Conceptual Physics in the VCCS

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Abstract
The author argues for increased and widespread teaching of conceptual physics courses in the VCCS, both to benefit a broad range of students and to support science programs at the colleges.

Conceptual physics (CP) is an introductory survey course in which basic concepts are emphasized instead of formula-driven problem solving. Mathematical derivation is replaced by verbal explanation, pictorial representation, observations of phenomena, and logical reasoning. Algebraic equations are used as guides to thinking rather than recipes for computation. Introductory physics at the CP level is accessible to a much wider population of students than the more math-based introductory courses.

History of the Conceptual Approach

CP was pioneered by two-year college professor Paul Hewitt at the City College of San Francisco. His textbook, *Conceptual Physics*, first published in 1971, remains the leader in the field although there are now several competing texts at this level. If we include in the CP category any introductory physics course which has no math prerequisite, then there are many courses and texts with various titles which fit this definition.

Variations of CP currently being taught in the nation's colleges and universities include the original Hewitt version with local adaptations, as well as other similar courses based on different textbooks, such as *Physics: Concepts and Connections*, Art Hobson's liberal arts physics text, *Physics: A World View*, by Kirkpatrick and Wheeler, or *Physics: A Practical and Conceptual Approach* by Wilson, and others. Two recent courses based on physics education research and intended primarily for prospective K-12 teachers as well as general education or pre-technical students are Lillian McDermott's *Physics by Inquiry* and *Powerful Ideas in Physical Science* from the American Association of Physics Teachers (AAPT). For two-year college students, many of whom are preparing for technical careers, perhaps the most appropriate approach is that taken by Louis Bloomfield in his successful course at the University of Virginia, How Things Work. This is a CP course that motivates the study of physics by understanding the principles of operation of common technological devices. The new Explorations in Physics by Jackson, Laws, and Franklin offers CP in an active-learning format.

Students Served By CP Courses

Most four-year colleges and universities and some two-year colleges offer some version of CP in order to serve a clientele of students who would not be able or willing to take a math-based physics course. These include students in liberal arts, education, business, and other majors that have a lab science requirement, as well as allied health and "soft" technology programs in which a basic understanding of physics is needed. Students in electronics and engineering technology programs who did not take physics in high school (and most do not) also benefit from a qualitative introduction to physics before tackling the more math-based course required in their curriculum. The conceptual approach is also appropriate for the physics component of a physical science general education course, especially for prospective K-12 teachers. Some students would like to take physics just because "it sounds interesting," but are daunted by the math requirements of most physics courses. A CP course is a valuable educational experience for *all* of these students.

Unfortunately, two-year colleges, including those in the VCCS, are shying away from CP. A recent national survey of two-year colleges reported that only about 16 percent of students who take physics at two-year colleges take CP (Neuschatz, p. 10) The Virginia Community College System's Transfer Module includes PHY 101-102, Introductory Physics, which has no math prerequisite and is taught at the conceptual level. According to the *VCCS Master Course File* website, in 2002, only three VCCS colleges taught PHY 101-102, and one taught PHY 100, the one-semester version.

This situation may be partially due to "transfer anxiety"; faculty in two-year colleges want to be sure that students who transfer to four-year schools do not lose credits and that they can hold their own in competition with other students at the four-year institution. There is some concern that CP is not "real physics" and not a legitimate college-level course.

Nevertheless, consider that most *four-year* colleges and universities teach CP themselves and offer transfer credit for it in most majors. The American Association of Physics Teachers (AAPT) publication *Guidelines for Two-Year College Physics Programs* includes "Physics Courses for Non-science Majors" in a list of courses appropriate for two-year college physics departments, and states that "The physics component of these courses would generally be conceptual" (p. 10).

Of course, some two-year colleges already recognize the need for CP. The North Carolina Common Core Curriculum includes CP as a "guaranteed" transfer course. In fact, CP has the largest enrollment of any physics course in the North Carolina Community College System (McAlexander).

Widespread Benefits

Engineering, physical sciences, and pre-med are majors for which transfer credit for CP is not appropriate, but, even in these cases, CP can serve as a "bridge" for those students lacking high school physics. The need for a stronger conceptual foundation for most physics courses is a consistent and strong finding in recent physics education research (McDermott and Redish).

The National Science Foundation report *Shaping the Future* advocates broadening the scientific education of undergraduates to include all students, not just those preparing for technical careers. This report also pointed out the important role of two-year colleges in science education, particularly for prospective K-12 teachers (George). Clearly, studying physics at the conceptual level would improve the scientific literacy of college students in general and would be especially valuable for those going into elementary or middle school teaching. One of the four "critical issues" identified by the AAPT Executive Board is to "increase the diversity and numbers of physics teachers and students" including promotion of "physics for all" (Khoury).

