SHOULD PHYSICS STUDENTS TAKE A COURSE IN ETHICS? -- PHYSICISTS RESPOND

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I. Introduction

Should physics students take a course in ethics? A National Science Foundation grant was written by the authors in an attempt (in part) to answer this question. One might first ask, Why might physics students take a course in ethics? There are three reasons that might combine to persuade one of the necessity. First, the formal training can be quite practical and useful in the daily life of a physicist, as discussed below. Second, the National Science Teachers Association suggests an ethical component in the training of high school physics teachers (NSTA Standards for Science Teacher Preparation, available at www.nsta.org). Third, there is increasing pressure from the National Science Foundation (NSF document 96-102) and the National Institutes of Health (NIH Guide, V.21, No.43, Nov. 27, 1992).

As of this writing, there are few ethics courses available purely for physics students. The authors know of only two -- the one taught by Marshall Thomsen at Eastern Michigan University, and one taught at Evergreen State College in Washington. Other courses are in development, as the idea/necessity is catching on, and many other more focused courses exist (e.g. on specific societal issues). One barrier to the development of such courses which has come to the authors' attention (and to the attention of others considering such a course) is the lack of a suitable textbook. The aforementioned grant was written, in part, to begin development of a textbook by holding an ethics workshop, the proceedings from which would become the basis of a text.

In an attempt to gather information from the physics community to target and address relevant issues for such a course, a survey was sent to over 400 members of the American Physical Society's Forum on Physics and Society and other physicists who may have an interest in this area. The sample population was intentionally biased in this way to try to obtain a better response rate. The key questions asked were, *What, if any, course should be taught?* and *What issues should be addressed?* Two subgroups of the targeted population -- physicists in academia and physicists in industry and government labs -- were sent two different surveys. Results are discussed below. Unless otherwise noted, all respondents not affiliated with academia are combined under the generic heading of "industry".

II. Sample Population Description

Of the over 400 physicists who received the ethics surveys, 137 responded. Of the 137, 56% (77) were identified as being from an academic setting (university, private college, community college, etc.) and 44% (60) were working in industry or a government lab. Different surveys asking differently connotated questions were sent to each group. The sample was 89% male and 11% female reflecting the continuing male dominance of the field. Other descriptive statistics for the two population samples are shown in Table I below.

Table I - Descriptive Statistics

Academia

Age range:
7% under 30 yrs 31% 30-45 yrs 23% 46-55 yrs 40% over 55 yrs

Type of Institution:
3% 2 yr. community college 23% 4 yr. college 48% public university

23% private university 3% other
Field: 47% theoretical 53% experimental

Industry

Age range:
2% under 30 yrs 34% 30-45 yrs 34% 46-55 yrs 31% over 55 yrs
Employer: 52% government lab 40% private industry 8% other
Field: 17% theoretical 63% experimental 8% both 12% other

We notice that the academic population tends to be a little older, although since specific ages were not requested, an actual average age could not be computed. Nearly half the academic physicists were from public universities, and just under one-quarter were from private universities. The distribution of institutions represented did seem to influence responses to some of the questions asked, as we shall see. It was an almost half and half split between theoretical and experimental physicists in academia, in contrast to many more experimental respondents from the population sample from industry. The industry sample tends to be more middle-aged, with a little over half in government labs, and only slightly fewer physicists responding from private industry. The "other" 8% were from non-profit organizations which seemed to have an affect on their responses to survey questions. The "other" field category represents supervisory/advisory positions. The academic sample was 88% faculty (5% students, 7% post-docs). Most of the industry sample (90%) had Ph.D.'s. The specific field of respondents from the academic sample, in decreasing frequency (numbers indicate multiple responses), are shown in Table II below.

