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Overlooked Aspects in the Education of Science Professionals: Mentoring, Ethics, and Professional Responsibility

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Science as a profession is generally defined narrowly as research. Science education as preparation for a profession in research is usually perceived as course work and laboratory training, even though the necessary knowledge and skills to pursue a research career are more extensive and diverse and are learned in one-on-one interaction with mentors. A complete education of science professionals includes the values, ethical standards, and conventions of the discipline since they are fundamental to the profession. Mentoring and education in the responsible conduct and reporting of research and in the ethical dimensions of science are among the professional responsibilities of scientists and need to be discussed as part of science education. Moreover, science as an enterprise is much more than research and includes a number of other components, including science teaching, science journalism, and science policy. Each of these contributes to the nature of science and its role in society.

KEY WORDS: mentoring; professional responsibility; science education.

INTRODUCTION

Facts and figures, terms and theories, concepts and principles are part of what is conveyed in science education. Science is also a way of seeing the world; of thinking about causes, effects, and relationships; of framing our observations. Science is measuring and designing experiments, developing clear questions and ways of answering them, putting observations in the context of previous research.

Science education is not just courses and laboratory techniques. Beyond the classroom and the laboratory, some of the most critical components of the profession are conveyed to students in their interactions with their instructors, their advisors, their mentors, and other science professionals. Students who are considering a career in science need to be able to understand the structure and function of the system: how research is funded, how to write and communicate ideas and information clearly, the conventions of the discipline, and the expectations of colleagues and of society. Embedded in this complex enterprise are potential sources of confusion and misunderstanding.

Although science as a profession is often equated with research, it encompasses far more than observation (with or without experimentation) and reporting the results and possible interpretation in scientific journals. Not only is scientific research itself far more intricate and complex than simply observation and interpretation, but science teaching, science journalism, and science policy are all aspects of the scientific enterprise. They require both a fundamental understanding and appreciation of an area of science and the capacity to place this understanding in another context. These latter professional areas are not always included in what is usually meant by "doing science," but they are in-

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deed science. This broader, inclusive definition of "science" as a profession has substantial and important implications.

The responsibilities of scientists as professionals are not limited to integrity in their work and fair allocation of credit for ideas [that is, avoidance of fabrication, falsification, and plagiarism (Panel on Scientific Responsibility, 1992)]. Educators, researchers, and all science professionals, especially those in the academic setting, have broader responsibilities to students and to their junior colleagues.

PROFESSIONAL RESPONSIBILITIES

In addition to our responsibilities as citizens, as parents, as children, as members of any social group, responsibilities come with a profession. These responsibilities reflect the expectations of society and of our colleagues.

Societal expectations regarding the duties of a professional underscore the fact that professionals, including members of the scientific community, are a part of society. They are serving a function, or providing a service, that society deems worthwhile. Professional responsibilities also stem from the expectations of colleagues that the behavior of others in the profession will uphold, and be consistent with, certain core values.

Professional responsibilities may or may not be codified. Some of these responsibilities may be well established, and others are evolving with our society. Physicians have the Hippocratic oath, but also are expected "to do no harm." In the last 15 years physicians have been required to obtain informed consent from patients for all procedures, not just risky and experimental ones. Increasingly it is expected that clinicians have as their goal informed decision making on the part of their patients, rather than simply consent. Thus, over time, the professional responsibilities of physicians have evolved.

Society and colleagues in the scientific community expect that research scientists will conduct research with care and valid methodology and publicly report it honestly and accurately. It is also expected that researchers will train future generations of scientists. Since it is through one-on-one interactions that future scientists are trained, mentoring is central to the profession of science. Moreover, as Stanford chemist Carl Djerassi (1991) recently pointed out "The ethics and conduct of research are hardly ever taught in formal courses. They are acquired in a mentor–disciple relationship that affects the very manner in which we speak and write about our work." Thus mentoring, ethics, and professional responsibility are interwoven strands, integral to the fabric of science and to the role of science in society.

MENTORING

Why Is Mentoring Important?

