COMPILATION: high school physics - effect in college (Philip Sadler's work)

Date: Tue, 10 Jul 2001
From: Chris Horton
Subject: Sadler's paper

[Someone] wrote to inquire about Sadler's article in which he brought into question the value of high school physics courses as preparation for college physics.

I don't have a copy of Sadler's paper in front of me so I will have to rely on my memory, but it made a vivid impression on me, as did his talk.

When I was a college physics teacher I sometimes polled my students about their backgrounds and then observed how they performed. I made no statistical analysis but formed some strong impressions. Whether they had had high school physics appeared to make little difference to the outcome of their efforts.

Most arrived clueless, and many remained clueless, although they learned how to solve algorithmic problems. How much math they had taken, however, clearly made some difference, but even those who had taken honors math appeared to have forgotten much of it, and I always had to include algebra lessons in the courses.

Sadler gave a talk at our Physics Alliance meeting at The Univ. of Massachusetts - Lowell and presented his findings to us. None of the physics professors present doubted his conclusions, which were the same as mine but supported by a sample size of over 1000 first-year college physics students at over 20 colleges and universities, and a thorough statistical analysis using tools borrowed from epidemiological studies.

Sadler found that whether the students had taken high school physics made little difference to their success in college physics, as measured by their grades. But there was a significant positive correlation between the amount of high school math they had taken and how well they succeeded in college physics.

It further turned out that which textbook they had used made <no measurable difference> to this outcome! Not one textbook stood out as having made a difference either way! No one who has studied them can deny that these textbooks represent an enormous range of approaches, often by talented and dedicated authors. Yet NONE of them showed up as making any difference! However the students who had used <no textbook> did slightly but significantly better than the others! This was the single most significant effect (other than math background) detected in the study!

One other positive correlation stood out. There was a small but distinct correlation between how long a high school class had spent on mechanics and how well the students from it did in college. The more time they spent on mechanics the better they performed, and no limit was detected on this, it was a linear relationship. As for other topics, it appeared to make no difference what else they studied, or how long they spent on it.

Some surprising negative correlations stood out. (All of these were small effects, but statistically significant.) The more time the students spent on labs, the worse they did in college. And the more time they spent on demonstrations the worse they did.

I personally hated seeing this. I considered myself a master of the demonstration. But I certainly had been impressed with how little difference my favorite demonstrations made to student understanding, even though I delivered them in an interactive way, having the students write down their predictions and then discuss the results. At the end of the course they could correctly predict the outcome of the demonstrations but could not explain the underlying principles.

As for the labs, I suspect that what was being measured was the effectiveness of cookbook style labs. These do nothing to challenge the students' understanding.

…

Sadler's work should be more widely known. I would like to see a popular version of the paper, with good graphics, prepared and widely distributed among high school and college physics teachers, to help them focus on the existence and nature of the problem.

Date: Tue, 10 Jul 2001
From: Jane Jackson <jane.jackson@ASU.EDU>
Subject: Re: Sadler's paper

In spring '97, Dr. Philip Sadler of Harvard University posted on PHYSLRNR, a listserv about physics education research:

"We have another article we are working on that examines how the decisions that both teachers and students make are related to later success in college physics. For example:

* Two years of high school physics is better than one.
* Concentrating heavily on mechanics in HS improved first semester college grades.
* Too many qualitative problems are related to poorer performance later on.
* Coverage of fewer physics topics in great depth seems to improve performance.
* Those with no high school textbook did much better in college than those with.
* Teachers who spent time explaining problems in many different ways had students that performed significantly better, while teachers who were viewed as friendly or knowing lots of physics were not at any advantage."

Excerpts from a '97 draft of:

"Success in College Physics: the Role of High School Preparation", by Philip M. Sadler and Robert H.Tai, Harvard University. This is a study of performance in introductory physics courses for almost 2000 students at 19 colleges and universities in the United States.

(p. 16) "Higher college grades appear to be associated with courses characterized as *covering few topics in great depth, with teachers that explain problems in many different ways, and with teachers turning from the text as the major guiding force to that of a resource.* A considerable portion of the text can be consulted over the course of the year, but there appears to be little advantage to spending large amounts of time reading it or completing a high proportion of text problems. A limited set of topics, dealing primarily with issues in mechanics, appears to be beneficial. This concentration on few topics should not exclude qualitative problems, but teachers should consider carefully the concepts that should be dealt with without mathematics and these issues should be included on tests and quizzes along with quantitative problems. Laboratory experiments as well should be carefully chosen to tie in with major themes and not be overdone.

Fewer lab experiments can be very effective if they relate to critical issues and students have time to pursue them fully. Classroom demonstrations are a favorite activity of many teachers, however there appears to be little to recommend a high frequency. Tobias (1992) found that demonstrations may be entertaining, but are more often confusing. This study finds that extensive discussion after a demonstration appears to be counter productive."

(p. 17) " ... *those teachers who choose not to use a text appear to have a real advantage.* Perhaps, they are freed from the most obvious rubric for measuring how much they have covered and may concentrate on only a few central ideas. Perhaps they use materials that they have written themselves or have been given to them by other teachers or researchers. In any event, avoiding reliance on a text appears to have real benefit."

Date: July 14, 2001
From: DoYost@AOL.COM

Some comments were made about the fact that having high school physics does not seem to affect success in college physics, but that math does have a strong correlation. This data could be interpreted as an indictment of secondary physics , but it could also be a strong comment on the quality of college physics. I can remember very few college physics programs that stressed concepts over math manipulation. Being able to calculate the correct answer was valued, but understanding the concept was often not even required.

I would argue that passing a college physics course is not necessarily a valid measurement of the success of a high school physics program, but is often a reflection of a student's ability at plug and chug.

Date: Sun, 15 Jul 2001
From: Jane Jackson <jane.jackson@ASU.EDU>

Right on, Don. The poor quality of traditional college physics is measured, in part, by Force Concept Inventory posttest scores. For example, David Hestenes has FCI data from traditionally taught calculus-based university physics courses here at ASU. Year after year over the past 15 years or so, the average FCI posttest score is only about 63%. You can read about this in the 1992 paper entitled "Force Concept Inventory", in the back of your Modeling Instruction teachers manual. Last year and the year before, the FCI posttest class average was STILL about 63%.

Contrast this poor class average with Dwain Desbien's sections of calculus-based university physics here at ASU, in which the class average FCI posttest score is always in the 80's. The same content is taught, for the same type of students, but Dwain uses Modeling Instruction. (High FCI posttest class average scores are obtained by Dwain's community college students, too.)

Date: Mon, 16 Jul 2001
From: Colleen Megowan <CKOZUMPLIK@AOL.COM>

I'm really glad Don brought that up--it occurred to me also that this seeming lack of correlation between success in high school physics and success in college physics was as much an indictment of the average college physics course as a condemnation of high school physics instruction.

Date: Mon, 16 Jul 2001
From: Chris Horton

Most senior college physics teachers know in their hearts and admit privately to each other that what they are doing is ineffective.

But isn't there some data to show that modelers do much better in a traditional college physics course? And if so doesn't this indicate that high school physics can make a difference?

[Jane's note: in fall 2001 at ASU we began to collect data on this. It'll take a few years to ascertain the advantage in an objective way. Many modelers report anecdotal evidence of their students' advantage in college. This is reported in the Nov. 2001 compilation, " **Modeling Instruction prepares students better for college"**.]