Table II - Specific Field of Respondents in Academia

condensed matter/solid state/materials research (31)
particle physics (10)
nuclear physics (6)
atomic physics (4)
biophysics (4)
computational physics (3)
history of physics/women in science/physics & society (3)
surface science (2)
fluid dynamics
quantum physics
cosmic rays
plasma physics

Notice the preponderance (40%) of condensed matter, solid state, and materials research physicists employed in academia (and in contrast to the number from the industry sample below, reflecting 17%). The authors are unsure of the meaning of this statistic and do not know if it is representative of the larger population of physicists in the country. It may mean that these physicists are less employable outside of academic settings, or that they are merely more likely to respond to surveys about ethical issues in physics. The specific fields of respondents from the industry sample, also in decreasing frequency (and showing a little more diversity), are listed in Table III.

Table III - Specific Field of Respondents in Industry

high energy physics/cosmic rays/nuclear/particle (10)
solid state/condensed matter (10)
optical physics/lasers (7)
chemical physics/materials science (6)
plasma physics (5)

solar/astrophysics (4)
operations research (3)
electronics/instrumentation (2)
magnetism (2)
electrical/mechanical engineering
fluid dynamics
magnetic resonance imaging
science and technology policy
medical physics
photovoltaics/energy
ultrasonics/shock physics
geophysics
computer science

When asked for a categorical job description, of the 60 physicists in industry, 23 were in applied research, 21 in managerial (supervisory) or advisory positions, 13 in basic research, and 11 in both basic and applied research. (Some physicists have more than one role, so the total is greater than 60.) It is important to note that just over a third of the sample were involved in management or advisory positions, which seems to have had an important bearing on the responses to the survey questions regarding ethical issues.

III. Academic Survey Questions and Results

The physicists in academia were basically asked four questions -- all related to the desirability and feasibility of offering an ethics in physics course for undergraduate and/or graduate physics majors. First, they were asked if they believed that a formal study of ethical issues in science should be a *requirement* for physics majors at the undergraduate level and/or the graduate level. For the undergraduate level, 32% thought it should be a requirement, 57% thought it should be an elective, and 12% thought it should not be required at all. At the graduate level, responses were not too dissimilar, with 37% voting for a requirement, 40% suggesting it be an elective, and a higher (compared to undergraduate) 23% saying neither should it be a requirement nor an elective, perhaps some of them assuming it to be an elective or requirement at the undergraduate level. When asked to make comment on their responses, the majority of physicists were supportive -- which is reflected in the combination of required and elective responses (89% for undergraduate and 77% for graduate), although some suggested that a full course would be a bit much, and that a seminar would do just as well. Another suggestion -- which eschewed a full course but agreed with the idea of studying ethical issues in general -- offered the idea of integrating ethical issues into existing required physics courses in the curriculum for a physics major. It is unlikely that this idea would become a reality, given the many comments to this and other questions to the effect that there are too many classes to take and too much material to cover in them already. Yet other respondents suggested that it may only be necessary for advisors to make graduate students aware of ethical issues in their advising, and to "teach by example," as role models for their students. Those who were opposed to offering an ethics course in the physics department suggested that perhaps the study should not be confined to ethical issues specifically in physics, but should entail a broader context of science and ethical issues. Of the minority of respondents who felt studying ethical issues in physics should be neither a requirement nor an elective at the undergraduate or graduate level, some suggested that ethics cannot be improved with study. The perspective is that by college, you "either have it or you don't." A similar caveat is that physics is "ethical by nature," implying that the entire idea of unethical physics is an oxymoron -- a statement that perhaps underestimates the human (i.e. not infallible) aspect of any scientific endeavor.

Given the likelihood of a mixed response to this first question regarding requirements, the second question asked if the physicist thought it would be important for physics majors at least to have *access* to a course focusing on either ethical issues in *science*, or specifically ethical issues in *physics*. Ninety-one percent of respondents thought it important for physics majors to have access to a course on ethical issues in science, but only 28% thought it important to have access to a course on ethical issues specifically in physics. When asked to elaborate, comments suggested that there are plenty of good ethics problems in other sciences which could adequately acquaint the physics majors with some ethical issues -- without appreciably compromising the physics curriculum.

