COMPILATION: Physics First at Clayton High School (Rex Rice's school)

Date: Feb. 18, 2003
From: jane.jackson@asu.edu (Jane Jackson)

FCI scores when 9th graders are taught physics using Modeling Instruction:

At Clayton High School, a public high school near St. Louis, 4 teachers taught physics using Modeling Instruction to 148 9th graders in 2001-02. (20% of the students are bussed from inner city St. Louis.)

One teacher was brand-new to physics, with a degree in biology and several years' experience teaching science in elementary school. He took our 3-week Modeling Workshop in summer 2001, had a job for the rest of the summer, and then began teaching. The other three teachers are experienced physics teachers. Rex Rice <RexRice@swbell.net> is an expert modeler; and the 2 other experienced teachers had participated in one 3- or 4-week Modeling Workshop.

Their 9th grade students' FCI pretest and posttest average scores are as follows.

89 regular students: (roughly 30% are inner city students bussed to Clayton HS)
pretest: 20%. This is a random guessing score!
posttest: 44% (The new physics teacher's 58 students averaged 43%; and the experienced teacher's averaged 47% .)

59 honors students (taught by the 3 experienced physics teachers):
pretest: 28%. This is typical in honors courses in 11th & 12th grade.(Note #2 below.)
posttest: 71%. This is a little lower than 11th and 12th grade honors classes of some of the best teachers of Modeling Instruction.

In contrast, when conventional (teacher centered) instruction is used, we found that average posttest scores are in the upper 30%'s for regular 11th & 12th grade courses, and the lower 40%'s for honors courses.

The normalized gains (Hake gain), <g>, for the Clayton High School freshman physics courses were:
regular: <g> = 0.3
honors: <g> = 0.6
These normalized gains are HIGHER than those for conventionally taught high school and college courses. We found that for traditionally taught high school physics courses, <g> is typically 0.2.

The bottom line is:
1) these 9th grade regular FCI posttest scores are HIGHER than 11th and 12th grade classes under conventional instruction, even though the main teacher is a novice physics teacher with a degree out of field, and even though the 9th grade students are the BOTTOM 70% of the class, whereas 11th and 12th grade regular physics courses draw from the TOP 25% of the class!
2) these 9th grade honors FCI posttest scores (71%) are SUPERB, compared to conventionally taught honors courses in 11th and 12 grade (the low 40%'s)!

Rex Rice wrote me: "*This is important stuff, and the more people hear about it, the better.*"

[For a longer version to give to school administrators, contact me.]

Date: Wed, 19 Feb 2003
From: "Rex P. Rice" <rexrice@SWBELL.NET>

I suppose that it is time that I weigh in on the subject of physics first. I have been teaching high school physics for 23 years, and since about five years into that tenure, I have been intrigued by the idea of teaching physics as the first course in the high school curriculum, followed by chemistry and then biology. At the time that I started trying to learn more about the possibility of doing this, I was in a large suburban school district (5 high schools of about 2400 students each in grades 10, 11, 12) with no chance of promoting such a radical idea and having any chance of it happening. (This district, which is even larger now, is actually seriously considering the idea now, nearly twenty years later.)

Fourteen years ago, I moved to St. Louis, MO to a small, well-regarded suburban school district with a single high school of about 800 students (in grades 9-12). Here the inertia wasn't nearly so large. At the time that I started teaching at Clayton High School, the school district was going through a curriculum revision and the district curriculum committee was trying to figure out what to do with a fledgling 9th grade science program. I saw my opportunity, proposed that we teach physics as the first course in the high school sequence to all of our freshmen. The idea was met with remarkably strong enthusiasm, and we have been teaching physics to all of our freshmen since the 1991-92 school year.

It took a little longer to convince all of the science teachers in the school that the physics-chemistry-biology sequence made the most sense for our students. After going through the hassles of fully "inverting" the sequence that Colleen has already explained, we had completed the inversion for all students by the 1995-1996 school year.

