Research vs. Teaching: An Ethical Dilemma for the Academic Physicist

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I. Introduction

The usual discussions of academic ethics and freedom revolve around the issues of what we may teach. Here, I'm concerned with how we teach and examine. Thus this paper is concerned with process rather than substance--perhaps an unusual concern for an academic but currently of interest to me, having recently served a year in the federal bureaucracy where process is dominant over substance.

A physician who knew of improved procedures to facilitate the health of a patient but chose to use older, proven less effective, means, purely for his/her own convenience, would clearly be guilty of medical malpractice--unethical behavior. I contend that the same accusation is valid against many university physics faculty engaged in the traditional forms of teaching introductory physics, to the growing bodies of non-traditional students, and showing very little concern for what these students are actually learning. This failure to distinguish between teaching and learning not only has ethical implications; it contributes to the growing public disenchantment with its public universities, the decline in support and resources extended to such academic institutions, and to a swelling chorus of attacks on tenure and other customary and useful faculty prerogatives. Tenure has honorably served as protection for the ethical curmudgeon in academia. Growing unethical behavior of the academics will remove this protection from all--ethical and pragmatic alike.

II. Expectations of Physicists in Public Research Universities

Physicists at typical public research universities have three roles to balance: research scientist, public citizen, and teacher. In the role of research scientist, physicists are expected to help maintain the United States' leadership position in research despite increasing limitations on resources. As our society attempts to prioritize its, belatedly recognized, finite resources, grant competition is increasing while support for research facilities is decreasing.

A second component of being a research scientist is training others to carry out research. We continue to do well in training new research physicists; however it is not clear if we are doing as well as in the past. We certainly continue to turn out superbly competent individuals but we are drawing on a larger, international pool of students and have access to bigger and better resources than were previously available. There are also some hints that the contemporary students and graduates are more narrowly focused than those of the recent past.

The role of physicist as public citizen includes providing advice and service to the public on both a local and a national level. Such service may be of a formal nature through government commissions and other official structures, it may occur through panels or study groups put together by a professional organization, or it may be much less formal in nature, involving a letter to the editor or a radio interview. While the physics community as a whole is reasonably effective in this role, too few individual physicists engage in it. This point is illustrated by noting that fewer than one in eight members of the American Physical Society are members of its Forum on Physics and Society.

The final role, physicist as teacher, is the focus of my ethical and pragmatic concern in this paper. It is clear that students and society are turning away from physics--enrollments, respect, understanding, and budgets are all declining. A deeper understanding of the role of physicist as teacher can help halt these declines.

III. Expectations of Society from its Public Universities

Society is growing increasingly concerned about both the escalating cost of public universities and the apparent decline in the quality of the "product" (i.e., the graduates). These concerns were highlighted in a recent issue of Newsweek which reported on the typical expenditure of one thousand dollars per week to educate an undergraduate student. Much of this cost is reflected directly in the student’s bill at private universities, but the cost at public universities is comparable once public funding is accounted for. Elites from the business community characterize the payoff for this investment as being a class of graduates which are most often non-knowledgeable, non-thinking, non-flexible, and non-capable of new learning. Yet we like to think that the products of a good science education should be very knowledgeable, thinking, flexible, capable individuals.

When we look specifically at the sciences, we find that a higher portion of the American population has studied science formally at the college level than is true of any other population, now, or in the past. Yet there is growing distrust of and antipathy towards science, and there is an increasing susceptibility to pseudo-science (e.g. astrology, creationism, flying saucers, magical cures). There is, in fact, a growing body of data indicating that students learn little in our usual introductory physics courses. Hestenes has administered conceptual physics diagnostic tests at the beginning and end of traditional physics courses and found little improvement in too many cases. Anecdotal evidence through word of mouth and through Sheila Tobias’s more careful study further support this view.

According to NSF studies, students are not only not learning much in our courses, they are walking away from our programs in droves: "Despite high levels of freshmen intentions for an S&E major, in actuality, the percentage of students majoring in natural science, mathematics, and engineering fields declines from 27 to 17 percent between freshman and senior years. Women and minorities experience even higher rates of attrition." And after their formal education, which officially includes a great deal of formal science education, the American people are distrustful of science and--to a large extent--ignorant of its methods and results: "... over 50 percent agreed with the statement that ’many scientists make up or falsify research results to advance their careers or make money.’ The tendency to believe that many scientists falsify results was only partially offset by a recognition that the scientific tradition of repeating other scientist’s work provides a check on fraud or cheating." "...evidently not more than a third of American adults have a minimal understanding of scientific processes." "However, fewer than half of the respondents knew that the earth travels round the sun once a year or that electrons are smaller than atoms; about the same proportion did not accept the idea of evolution. While the response indicate some understanding of the planet, a majority of adults apparently do not understand the nature of the solar system or the origin of stars or galaxies. The American understanding of science is, indeed, rather earthbound." "The results of the 1992 study point to substantial gaps in the public understanding of environmental science concepts." Even when in school, Americans’ insight into science is woefully lacking: "Only a third of 1993 high school seniors accepted the idea of evolution; almost a quarter did not. Only 44 percent agreed that life could have developed on other planets. Only 37 percent rejected the idea of lucky numbers."

The American public, in paying its tuition dollars, thinks it is paying for teaching. It does not seem to distinguish between teaching and learning, and it is growing increasingly disenchanted with the end results. It is aware of the human and physical resources wasted due to the large and growing student drop-out rates.