Much has been written about mentoring and its various forms and permutations (e.g., comentoring and networking), in a number of excellent books, manuals, and pamphlets (see especially Hall and Sandler, 1983; Faddis *et al.* 1988; Kram, 1988). However, little has been written on mentoring in science (Djerassi, 1991; Marsa, 1991; Bird and Didion, 1993; Fort *et al.,* 1993), even though the mentor–student relationship is a key component of science education. Much that needs to be learned in order to succeed as a professional in science is between the lines. A variety of topics critical to a research career, such as data selection, data reduction, the conventions and responsibilities of authorship, manuscript and grant reviewing, where best to publish, effective scientific presentation, funding sources and procedures, etc., are practical issues rarely discussed except in the doing, and then only with great variability from one laboratory to another.

As testimony to the potentially critical role of mentoring in career development, women and minority junior scientists who continue in science usually were mentored. Extensive documentation restates the obvious fact that women and minorities are underrepresented in science and technology in every sector: academe, business, and government (Task Force, 1988, 1989). The implications for U.S. long-term economic competitiveness have been widely discussed and debated. Whether there is indeed an impending shortage of scientists, the underrepresentation of women and people of color is a reflection of inequities in education, training, and career advancement. Mentoring can be a way of removing artificial and unfair barriers to career choices.

It has also been argued that, through mentoring, the public image of science, which has been stained by publicity surrounding cases of scientific misconduct, can be rectified (Djerassi, 1991). Although misconduct has been primarily a problem of established scientists rather than of students, attention to, and articulation of, the central values and ethical standards of the profession are likely to be widely disseminated and to influence the context in which all individuals carry out scientific pursuits.

What Is Mentoring and Who Should Do It?

However mentoring is done, its roots are in sharing experience and expertise. It requires looking back to see what we have learned; what we "did right" and would recommend to others, and what we would do differently if we were starting again. Mentoring is a matter of sharing with others what we have learned in a manner and form that makes it understandable and useful to them.

The ideal mentor is omniscient, sensitive, wise, and powerful. She or he understands all of the social and political aspects of science and its implications, as well as the issues and nuances of all subfields in a particular discipline; is sensitive to the strengths and weaknesses of the student and understands how best to build on the former and build up the latter; and is in a position to oversee and advance the career of the mentee at every stage. Of course, ideal mentors are few and far between. Furthermore, not everyone can become a good mentor, although education and training can help. Certain characteristics and qualities have been suggested as important ones to emphasize. The following list is a modified and expanded version of one presented by Bonnie Faddis and colleagues at the Center for Sex Equity (Faddis *et al.*, 1988) in *Hand in Hand: Mentoring Young Women*:

- *Experience*: Each of us has knowledge and information that would be invaluable to others. This knowledge can include what courses to take and in what order; who are the most stimulating instructors; how to select a graduate program, a thesis topic, and a thesis advisor; where to publish; how to develop, write and submit a grant; what to look for in a secretary or a technician; how to cope with a dual career family; how to handle sexual harassment; etc. Thus students can serve as valuable mentors to those less far along in their professional education since their experience is more recent, and on some topics, more relevant, as course requirements, faculty, and the institutional environment change over time. The fact that students can serve as mentors for each other highlights the fact that the notion of a mentor as an older, or at least more established professional is unnecessarily limiting. It runs counter to the reality of a scientific community that is dynamic, interactive, and collaborative. Effective mentors must assess the various kinds of information and knowledge that they have and can provide, while recognizing and acknowledging their own biases. The range and value of the experience that we have is far wider than many of us, especially women, commonly realize.
- *Enthusiasm*: The enthusiasm one has for one's work, and for science in general, is a critical component of mentoring. It is important to share, encourage, and nurture the excitement and sense of wonder in students. These qualities are valuable not only in and of themselves, but also because they will help provide motivation for sticking to the challenge when concepts prove difficult, experiments fail, and grants are not funded.
- *Belief that individuals can and should "do science" regardless of gender or ethnicity*: This is not a trivial issue. Particularly for women and minority students, there are countless, often unintentional, messages in every facet of our society, portraying science as a profession for white men. For example, the U.S. Department of Labor (1989) provided a guide for teachers and counselors to assist them in advising high school girls regarding career options and opportunities, including occupations in science. This well-intentioned and excellent resource was unfortunately entitled "Women in Non-Traditional Careers," a title that conveys the unconscious message that these are occupations for women who want to be different—not a popular sentiment or common goal among teenage girls.[3]

