Ethics Education and Scientific and Engineering Research: What's Been Learned? What Should Be Done?

Summary of a Workshop at the National Academies Keck Center, August 25–26, 2008

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On August 25–26, 2008, the National Academy of Engineering (NAE) held a workshop on "Ethics Education and Scientific and Engineering Research: What's Been Learned? What Should Be Done?" This summary, prepared by NAE and National Research Council staff, provides summaries of the workshop presentations and discussions.

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Introduction

Increasing complexity and competitiveness in research environments, the prevalence of interdisciplinary and international involvement in research projects**,** and the close coupling of commerce and academia have created an ethically challenging environment for young scientists and engineers. For the past several decades, federal research agencies have supported projects to meet the need for mentoring and ethics training in graduate education in research, often called training in the responsible conduct of research (RCR). Recently, these agencies have supported projects to identify ethically problematic behaviors and assess the efficacy of ethics education in addressing them.

Congress and the public continue to pay attention to these issues, and the America COMPETES Act (HR 2272) of 2007 specifies that proposals for National Science Foundation (NSF) grants include mentoring for postdoctoral fellows and ethics training for graduate and undergraduate students in science and engineering.[1] The NSF guidelines also include a requirement that proposals for funds to support postdoctoral researchers include a description of mentoring activities. In light of the history of support for educating students and researchers in ethical or responsible behavior and the current political interest, this seems an appropriate time to review what we have learned so far and to identify directions for the future.

With support from the NSF, the National Academy of Engineering (NAE) Center for Engineering, Ethics, and Society (CEES) held the workshop "Ethics Education and Scientific

[1] The America COMPETES Act is accessible on line at *http://www.cfr.org/content/publications/attachments/2272.pdf.*

and Engineering Research: What's Been Learned? What Should Be Done?" at the Keck Center of the National Academies in Washington, D.C., on August 25 and 26, 2008. The Division of Policy and Global Affairs (PGA) of the National Research Council (NRC) and the National Academies Committee on Science, Engineering, and Public Policy (COSEPUP), which has produced the third edition of ***On Being A Scientist,***[2] provided advice and support for the workshop. *On Being a Scientist* is a guide that is widely used by academic institutions and faculty members to teach research ethics (e.g., issues related to publication and authorship, the use of human subjects in research, conflicts of interest, and intellectual property rights).

Many participants suggested that the workshop summary be organized around the themes of the panel sessions and discussions rather than chronologically, because these themes tended to come up repeatedly and participants in each session addressed a number of different themes. Thus readers will find that this summary focuses on themes rather than the chronology of presentations and discussion.

The summary follows, loosely, the thematic order of the workshop agenda (see Appendix). The first topic (Chapter 2), the social environment of science and engineering and ethics education, explores the context in which ethics mentoring and ethics education take place and the issues that context raises for future directions in ethics education. Chapter 3 focuses on the need for ethics education for graduate students and postdoctoral fellows in science and engineering. Chapter 4, on models for effective programs, provides pragmatic guidance for academic administrators and research investigators who want to develop programs or activities in ethics education; this chapter includes information on instructional and institutional approaches to

[2] The third edition is available through the National Academies Press at *http://www.nap.edu/catalog.php?record_id=12192*.

mentoring and ethics education. Chapter 5 is about assessment of approaches to ethics education. Chapter 6 is a summary of the discussions about next steps.

An ad hoc workshop planning committee helped develop the agenda and nominate participants. Members of the committee included physicist John Ahearne, NAE member and chair of the CEES Advisory Group and former director of the Ethics Program of Sigma XI, the honorary scientific society. Other members were University of California, Irvine biologist Francisco Ayala, a member of the National Academy of Sciences and a member of the committee that worked on the third edition of *On Being a Scientist*; astronomer Kathleen Flint, director of the Bring RCR Home Project of the National Postdoctoral Association; political scientist Mark Frankel, director of the Scientific Freedom, Responsibility and Law Program of the American Association for the Advancement of Science (AAAS); and psychologist Felice Levine, executive director of the American Educational Research Association.

Four of the five committee members attended the workshop and met with the CEES director after the first day to review progress. Levine then developed a thematic outline to help organize the discussion on the second day. Frankel and Levine also met briefly with Rachelle Hollander, CEES director, right after the meeting to go over material for this summary and plans for follow-up activities. Twenty-five people, as well as a number of NSF observers, attended the meeting (for a list of attendees and committee members, see Appendix).

Four sessions, chaired by members of the planning committee, were held on the first day of the workshop: Needs and Issues for Ethics Education in Scientific and Engineering Research; Pedagogical Methods and Materials; Outreach and Assessment; and Review. The first three sessions opened with brief presentations and responses by workshop invitees. These were

followed by group discussions on the topic of that session and related matters. The fourth session was a general discussion and review of the previous sessions. During lunch, a scenario used for ethics training was presented, followed by a discussion. Dinner included a talk about *On Being A Scientist*.

The second day began with a general discussion of next steps, chaired by the CEES director. The group was then divided into four smaller groups, two of which focused on the larger environment that affects scientific and engineering research and two of which focused on programmatic and assessment issues. The final session included reports on these discussions and a plenary discussion highlighting ideas for the workshop summary, again chaired by the CEES director.

