obispo, CA, by Paul Hewitt. He told the PTRAs there assembled that he had just adapted his *Conceptual Physics* course, originally developed for nonscience undergraduate majors, for high school students. With no mathematics more advanced than what is learned in eighth grade, it could be taught to high school freshmen. This also made sense in terms of good science education, he went on. Physics is the most fundamental science – it had been relegated to the later high school years because people thought you had to wait that long to get the math to do it. Now it could be taught *before* biology and chemistry instead of after it – and, with biology now being so dependent on chemistry, chemistry should now be taught *before* biology. In short, the “traditional” biology-chemistry-physics sequence should be reversed.

It all made sense to me, and I could easily make the change – by changing the physical science course focused on energy that I had been teaching one of the two sections of ninth graders at The Calhoun School to Conceptual Physics. I would then follow this by teaching chemistry (which I also taught at the time) to those students in their sophomore year. I obtained my Upper School Director’s permission to do this and the change was made in the fall of 1990.

Two years later, my Upper School Director approached me to say, “I think we’re ready to switch both sections of freshmen to Physics First.” (The other section had been taking an earth science course in their ninth grade year.) Fortunately, our biology teacher at the time could teach the additional section of chemistry needed to make the switch, and The Calhoun School has taught a Physics First course to its ninth graders, chemistry to its sophomores, and biology to its juniors ever since.

Half a dozen years later I came to realize that I was part of a new movement, championed by Nobel Laureate Leon Lederman, who had started ARISE (American Renaissance In Science Education). He had written a piece about it with Marjorie Bardeen in the 10 July 1998 issue of *Science*, at which time they listed two dozen participating schools. By the time Lederman spoke about it to the Northeast Regional AAPT meeting on 7 November 1998, this number had increased to 30, and it further increased to three dozen before he left. By the January 2009 AAPT meeting when Paul Hickman spoke at the Symposium on Physics Education, devoted to Physics First, the number of Physics First schools had increased to 1200, causing the percentage of high school students taking a physics course to increase to 37%; and by the time Gabriel Popkin wrote about Physics First in *APS News* the following July, it had increased to 2000, according to Lederman’s estimate. Also in 2009 the American Institute of Physics added Physics First to its categories of physics courses. Their polling in both 2009 and 2013 showed that 6% of all students taking physics took Physics First courses; their next polling occurs this year (2017). Of

these students taking Physics First courses, 22% of them are from private schools (which account for only 9% of high school graduates and 14% of high school physics students). This is consistent with AAPT's 2006 "Physics First" booklet, which characterizes 3% of public schools as teaching Physics First and 9% of private schools doing the same.

Little has been broadcast about the "State of Physics First" since that January 2009 AAPT Symposium on Physics Education and a session at the winter 2008 AAPT meeting in which Arthur Eisenkraft (director of *Active Physics*), Tom Hsu (then CEO of the Cambridge Physics Outlet, more commonly known as CPO), and Hewitt spoke about the use of their materials in Physics First courses. Hsu spoke about his materials being field tested in Rhode Island, and the 2009 Symposium included reports about Physics First in Rhode Island and Missouri (the latter known as A TIME for Physics First).

The state of Physics First in Missouri is well presented on the A TIME website, (www.physicsfirstmo.org). A TIME stands for Academy for Teachers using Inquiry and Modeling Experiences for freshman physics in Missouri. The website reports that the National Science Foundation funded it for 2009-2015 as a partnership between the University of Missouri at Columbia and 37 Core Partner districts to prepare ninth grade science teachers to teach yearly freshman physics course digital curriculum units developed by the project, published under the title *Exploring Physics*. The unit topics are Introduction to Electricity, Uniform Motion, Accelerated Motion, Electrical Circuits, Forces and Newton's Laws, Applications of Newton's Laws, and Momentum and Energy. As of a year ago, a beta version for iPad was available for the first three.

I couldn't find any Internet posting of the state of Physics first in Rhode Island, so I put in an inquiry through the Rhode Island Department of Education. I received responses from two Rhode Island teachers, the first from a teacher in Providence, who reported that they had started with Physics First but then switched their physics course back to 11th-12th grade:

Our district (Providence, RI) had been going with Physics First, and my original school actually started even before the district did, by about 6-7 years. I've used 3 different Physics First curricula as well as Tom Hsu's equipment. Even though we switched back (not really sure why, since math scores did go up, but I'm not complaining since I much prefer working with 11th/12th graders on a personal level), we still use CPO equipment.

Although this teacher still uses CPO equipment, she prefers to use Hewitt's *Conceptual Physics* to Tom Hsu's text. A second teacher, from Portsmouth, which continues to teach Physics First, described how her district made the transition and of their work with Tom Hsu:

We have been a Physics First school for many years. We have worked directly with Tom Hsu through workshops at the East Bay Collaborative in Bristol, RI. Our then department chair, Jeffrey Schoonover, was a physics teacher and was in total agreement with the philosophy of Tom Hsu. We actually changed our entire curriculum to enable us to follow the Physics First, Chemistry, Biology sequence. This was a challenge the first year as all grade 10 and grade 11 students had to take Chemistry in order to implement this sequence. We have also started using Tom Hsu's Essential Physics text with our honors level grade 9 students. Tom actually came into our school to work with our teachers on piloting this program.

We recently did change the name of the Physics First course to the Principles of Earth, Space and Physics. We did this because too many students (as well as guidance counselors) believed that since students had already taken "Physics," they would not have to take it again. Also with the alignment to the next generation science standards (NGSS) the grade 9 course is integrated with earth and space science standards.