  Furthermore, a widely held notion is that a man is better at almost everything than a woman, whether as an airline pilot, astrophysicist, composer, or chef. This judgment is reflected in classroom behaviors docu-

[3]The 1991 version of this useful document is entitled "Directory of Non-Traditional Training and Employment Programs Serving Women" and is available through the U.S. Department of Labor, Office of the Secretary, Women's Bureau, 200 Constitution Ave., N.W., Washington, DC 20210-9990.

mented in the recent AAUW report "How Schools Shortchange Girls" (Wellesley College Center for Research on Women, 1992). Teachers are more attentive to boys, interact with them, challenge them, and encourage them to a much greater degree. This kind of behavior, seen at the primary grades, continues in the secondary grades and at the college level. It can have a long-term negative impact on self-confidence. It is critical that mentors be aware of this unconscious cultural bias and work to counteract it.

- *Willingness to expend time and effort*: Mentoring takes time and usually needs to be done in the timeframe of the mentee. Unfortunately mentoring is not generally recognized or rewarded by peers or supervisors. While mentors find the experience gratifying, it is essential to acknowledge it for the investment it is in order to avoid aggravation and misunderstanding.
- *Sense of humor*: Always valuable, a sense of humor can help both the mentor and the mentee through difficult times.
- *High standards and expectations for themselves and colleagues*: Students learn from the example set by their mentor, so professional standards and the expectations of colleagues are conveyed by the values expressed consciously and unconsciously by respected science professionals.
- *Ability to articulate and address sensitive issues*: To be most helpful to a mentee, the mentor has to raise and address forthrightly problems and concerns, to help identify underlying assumptions of the student, or of others, and to assist in clarifying the benefits and risks of difficult choices. This means active listening and questioning.
- *A positive outlook*: In order to support others in their career choices, a mentor needs a positive attitude regarding his or her own decisions. It is not possible to encourage another to pursue a career in science if one regrets having made that choice oneself. (One can, of course, regret difficulties encountered in unsympathetic settings of one's own career.)
- *An open mind and recognition of the value of diversity*: "Success" can be defined in different ways. For each definition, a variety of paths can be taken to achieve it. Mentors need to recognize this fact, and to value different perspectives, in order to be able to encourage students and to help them develop alternate strategies for achieving their professional goals. For example, women who have chosen not to marry or have children in order to succeed professionally must be able to recognize that society changes and the same sacrifice may no longer be necessary.

Although this discussion has focused on the role of the mentor, the role of the mentee is no less active. The ideas and experience of the mentor come from a context and a perspective that may vary greatly from that of the mentee. Mentees need to consider, analyze, and evaluate the advice and views of the mentor and to determine the extent to which they are consistent with his or her own experience, values, goals, needs, resources, and expectations. A mentor provides an additional perspective and shares experience that the mentee does not have. Mentors do not necessarily know what is best for the mentee. What was a useful and effective strategy for the mentor may not be appropriate for the mentee. It is up to the mentee to examine the advice of the mentor in the context of his or her own life and to decide how best to use that advice. It is critical that both mentors and mentees understand the advisory capacity of the mentor and its limits.

ETHICS IN SCIENCE

Science has often been perceived and portrayed as an objective search for "the truth." However, today the scientific community itself has come to acknowledge that values are intentionally and unintentionally embedded in the practice and application of science (National Academy of Sciences, 1989). These range from honesty and integrity, to personal, cultural, and religious values.

Over the last decade concern about ethics in the scientific professions has arisen, in part, as a result of instances of egregious misconduct that have threatened both the reputation and the fabric of the professions. In addition, highly publicized problematic practices have heightened awareness of the potential for misunderstanding, confusion, and conflicts of interest and values. Publicity associated with actual or perceived instances of misconduct in science has shaken public and governmental confidence in the efficacy of informal methods of maintaining high professional standards in scientific research.