Conceptual physics courses at two-year colleges can take different forms and serve various student and institutional needs. Many two-year college physics departments facing declining enrollments, due in part to curricular changes in technical programs, could reach out to an untapped clientele of non-technical students by offering and promoting CP as a lab science elective.

At Tidewater Community College, PHY 100 is offered in both fall and spring semesters. Physical Therapy students enroll (it is required), as do some students with no high school physics preparation, those who need it as a preparation for the algebra/trig-based course, and some non-science students who choose it as a lab science elective. Professor David Wright reports that this is a successful course with steady enrollment and that he is considering ways to expand and promote it:

> From my prospective it is a fun class to teach, because most of the students have never had physics before, and so it is all new to them. I try to open their eyes to the "wonder of physics." Because it is a conceptual course, we can spend more time on the concepts than is possible in the Algebra and Trig course. I try make it as practical as possible. We take a field trip to Busch Gardens; we use Hewitt (which really emphasizes practical applications), and do lots of demonstrations in class. I hope that they leave the course with new insights into how the world works (Personal communication, Nov. 11, 2005).

Sherman Frye started teaching CP at Northern Virginia Community College more than twenty years ago:

> The lecture material covers all of the main concepts in physics and the lab work is equivalent to the college physics course given to pre-med majors. We now have at NVCC three campuses offering up to 6-8 sections of PHY 101-102 each semester. Students that typically take the courses include liberal arts, pre-teacher education, veterinarian science, physical therapy, business, general studies, and science majors who have not had physics in high school. . . . I might note that with the addition of this physics course, our physics enrollment has remained steady and firm over the past 10 years. The PHY 101-102 course is one of the most popular of the physics courses at NVCC (Personal communication, April 7, 2005).

Frye also developed a distance-learning version of this course using Paul Hewitt's videotaped lectures (Hewett, 1992), in addition to some of his own videotaped material. Students used take-home kits for laboratory activities, plus two on-campus labs and two "field-trip" type labs. Since Frye's retirement, the distance learning version of PHY 101-102 is no longer available, and fewer sections are offered – although these are usually filled (Personal communication, April 7, 2005).

Arthur Bryant of Sandhills Community College in North Carolina describes his experience with CP:

> Sandhills Community College selected Conceptual Physics to meet the physics requirement for the Automotive Systems Technology (AAS) and Auto Body Repair (Diploma) Programs starting in the fall semester of 1997. This was the correct

> Physics course for our automotive programs. That first semester, we had the largest number of automotive students ever to complete a physics course (26) and the fewest number to fail (2).
>
> The automotive students knew they were enrolled in a college transfer course, and their final grades and attendance showed that they were ready for the challenge. The college transfer students in the class . . . had a very positive influence on the automotive students, providing a diversity of classmates. I would not, if asked for a recommendation, choose to return these students to a technical physics course.
>
> For a conceptual physics course to be a success with these students, you will need the full support of the automotive faculty. Here at Sandhills, our automotive instructors give their full support to the course. They take this attitude even with the students enrolled in certificate options within their programs, constantly reminding their students of the need for an understanding of basic physics. The automotive instructor's support makes a strong physics class possible (Personal communication, June 10, 1998).

My own experience with CP aligns with that of these colleagues. I have taught PHY 101-102 at Lord Fairfax Community College since 1989. The students are mostly in non-science transfer programs, including prospective elementary school teachers and respiratory care students in a 1+1 articulated program who take only the first semester. I am not aware of any problems with students transferring this course. Since 1992, I have used the Force Concept Inventory (Hestenes, Wells, and Swackhamer, 1992) as a pre-test/post-test assessment of all my first semester classes. The gains (about 0.2) shown by the CP classes have been about the same as those shown by my algebra/trig-based and calculus-based classes.

Recommendations

CP is a useful and appropriate course for many college students in a wide variety of programs and with various academic goals. VCCS colleges should provide greater opportunity for its students to take this course.

We can increase the number of CP courses offered in the VCCS by taking several actions. First, we can encourage and support faculty efforts to offer CP courses. We can ask faculty who are currently teaching successful CP courses to share their experiences with their colleagues who are considering or developing such a course. As more faculty introduce a CP course at their colleges, we must make sure that appropriate administrators, advisors, counselors, and other faculty are aware of the nature of the course and the students it is intended to serve. Likewise, as a CP course is first offered at a college, the college community must promote it to potential students and local high schools. Finally, our VCCS leaders must work with four-year colleges and universities to remove artificial barriers to transfer of courses that are similar to those they themselves offer.

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