The third question posed to the academic physicists population sample attempted to zero in on some commitment on the part of these physicists as to the feasibility of actually offering an ethics in physics course for *physics credit toward a major* in their department. Over a third (39%) did not think their department would even be receptive to offering any credit for such a course. Another third (33%) were not sure, but 29% thought it would be possible to offer some credit (one, two, or three hours), with the majority (19% of the total) opting for offering a one credit hour course. The most common caveat was that there are too many requirements for a physics major, and there simply is no room for another course in the curriculum. Physicists teaching at smaller colleges or universities also didn't think they had enough students for such a course to run. Other physicists speculated that there was probably no one qualified or interested enough in their department to teach such a course.

A fourth question was asked regarding the possibility of creating an *interdisciplinary* course -- perhaps run by both the physics and philosophy departments -- focusing on ethical issues in physics. The responses were slightly more positive with 43% of these physicists answering that this was probably possible, 32% thought probably not, and 25% were not sure. Those who felt such an interdisciplinary effort was possible tended to be from private universities. Many from public universities cited political obstacles to creating such a course.

Finally, the academic physicists sample was sent a topical outline for the ethical issues in physics course offered at Eastern Michigan University (a one-credit hour course required of all physics majors), and asked to delete from the list those topics that might be viewed as unnecessary or undesirable for some reason, and to add other topics that might be useful for studying ethical issues in physics. The outline is presented in Table IV. Numbers in parentheses indicate the frequency of deletion by the 77 respondents.

Table IV - Ethical Issues in Physics Course Outline

Introduction to Ethics
- Ethics terminology (3)
- Ethical standards in physics (4)
- Dealing with conflicting standards (1)

Research Issues (1)
- Data analysis (3)
- Fraud, carelessness, and self-deception (2)
- The publication process (3)
  - responsibilities of authors (3)
  - responsibilities of referees (4)
  - authorship criteria (4)

Physicist as Public Policy Science Advisor (3)
- Impartiality (4)
- Political interpretations of technical advice (5)

The Manhattan Project (8)
- Physicists and their responsibility: (6)
  - for consequences of their research (6)

for their obligation to do research for their country (8)
Flow of Information (4)
In academic, industrial, and military environments (4)
Funding Issues (3)
Truth in advertising in formal proposals (3)
Obligations when receiving funding (5)

Only the Manhattan project and the subheadings of physicists' responsibility for consequences for their research and obligation to do research were deleted by an appreciable number (even so, by only about 10% of the respondents). Most of the respondents who deleted this topic indicated that the reason was that the example is so outdated. Table V lists the additional issues which were suggested by the academic physicists (numbers represent frequency of the responses).

Table V - Academic Physicists - Suggested Additional Issues for Course
Weapons/SDI/military (6)
Public education/truth in media (5)
Research credit (3)
Funding/monopolies (3)
Risk assessment/effect of science on public (3)
Human radiation experiments/informed consent (3)
Policy advice in face of scientific uncertainty/statistical error/limits (3)
Responsibility in review/proposals (2)
Conflict of interest (2)
Sexual harassment (2)
Whistleblowing (2)
Compare Manhattan project with other countries/regimes; cultural ethics (2)
Plagiarism (2)
Cheating/record keeping (2)
Teaching all sides of an issue/academic standards (2)
History of ethics (2)
N-rays
Bureaucracy/"dumb" regulations
Teaching vs. research
Practical consequences of ethical behavior
Nuclear power/waste
EM fields on health
Pure vs. applied research
Software piracy
Letters of recommendation - truth and confidentiality
Hiring practices
Religion and science
Responsibility to colleagues
Responsibility to society
Social influence of science
Self-deception

Given that this was an open-ended question (respondents were not prompted in any way), it is interesting to note that despite the frequent deletion of the Manhattan Project from the original list, similar categories (weapons/SDI/military) still top the list. The sheer number of suggested issues was also somewhat surprising -- perhaps an indication of how much thought these physicists have given to ethics, despite their overall reluctance to include specific study of such ethical issues in the physics curriculum.