In addition, there is an often unarticulated expectation on the part of students, the public, and professional colleagues that a complete education in the sciences and engineering should address matters of professional ethics. There is increasing awareness of the responsibility of professionals to train students and younger colleagues not just in concepts and techniques, but also in the standards of the profession. Within the scientific community, there is concern that the time-honored techniques for transmitting professional standards are inadequate in the face of rapidly increasing numbers of scientists, which exceed the availability of research funding, the fast pace of many areas of research, and the expanding potential for linking basic research to profit-making applications.

Science professionals also recognize that the behavior of their colleagues is a reflection on them. They have much to gain by counteracting widespread public doubts and misperceptions. Thus there are internal and external pressures on the scientific community to develop educational programs that address these issues. It is essential that students (and colleagues) recognize and understand the wide range of ethical issues that are inherent and integral to science as a dynamic and multi-faceted human enterprise that is frequently expected to guide societal decisions.

One can identify at least three categories of ethical issues in science. Some are common to many professions because they arise in a variety of workplace settings. Others are inherent to science because of the nature of the conduct and reporting of research. Still other issues are specific to particular disciplines and to the use of information from that discipline to develop policy. Naturally these categories shade into each other in practice.

Common Professional Ethical Concerns

These issues cover a variety of topics and may have particular relevance in different scientific fields. Radioactive substances, toxic or hazardous chemicals, and other aspects of the work environment generate expectations and responsibilities to maintain a level of cleanliness or awareness of potential hazards and attentiveness to issues of workplace safety that might not be the common mode of operation for a given individual. Prejudice, unfair discrimination, and sexual harassment are ethical concerns common to many if not all workplace settings, although they may be more common and troublesome in professions where the standard professional is, or is perceived to be, a heterosexual white male. These ethical issues need to be addressed in science, as they do in all professions.

Ethical Issues in the Practice of Science

Because science is a body of knowledge created through a collaborative effort in which each piece of information is built upon and seen in the light of other bits of information, the integrity of the scientific process is of fundamental concern. The conduct of research must be presented as accurately, openly, and clearly as possible. Falsification and fabrication of data are universally regarded as unacceptable and a breach of ethics. Similarly, because intellectual property is highly respected and recognition for contributions to the body of scientific knowledge is a primary form of compensation, plagiarism is equally heinous.

Other topics may be related to these. Authorship, the fair allocation of credit for one's contribution, and the attendant responsibilities, are a source of concern and discussion (CBE Style Manual Committee, 1983; Croll, 1984; Jackson, 1986). How much and what sort of effort qualifies one for authorship? Who decides? In what order should authors be listed? What are responsibilities of authors for the work as a whole? for the appropriateness of the methodology? for the interpretation of the data and the conclusions drawn?

Data selection, methodological issues, and conflict of interest can also be sources of concern and confusion. Should any datum be discarded? Should this information be conveyed to readers, and if so, how? How much data are required to establish the efficacy of a drug, therapeutic device, or treatment regimen? Should animals be used in research and with what limits? Should researchers have a financial stake in the marketing of the object of their investigation? With what limitations?

Science professionals other than researchers also must deal with a variety of ethical concerns basic to their professions. How much should journalists emphasize potential applications of basic research when reporting research findings to the public? How much should journalists generalize from the specifics of the research in order to make research understandable or interesting to the public? What is the extent of the journalists' responsibility to educate the public? Should the nature of science education vary with the student, and, if so, in what way and why? What should be the goals of science education and how should student achievement be assessed? What conflicts or problems arise as a result of teaching at a predominantly research institution and how should they be addressed? How should basic research be used in the development of public policy? How should potential benefits, and potential risks be weighed? How should policy makers portray the needs of the scientific community and how should they balance them against the needs of the public?

These are only a sampling of the range of ethical issues inherent in various aspects of science, but they illustrate the type of questions that need to be raised and addressed in the education of science professionals.

Ethical Issues Specific to a Field

The extent to which research findings are used to develop public policy will vary with the discipline and a host of political, social, and economic factors. Yet part of the public justification for funding of basic research is the assumption that research results can be applied to inform decisions about a vast number of public concerns such as the allocation of health care dollars, the development and regulation of energy production, location of hazardous waste dumps, effective methods of national defense, economic prosperity and competitiveness, and the just application of the insanity defense. Scientific results may be used inappropriately to support policy decisions, either intentionally or unintentionally. The responsibilities of science professionals to identify, clarify or address the limitations or inappropriate applications of science in the development of policy, receive much discussion, often without resolution. However unresolved, students need to be aware of the ethical dimensions of science.