I have learned a lot about teaching physics to freshmen in my twelve years of experience with it. Many of these thoughts have been expressed before in the numerous contributions to this discussion. Here is what I think in my twelfth year of involvement with physics first.

1. It is at least as good an idea as I thought it would be back early in my career.

2. It doesn't work well with teachers who are not comfortable with the prospect of teaching physics and who have not been specifically trained to implement it. It is not, however, even under circumstances of ill-prepared teachers, any worse than the courses it was designed to replace.

3. Teachers who are not comfortable with the physics, tend to compensate by trying to "cover the book", leading to students who have been exposed to the terminology of physics, but who leave with no real understanding of physics. This problem, however, is not unique to under-prepared teachers of physics to freshmen.

On the other hand,

4. <u>Teachers who have not started their careers with the notion of teaching physics, can become excellent physics teachers</u>, particularly in a freshman course for which the intent is to help students really learn a more focused bit of physics. In the case of Clayton High School, this has been accomplished by *requiring the teachers who are teaching freshman physics to take a three-week or longer Modeling Methods in High School Physics course.*

The growth is even more pronounced when this cadre of physics teachers build the freshman physics program together, and spend time discussing the special challenges of teaching physics, and more specifically teaching physics to freshmen. This interaction among teachers helps each of them (regardless of experience level) become better physics teachers.

5. <u>A course in Modeling really can help a teacher with relatively little physics background fill in the holes</u>, both with regard to the content and the methodology of teaching physics.

6. <u>Freshmen really can do physics.</u> We teach physics to freshmen at three levels. About 30% of our students take Honors Freshman Physics. About 65% take our regular Freshman Physics course. The remaining students have, in the past, taken a course called Algebra/Physics which is a block class taught jointly by a physics teacher and a math teacher for students who failed the eight grade algebra course and who are thought to be likely to be more successful when the algebra is taught in the context of its application to physics. The difference in the courses is primarily one of

expected mathematical fluency. Most of the students in the Honors course are fluent in algebra. The students in the regular course range from reasonable fluent to scared to death of algebra (although managed to pass it in the eighth grade.)

All of our freshman physics courses are taught using the modeling method. The content is largely the same in each of the courses, although the order of presentation varies among the courses.

In the regular freshman physics courses we start with CASTLE electricity because of the nonexistent math requirements and the fact that it is very model centered. It gives students experience building physical models, and with having to provide evidence to support conclusions they draw from experiments (something we find most students are fairly weak at). We spend about a quarter on CASTLE. We have developed our own version of Unit 6 in CASTLE that introduces the use of graphical representation of models via a couple of different Ohm's Law experiments, one of which yields a linear graph with the other yielding an inverse proportion. We let this unit be the bridge to Unit II in the Modeling Mechanics materials. We skip Unit I, having introduced graphical analysis methods in the last unit of CASTLE, and sprinkle the other ideas of Unit I into future units on an "as needed" basis. Units II, III, IV, V, and VII from the Mechanics curriculum are included, with the only modifications being the minimizing of the mathematical expectations in solving problems algebraically. Also, in units IV and V, students don't solve for values of components trigonometrically, even though they are expected to be able to deal with forces through force diagrams in 2-dimensions, and to be able to show with components in force diagrams the net force acting on a system. We include a unit on electrostatics, usually during the winter sometime after the force concept has been dealt with in unit IV. We place a high value on unit VII (Energy) and consider it to be the major thread that links physics, chemistry, and biology. We are dealing with some of the issues that have been mentioned by Gregg, and considered the weaving of the energy thread into our science curriculum a work in progress. Time permitting, we finish the year with a unit on Mechanical Waves.