IV. Industry Survey Questions and Results

The physicists in industry and government were basically asked two questions: 1) Do you think it would be valuable to your lab or department if entering physicists had taken a course dealing with ethical issues in physics? and 2) What ethical issues (such as conflict of interest) would it be *most important* for a research physicist *in your lab or department* to understand (either through formal training or on the job instruction)?

An overwhelming 74% answered "yes" to the first question. It *would* be valuable if physicists had a course on ethical issues in physics. We can see some variability in the reasons for the yes or no choice in the separation of comments made by physicists in government labs, private labs, and non-profit organizations in Table VI.

Table VI - Comments on Yes or No response to Question 1

Yes - Government Lab
Office politics
Voluntary course/broaden views
Intellectual property important private industry
Trust co-workers; customers pay for reliability
3 hours good course length
Formal course not required major of physics
Deal with issues daily
Course not replace work environment which encourages ethical behavior
Good to remind of obligations as humans
Should have some ethics, not necessarily physics
American social collapse; no more honesty or integrity
Pressure to overclaim certainty
Forum or informal course
Issues cross disciplines
All actions should be ethical

Yes - Private Industry
Avoid public relations problems
What priority of course?
Large, complex organizations mistrust employees, conflict of interest
Discussion groups may be enough
Industry different from university
Need broader outlook
Fraud, carelessness, self-deception
Not just focus physics; 100x increase defense science
Teamwork, relationships
Good physicists have to set example

No - Government Lab
Berkeley and Cal Tech established honor system
Government labs higher ethics than universities obvious
Course not effective - complex roots (2)
No ethics problem in physics - peer review works employers
Fraud unthinkable in lab unsuitables

Neither-Gov. Lab
Seminar appropriate
Unethical behavior

Neither-Priv. Ind.
Effect immaterial on
Interviews weed out

No - Private Industry Depends on course
Ethics learned young
Integrity and common sense enough
Little value for everyday setting
No - Other - Non-Profit
Course best in history/philosophy
Ethics in culture of science

Some physicists did not respond yes or no ("neither"), but made comment, nonetheless. Some of the "no" comments echo the beliefs of some of the physicists from academia (e.g. ethical behavior having complex roots and cannot be taught, and that there is no ethics problem in physics). No one from a non-profit setting answered yes -- indicating an ethics course would not be valuable to them. Perhaps when one removes the profit motive, unethical behavior disappears. However, most of the "yes" respondents made it quite clear that ethical issues are an important component of their work, whether it is in the context of office politics, intellectual property rights, trust and reliability, pressures to overclaim certainty, conflict of interest, fraud, carelessness, or the lack of honesty and integrity in much of American society. For some, ethics issues arise on a daily basis.

The second question then focused on those issues that would be most important for a physicist working in a lab to understand -- either through formal training or on-the-job instruction. As an open-ended question (with only the "conflict of interest" prompt), it generated quite a variety of responses, as can be seen in Table VII (where numbers indicate the frequency of a particular response).

Table VII - Ethical Issues Most Important for a Research Physicist to Understand
Government Lab
Honesty (data, fraud, uncertainties) (6)
Conflict of interest (6)
Treatment of co-workers, subordinates (3)
Process of getting funds (3)
Truth in advertising for proposals (3)
Intellectual property rights (2)
Publication (criteria for authors) (2)
Ethics are relative
Evaluation of individual contribution to group effort
Data analysis
Balance between cooperation and competition
Career choices and government weapons research
Responsibilities of authors and referees
Confidentiality
How maintain vitality of research with government cuts
Accountability to taxpayer
One doesn’t forget if promise the sky and don’t deliver
Self-deception/carelessness
Pressure to overclaim certainty (in nuclear power safety analysis)
Don’t need formal training
No on-the-job training
Private Industry
Confidentiality/flow of information (4)
Conflict of interest (4)
Share of credit for teamwork (4)