IMPLICATIONS

If mentoring and education in ethics are components of the profession, then professionals need to behave accordingly. Because mentoring and teaching about the professional standards, values, and ethical dimensions of science require time and effort, these activities should be acknowledged as the professional responsibilities that they are. The energy one devotes to these activities is not expended on other tasks. The extent to which the scientific community fails to recognize this minimizes the importance of these responsibilities and those who take them seriously. Colleagues, as peers, determine professional values and standards. Students, as well as faculty, learn what is important by observing where those they respect invest their time (the most critical and limited resource) and what accomplishments they value and, therefore, reward in their colleagues. Thus, when employment, advancement, and tenure decisions are being made, department faculty and administrators must speak up and highlight the extent to which candidates take mentoring and education in ethical concerns, as well as other professional responsibilities, seriously.

This will require a fundamental change in attitude and behavior. Currently, teaching and community service (in addition to research) are generally acknowledged as appropriate components of the tenure decision. Yet good teaching awards are all too often unofficially labeled "the kiss of death" awards for tenure. The widely held view among faculty at research institutions seems to be that those who take teaching that seriously must not be sufficiently focused on research. Hiring and advancement decisions primarily or solely based on published research papers (and often on the quantity rather than the quality of those papers) convey a clear message. This same message is expressed when good teachers, in spite of a reputation for good research, are not advanced, and when those with a reputation for good research, but a poor reputation with regard to graduate student relations, are hired or promoted.

Furthermore, mentoring is not entirely consistent with the widespread, if somewhat distorted, definition of "good" science, which is increasingly portrayed by those in and out of the profession, as competitive. For example, a post-doctoral fellow for whom English is a second language sought assistance from a colleague to edit manuscripts for grammar and syntax and to correct pronunciation in oral presentations. The chairman of the department considered these efforts at addressing a potential obstacle to clear, effective communication unacceptable. Our colleague was told he should not get help from others but should do it on his own. It is not clear what "doing it on his own" would mean, but the focus was not on collaboration.

Prizes for great achievements in science continue to be given to one, perhaps two, individuals, belying the fact that science is in reality a collaborative effort with several individuals working together (as evidenced by multiauthored research papers and credits to technicians and other support staff) building on the work of colleagues in the field. When Radcliffe College president Linda Wilson indicated that the fierce rivalries and ruthless competition that predominate in science today are not appealing to the upcoming generation of potential scientists, the objection raised was not that science was being misrepresented, but the belief that without that level of competition, the quality of science would suffer (Mervis, 1992). The prevailing view would seem to be that quality science can only be attained through fierce competition, although in reality it is more likely to be achieved in spite of it.

Moreover, the focus on competition may result in a workplace environment that places a premium on shortcuts that are not conducive to good science, that is, to the building of a solid foundation of accurate and reliable data. Rather, having the right answer first, or having the appearance of doing so, can motivate questionable data selection, presentation, and publication practices. Indeed, overemphasis on competition is itself an ethical concern since, in addition to misrepresenting the fundamental nature of science, it may generate or exacerbate pressures, problematic circumstances, and conflicts of interest. It takes time to produce replicable data, to analyze it thoughtfully, to consider the full range of possible interpretations from a variety of perspectives. An emphasis on speed does not allow for human fallibility or the realities of life: spilled samples, contaminated chemicals, incorrect calibrations, misunderstood instructions, sick animals, sick people.

The collaborative, interactive role of scientists and of the full range of scientific professions, needs increased recognition and appreciation within the scientific community.

CONCLUSIONS

How science is defined by its proponents and portrayed to society as a whole is essential to understanding its role in our society. Mentoring, education in the ethical standards that underlie the profession and in the ways in which values are unintentionally as well as intentionally embedded in science, and aspects of the collaborative nature of scientific investigation are critical and interactive components that need greater attention as we prepare future science professionals. Substantial effort will need to be invested by the many facets of the scientific community to understand the relationships among these factors—how each reflects, and influences, the others.

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