In the Honors Freshman Physics course, we include the same major units, although in a slightly different order. We introduce graphical analysis in the context of Mechanics Unit II at the beginning of the course. In the first semester we manage to include units II through V in the modeling mechanics materials. These students are fairly functional in algebra, and we teach the course using modeling methodology in a way fairly similar to how it is done with juniors and seniors. We have an experiment in which students graphically build the equations for right triangle trigonometry, and so do quantitative vectors in 2-dimensions with these students. After finishing Mechanics unit V, we do an abbreviated CASTLE electricity unit (sections 1 - 4) followed by an electrostatics unit. We follow this with the energy unit from mechanics. We end the year in Honors Freshman physics with the modeling Mechanical Waves units 1 and 2.

7. As Jane has published regarding the FCI, our Honors Freshmen students do about as well as modeling trained Honors students do elsewhere in the junior and senior years, and considerably better than juniors and seniors in schools with traditional instruction. *More importantly, our regular freshmen students do better than students taught in traditional fashion, despite the fact that they represent the lower 70% of our students rather than the upper 25% that are typically found in most high school physics courses.* **Get that--regular freshmen (lower 70%) demonstrating better understanding than traditionally taught juniors and seniors.** This is hardly a case where the implementation of physics first is harming physics education reform. More specifically, as Colleen has repeatedly pointed out, it is physics education reform. Maybe more importantly, it spurs overall science education reform in our school, as chemistry and biology teachers have worked to adjust their methods to make use of what the students come to them with from freshman physics.

8. Physics taught to freshmen is not intended to replace physics taken during the senior year. In fact our enrollment in our physics courses taught to seniors has changed very little since the implementation of freshman physics. As freshman physics teachers have adopted the modeling method, the senior level physics courses have changed, because we can build on the foundation

laid during the freshman year, and ultimately make more headway toward combatting the "material coverage" problem that is often a complaint of teachers implementing modeling.

9. The chemistry and biology teachers have become champions of the inverted sequence and feel that they are able to do a better job of teaching students based on this sequence. We are still tweaking these courses to try to take maximum advantage of this more desirable course sequence.

Is physics first a possible detriment to physics education reform? At its worst it is no worse than most current physical science programs of which I am aware. However, I believe that in order to represent physics education reform, as it has the potential to do, physics first must be implemented based on research-informed methodology like Modeling. *My experience says that modeling really does work with freshmen and that the inverted sequence enhances the overall quality of science education* that our students receive.

About state standardized tests. This is one of the areas about which we were most concerned for a number of reasons. The Missouri Assessment Program (MAP) tests students in science at the end of their sophomore year. The test covers plenty of biology, and since our students don't get high school biology until their junior year, we are unhappy about the timing of the test. The timing is based on the 2-year science requirement in the state and the fact that for a large number of students statewide, the sophomore year is their terminal year of science. (It is common that these students take physical science in the ninth grade and biology in the tenth grade.) Districts for which that is true don't want there to be a great lag between the end of the science sequence and the taking of the MAP test in science. We are still unhappy about the timing, but despite the fact that our students only biology is what they might have retained from elementary and middle school, *our MAP scores in science are among the top 10% in the state.* These results have allowed us to
resist suggestions that we modify our curriculum to more closely address MAP.

Can these results be replicated in other places? They can if a dedicated group of professionals are willing to work very hard. They can if it is realized that you can't implement this on a large scale without support for the training of teachers, and all of the other elements of support required to implement modeling at any other level. We at Clayton High School are fortunate to be in an environment where such support has been provided and where the teachers involved are dedicated to the success of the program.

Despite my passion for teaching physics first and the "inverted" sequence, I know that it is not an easy thing to do. I don't believe that it has a much greater chance of success than more traditional approaches if it is not properly implemented. I feel strongly that properly supported modeling based physics first programs are great candidates for success. I am not so confident about many of the "non-modeling" based versions of physics first of which I am aware.

I apologize for the long and rambling nature of this email, but I felt like, as one of the more experienced practitioners of a physics first based program, that I ought to put forth my two-cents worth.

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