Reliability of product design and safety (3)
Accurate allocation of effort, expense (2)
Liability (2)
Data integrity (2)
Truth in advertising/results/public reports
Expense reports, gifts, lobbying, harassment
Contradiction between conservative military industry vs. liberal general physics
Ethics in publication
Use of controversial issues to get funds
Research issues
Funding
Ethical treatment of employees
Scientific method/skepticism/self-deception
Cooperation with competitors
Respect intellectual property

Other

Independence of research from sponsor's interest (gov. lab contractor)
Role of expert advice in democratic society (non-profit)
Honesty, ambiguity (non-profit)
Your research key to all -- not just physics (university hospital)

These issues all seem to fall under the categories of honesty and integrity, or the potential lack of these qualities in numerous contexts and situations -- publication, funding, advertising, competition, liability, accountability. Many of the issues in Table VII and the comments in Table VI seem to be a function of the many physicists who find themselves in managerial and/or supervisory roles in industry -- comprising just over a third of the 60 respondents. These respondents seemed particularly uncomfortable wearing two hats -- that of the pure scientist and that of the capitalist (or having to answer to those who see only the "bottom line"). They are the ones who most likely contributed greatly to the 74% of this group who thought it would be valuable if physicists had a course on ethical issues in physics.

The physicists in industry, like those in academia, were given the topical outline for the ethical issues in physics course taught at Eastern Michigan University, and asked to suggest additional issues that they thought might be useful to study in such a course. Results are in Table VIII. Here we see a slightly different perspective from the respondents in academic settings. There is more variety, and more of an economic/social flavor to the issues.

Table VIII - Industry Physicists - Suggested Additional Issues for Course

Role of physicist - entrepreneur, citizen, voter, career guide, teacher, obligations to students, media, public as taxpayers (6)
Responsibilities of reviewers/peer review/delay of publication, nit pik (6)
Confidentiality (5)
Ownership (4)
Patent process (3)
Credit/authorship (3)
Management protect own/ethical treatment of subordinates (3)
Human experiments/medical physics/informed consent (3)
Physics and war/peace (3)
Cultural difference in ethics (3)
Honesty with colleagues/steal ideas/favoritism (3)
Conflict of interest (3)

Overstatements to enhance funding/bias/exaggerate (3)
Proof of hypothesis/unknown variables (3)
Whistleblowing (2)
Conflict religion and science (2)
Product safety
Superconducting Supercollider
Cost/benefit
Physicists on dole
Priority government spending
Record keeping
Company hopping
Old-boy network
Test design/role of adequate controls
Multiple funding overlap
Science and society/history
Wall Street physics
Different interpretations of data
Repeat publishing
Ethical hiring
Different responsibilities academia, industry, government lab
Politicians ignore advice
Referencing unpublished works
Interactions with minorities/women
Compare ethics in engineering, other sciences
Full data disclosure
Pressure for pleasing results

This list, combined with the suggested additional issues for an ethics in physics course from the physicists in academia, create a fertile data base from which one could extract a number of controversial ethical issues to discuss in a course or seminar. Any one of them can create a context within which undergraduate or graduate physics students can grapple with their own beliefs and values underlying their decisions to act one way or another.

V. Conclusions

Given the results of this survey, it seems clear that there is a difference in perspective between physicists in academia and those in industry. Obviously, it is the opinion of the authors that there is a need for an ethics course in the physics curriculum. The issues may not be as prevalent in academia, and the problems may not present themselves with as much urgency, but those physicists in physics departments across the country might consider the preparation of their students, and whether it is adequate, given the reality of their likely future employment in industry, and the ethical issues they will undoubtedly face.

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