Physics 100—Science Literacy

What to do with your physics course for nonscience majors

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The great ideas of literature and philosophy are expected to be in the repertoire of all educated individuals, and yet, in a democratic society where citizens vote increasingly more often on issues concerning the interplay of technology and the environment, true science literacy is not demanded of nonscience students.

To address this lack of science literacy, I designed a course and taught it in the summer of 1990 as an alternative approach to the standard one-semester survey course for nonscience majors. The 14 students in my class were majoring in business, psychology, philosophy, and general education.

For the course I chose eight broad categories to represent some of the fundamental ideas of physics: Newtonian mechanics, thermodynamics, relativity, electricity and magnetism, electronic structure of the atom, quantum mechanics, nuclear structure, and the relationship between mathematics and physics. I selected current general-readership science articles to correspond to each of these eight fundamental areas and assigned them as reading prior to a class discussion. During the classroom discussion each article was analyzed line by line for content and accuracy using P.G. Hewitt's *Conceptual Physics*[1] as a reference.

One article that provides good examples of the procedure followed in the course and serves as an excellent introduction to basic aspects of mechanics is J.F. Coutes's discussion of the Roman trireme.[2] Coutes reports on attempts to reconstruct a full-scale working model of the ancient ship based on written descriptions and simple mechanical limitations. It is easy to extend comments on the speeds achieved by ship crews in ancient times to motivate a classroom discussion on average and instantaneous speed and acceleration. The effect of viscosity and friction on maximum boat speeds provides an opportunity to examine Newton's laws and the relation of force to acceleration. An opportunity for a discussion of power is presented from comments on the number of crew members and the available human power. Stability of the trireme involved the builders in a calculation of the center of gravity by applying Archimedes' principle, providing us with topics for classroom discussion.

There are several advantages to approaching the content of the course in this fashion. Some concepts appear in several articles and are thus reinforced by repetition. Another strength is that different areas of science can be seen as related to each other and not as isolated bodies of knowledge.

In order to motivate students in the course and to test the depth of their understanding of the concepts, I gave biweekly quizzes consisting of hypothetical thought problems similar to questions found at the end of each chapter in Hewitt's text. Problem-solving, in-class tests were not given.

The students performed 12 experiments relating to classroom discussion on a weekly schedule. By this means they learned how to take and analyze data, how to tell if data support a theory, and how data are related to mathematical equations. By looking at standard deviations and relative errors, students began to understand how strongly or weakly data support a certain conclusion and how this can leave room for further interpretation or a better theory.

By looking at the relationship between equations and data, students also saw how mathematics works as the language of physics. The strong math anxiety sometimes evident in nonscience students was abated somewhat by placing the math component in a laboratory setting. Mathematical manipulations seemed to be less threatening in a group setting where I was available as a consultant.[3]

To hone their reading and analytical skills and encourage a healthy, informed scientific skepticism, I required the students to find two science articles on their own (with my approval), which they were to analyze using the same approach used in class. These two exercises included finding reference sources for new concepts and writing an expository essay demonstrating an understanding of the material appearing in each article. Students were allowed to rewrite the essay if they were not satisfied with their grade. The essay assignments were coordinated with the writing laboratory on campus so that additional help was available to the students with problem essays. Students were also asked to comment in one or two lines why they chose a particular article. This proved quite revealing. One student did an extensive analysis of an article on submarine noise-reduction techniques and gave as her motivation the fact that her husband was stationed on a submarine.

In order to further enhance critical reading skills in science, I also asked the class members to find and comment on examples of incorrect or misleading science articles. Requiring this kind of careful reading brings students to an appreciation of the exacting nature of scientific terminology and logic and the strength of the conclusions that can (and sometimes cannot) be drawn in the sciences. This proved to be one of the more difficult assignments in the course, although all students did eventually find at least two mistakes each. Students found such typical mistakes as an article reporting that a prisoner was electrocuted when 100,000 volts of current flowed through his body.

One change I will make in future offerings of the course is to ask the students to keep a running vocabulary list of terms encountered in the articles that had a special scientific meaning different from the normal one. Another improvement will be to ask students to look into the recent history of a particular scientific endeavor, preferably one which has not yielded general scientific acceptance, for example, the cold-fusion controversy. From this students would gain a sense of the ongoing and controversial aspect of scientific inquiry. Other historical perspectives of scientific progress that could be examined might include the political aspects of some scientific projects; for example, the decision of where to build the superconducting supercollider.

Science literacy for the voting public should be a high priority of the physics community. Hopefully the course described here is a step toward that goal.

References

1. P. Hewitt, *Conceptual Physics* (Scott, Foresman, Glenview, IL, 1989).
2. J.F. Coutes, "The trireme sails again," *Sci. Am.*, **260** (4), 96 (1989).
3. S. Tobias, *They're Not Dumb, They're Different; Stalking the Second Tier* (Research Corporation, Tucson, AZ, 1990).