Knowing that Montgomery Township High School uses Modeling Instruction in its approach to Physics First, as you learned this morning from Craig Buszka, I also put in an inquiry to the Modeling listserv to learn what other schools are using Modeling Instruction for Physics First. I received responses from teachers at the following schools using Modeling Instruction for Physics First:

Storm King School, Cornwall-on-Hudson, NY
Utica Academy for International Studies (IB school), Sterling Heights, MI
Pope John Paul II High School, Hendersonville, TN
Briarwood Christian School, Birmingham, AL
Oakland Christian School, Auburn Hills, MI
Ursuline Academy of Dallas, Dallas, TX
North High School, Evansville, IN
Palmdale Aerospace Academy, Palmdale, CA
Cape Elizabeth High School (15 years), Cape Elizabeth, ME.

Although this list shows a diverse geographical distribution, it is definitely dominated by private schools.

As a user of *Active Physics* since 1994, I also asked its publisher, It's About Time, for a list of schools and districts using this curriculum for Physics First. They responded that *Active Physics* is being implemented in several hundred schools across the country provided the following list of key places that are currently implementing it as Physics First:

Aurora Public School District, CO
Boston Public Schools, MA
Caroline County School District, MD
Carroll County Public Schools, MD
Dearborn STEM Academy, MA
Friends Select Academy, PA
Loyola High School of Los Angeles, CA
MC2STEM High School, OH
Southbridge High School, MA
Vista Peak Academy, CO
Winters Mill High School, CO.

This list seems dominated by CO, MA, and MD, but it seems to include more public schools.

But, as has been the case in the Rhode Island schools, not every district that once implemented *Active Physics* continues to use it today. Perhaps the best-known example of this is San Diego, which was cited by Popkin in his 2009 *APS News* story. According to Arthur Eisenkraft, "the administration took a top-down approach and mandated Active Physics for all schools. There was a big pushback from affluent La Jolla that did not think that they should have the same mandates as the poorer schools in that district. One of their reasons for objecting to Physics First was that it would provide for ALL students taking physics which would make the students who presently enroll in physics in La Jolla less 'special.' The 'mandate' was lifted after a few years. Many schools found Active Physics and Physics First an enormous success. Some schools continue to use Active Physics."

Two other districts cited by Popkin as teaching Physics First and used *Active Physics* but are no longer doing so are Little Rock, AR, and Prince Georges County, MD. In fact, it was for Prince Georges County that *Active Physics* customized its CoreSelect version, subsequently considered to be its second edition.

It seems clear from the above that the State of Physics First is that it accounts for 6% of all US physics students, more in private schools than in public, and that it is taught in many different ways. I expect that the expectations for and from a Physics First course are as diverse as the ways of teaching it. For me, I have taken Paul Hewitt at his word – that Physics First should expect nothing mathematical beyond what students have learned in the eighth grade. Because I feel that Modeling Instruction goes beyond this level of mathematics, I use it for the more traditional physics course I still offer to juniors and seniors. And it is this course that I continue to call “Physics,” naming the Physics First course after the textbook I have used.

I do introduce the concept of slope in a graph in the context of kinematics, and I do write equations on the board, often, though, in word rather than symbolic form. But I don’t have my students do “plug and chug” calculations. In fact, the most significant lesson I have learned in teaching Physics First this way is that it requires my students to explain what they have learned in English, which is far more revealing than getting right answers to “plug and chug” problems.

The *Active Physics* curriculum I use requires students to measure phenomena on a continuous basis (not your typical once-a-week lab period). Because of my students’ limited math experience, I teach them how to enter their data onto spreadsheets and use the spreadsheet as a tool for data analysis. I use this approach to motivate experimentally many relationships that are more often motivated mathematically:

- the relationship between position and time for constant velocity
- the relationship between velocity and time for constant acceleration
- Newton’s laws of motion
- the equality of impulse and momentum change
- the dependence of centripetal acceleration on speed and radius
- Ohm’s law
- the dependence of power on voltage and current
- the concept of specific heat
- the relationship among wavelength, frequency and wave speed and its application to musical sounds
- the ray model of light and its application to shadows, reflection, and refraction
- the focusing of rays to project images by concave mirrors and convex lenses
- the relationship among work, gravitational potential energy, kinetic energy
- projectile motion
- the relationship between the period and the length of a pendulum

Are you interested in implementing Physics First at your school? Although the factual data in AAPT’s booklet on “PHYSICS FIRST” has not been updated since its original publication in December 2006, the advices contained in that booklet is still sound. Most importantly, you will need to make your case to all the stakeholders – parents, administration, guidance counselors, and fellow faculty – and you will need to provide for the required restaffing: you will need additional physics teachers to accommodate the first ninth grade class to experience Physics First (ideally you would like to retrain the teachers who had been teaching the former ninth grade science, because there would be nothing else for them to teach). If that class will continue into Chemistry the following year, you will need to provide enough chemistry teachers to accommodate them; not until that class moves into Biology in their junior year will you need a full contingent of biology teachers. Meanwhile, the physics teachers who had been teaching juniors and seniors will still be needed to teach physics at that higher mathematical level as an elective, pretty much as at present, although I would hope that some of them would want to be involved

with Physics First as well. This was my assigned topic at the Physics First conference in summer 2003 at Cornell (sponsored by their Laboratory for Elementary Particle Physics).

In addition to continuing to teach Physics First at The Calhoun School in New York City, this coming summer will find me embarking on a new challenge – as one of the participants in the 3-week development project at Teachers College in New York City from 31 July through 18 August to integrate computational modeling using Bootstrap's Pyret language in Modeling Physics First. That NSF has awarded AAPT a grant of nearly \$1.25 million to do this suggests that Physics First is still on an upward trend.