IV. How is Introductory Physics Usually Done in Large Universities?

Introductory physics courses are typically taught to large, passive audiences using lectures closely following the text. Occasional lecture demonstrations are included. In the traditional format it is alright to remind students of their acquaintance with the physical world upon which science is to be built, but growing numbers of students have very little effective acquaintance with the physical world! It is also alright to point out the structure of science (logical relations and the importance of consistency) and discuss this in the light of ideas about the physical world already in the student's mind. However, television addicts may have little notion of consistency, since their world is made up of changing and contradictory images. Couch potatoes have few logically consistent ideas about the physical world.

How then is it that these trends do not raise more warning flags in the academic community? The discrepancy between how much teaching takes place and how little learning takes place is masked by "lowering the bar" on exams or by giving a priori guarantees as to the grade distributions.

V. Alternative Student Paradigms and Teaching Methods to Address These Problems Exist

It is very important to realize that the typical student in an introductory class is not a clear blackboard upon which the teacher can write. Extensive erasing of erroneous non-Newtonian concepts must be done. Both teachers and students must be made aware of these non-Newtonian preconceptions and their conflict with successful modern ideas before the students can successfully master the Newtonian concepts.

What approaches are successful in helping the students learn? First, student interaction in small groups is known to be an effective tool. Second, continuous feedback from students via multiple oral questioning, quizzes, and exams is required. This feedback not only serves to let the students know where they stand but it also lets the instructors gauge how successfully they are conveying physics to the students. Third, student familiarity with the "real world" must be enhanced via many in-class demonstrations, laboratory experiments, at home experiments, and practical examples. Simple, non-abstract participatory examples are very important. Finally, individualized tutoring and repetitious exercising can be effectively done via desk computers.

There are other, more general structural considerations which are also important. More is not better: Prioritization of material taught must be based upon career and life requirements of the specific student body. Moreover, moderate "pressure" must be kept on the students. Easy drop and grade policies for students, though often resulting in high faculty "grades" in immediate student evaluations, lead to superficial (at best!) student learning.

VI. An Ethical Dilemma: Why Aren't These Widely Understood Ideas More Widely Used?

The alternative approaches to teaching just described require both time and commitment from the instructor in order to introduce them into the classroom. Furthermore, they may require additional physical and staffing resources from the department. If instructors are to take a firm stand on maintaining academic standards, they will need support from both their colleagues and the institutional bureaucracy. It is difficult to maintain standards when instructors are under the gun to keep students satisfied with high grades or when students flee one section of a course for another whose instructor is perceived to be easier. (I've had students stand up in class to say "Why are you trying to make us think?" and then transfer to other sections where, presumably, thinking is not required!) Finally, both the department and the school hierarchies must provide emotional and financial support, specifically by recognizing the importance of effective teaching when performing evaluations for tenure, promotion, and merit raises. In doing so, they must recognize that effective teaching is not implied by "successful" student evaluations.

A major fraction of American "research universities" do not have long, well-established, research ethos and traditions. They see research and external research support as a way of gaining institutional prestige and of generating additional internal funds which the administration can manipulate. Hence there is great external pressure on young faculty (in addition to varied internal drives) not to let teaching commitments or interests interfere with "productive research". Furthermore, it is hard to immediately gauge results of effective teaching in the American educational system in which, most often, the teacher and the examiner are one and the same person. It is much easier to gauge the number of research papers and the number of external grants received. Hence, in spite of the common rhetoric, effective teaching is not commonly rewarded though pandering to students and research (effective or otherwise) usually is.

The context in which this dilemma takes place varies from one institution to another. There are the old-line research establishments: When you are assured of your support, prestige, and standing as a researcher, it is easy to contemplate producing one less research paper in a year and instead think more about faculty teaching and student learning. It is even easier when your only teaching responsibilities are in the area of your expected research productivity. At the other end of the spectrum are the purely teaching colleges. There the only limitations are the availability of resources and the capabilities of the faculty and students. However, even in this setting there may be pressures or at least urges to publish. This setting also raises the question of whether the often claimed relationship between engagement in research and teaching capability is a reality. The final setting is the new "research university." To succeed in this setting, faculty must constantly reiterate that they are "researchers", not letting any opportunities for research paper production or grant securement go by untouched. Faculty are encouraged to get by with the minimum teaching effort and not to rock the boat. The primary concern for students is that they pass, not that they learn!

VII. Research vs. Teaching: the Graduate Student Dilemma

Concern with teaching implies concern with the well being of the student. However, there may be conflicting interests among different groups of students, as is the case between graduate students/teaching assistants and undergraduate students. The graduate students' primary goal is to get a degree while supporting themselves with assistantships. Teaching a lab or recitation section may be viewed as a diversion from this goal. The undergraduate student on the other hand typically wants an instructor who is motivated to teach the class. Furthermore, in the past it has always been assumed that the interests of graduate students and their faculty advisors coincided. Now the concern of faculty (for pushing out the research) and of students (for preparing for a productive career) may be in contradiction. In particular, as the job openings in academia dwindle, having students focus on traditional academic topics to the exclusion of aspects which may have more application in a wide variety of corporate settings may help the faculty advisor's research program at the expense of the student's job prospects.

VIII. Concluding Remarks

Some faculty avoid the ethical dilemma of conflicts created by teaching priorities and research priorities by giving up research and concentrating on teaching. They either remain in their initial institutions or transfer to more teaching-oriented ones. They may not necessarily end up as better teachers.

As society's infatuation with, and support for, research lessens, the less gifted and/or internally-driven researchers may leave the field. The remaining "teacher-researchers", being "better researchers", may have less internal and external constraints on their road to becoming good teachers. However, they still may not have either the gift or the interest to teach well. Finally, this is a human dilemma, perhaps to be treated in the same way society treats the corresponding medical dilemma. Great effort should be expended to find a means to determine who teaches well. Those who do teach well should be rewarded; those who don't should be shunted into alternative fields through counseling, internal drives, or external threats of malpractice.

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