Links to background materials from the workshop can be found on the CEES home page at *www.nae.edu/ethicscenter*. These materials were provided by participants, who submitted citations and resources they thought attendees and others would find useful.[3] Most presenters and some respondents also submitted brief statements or PowerPoint slides that can also be found on the CEES home page.

[3] Persons and organizations with information about other resources should feel free to send their suggestions to CEES so they can be added to the list of resources and citations.

2
The Environment for Science and Engineering

This chapter provides a summary of material from the presentations, responses, and discussion related to the first session, *Needs and Issues for Ethics Education in Scientific and Engineering Research*. In preparing their remarks, panelists were asked to consider the following questions:

> Investigators and students exist in complex research and learning environments that include academic and other organizations, such as professional societies, commercial research laboratories, government funding agencies, and peer-reviewed journals. What do these individuals and groups identify as the main impediments to developing effective responsible research programs? Are there conflicting ideas about what these impediments are and what to do about them?

The panel was chaired by Francisco Ayala, a member of the NAS and of the project's advisory committee, and University Professor and Donald Bien Professor of Biological Sciences, Ecology and Evolutionary Biology at University of California, Irvine . The speakers were Joseph Helble, dean, Thayer School of Engineering, Dartmouth College; Deborah Johnson, chair, Department of Science, Technology and Society, University of Virginia Charlottesville; Michael Mumford, professor, Psychology Department, University of Oklahoma Norman; and Wendy Williams, director, Research Education, The Children's Hospital of Philadelphia. The respondents were NAE member Paul Citron, chief technology officer (retired), Medtronic; Hugh Gusterson, professor, Department of Sociology and Anthropology, George Mason University; and Susan Silbey, Leon and Anne Goldberg Professor of Humanities, Massachusetts Institute of Technology (MIT).

At the beginning of the meeting, when attendees attempted to explain why ethics education is important, they proposed a variety of answers. Some described well-known instances of research misconduct. Others referred to less well known, but equally deleterious research practices that undermine both public trust in science and engineering and the integrity of research, for example, honesty in recording data and acknowledging research contributions. Still others noted that the responsibilities of academic institutions and research faculty include training and education that promotes the understanding and application of the ethical standards of academia and specific fields. Some referred to former students, who had told them that only when they were faced with difficult ethical questions on the job did they recognized the value of the time spent on those and other ethical issues during their education. And some noted that sometimes the brightest and most socially aware students turn away from research programs and careers that do not live up to their ideals.

> A lot of research investigators are alienated by an incentive structure that makes their community nasty, individualistic, and competitive. . . a lot of graduate students, especially female graduate students, but I have also heard it from male graduate students, . . . quit. They say, "I don't want to become that kind of person, so I'm going to find some other way to spend my life." *Caroline Whitbeck, Online Ethics Center*

Many participants noted that ongoing changes in American culture influence ethically responsible behavior. To develop ethics and mentoring activities and assess the results, program leaders and staff must be aware, for instance, of the internationalization of U.S. graduate programs, the nature and priorities of current undergraduate culture or mores, and the disparate pathways into graduate education, furious competition for federal grants, and the growing number of university-industry partnerships. Program leaders must recognize that new

technologies promote globalization and change faculty-student interactions. In discussions throughout the meeting, some workshop participants noted that increasing pressures for tenure and increasing competition for grants have led to a variety of problems, including instances of competitive mentoring—the same project being assigned to more than one graduate student, only one of whom receives credit for the work.

Panelist Susan Silbey of MIT reminded participants that these "structural forces … tend to produce unethical behavior."[4] Other attendees agreed on the need for new, creative responses that include attention to ethics. Many pointed out past efforts by leaders in scientific and engineering fields, as well as leaders of professional societies and academic organizations, to strengthen codes, issue reports, cooperate in government efforts to devise and implement policies, and initiate new educational activities. These responses are reflected, as Deborah Johnson of the University of Virginia said in her remarks, not only in ABET[5] criteria requiring student competencies in ethics and an understanding of the social context of engineering, but also in new NSF requirements that proposals for research projects must include a description of their societal relevance (NSF evaluation criterion 2).[6]

In a general discussion, NAS member W. Carl Lineberger, University of Colorado, Boulder, commented that "…we really do have a wonderful opportunity. … I've been going around, talking to various groups of chemists about … how can they do a better job on broader impacts [NSF criterion 2] … I believe you have a very large number of receptive people to pay attention

[4] See for instance Vaughan, D. *"The Dark Side of Organizations: Mistake, Misconduct and Disaster"*, Annual Review of Sociology, 25 (1999): 271-305. Also, Anderson, M. S., Ronning, E. A., De Vries, R., and Martinson, B. C. (2007). *The perverse effects of competition on scientists' work and relationships. Science and Engineering Ethics*, 13(4), 437-461.

[5] ABET Inc., the recognized accrediting agency for college and university programs in applied science, computing, engineering, and technology, is a federation of 29 professional and technical societies representing these fields. See *www.abet.org*.

[6] The NSF *Grant Proposal Guide* provides the NSF review criteria concerning societal relevance; see particularly *http://www.nsf.gov/pubs/gpg/broaderimpacts.pdf*. For recent notification of intention to address ethics, see also *http://www.nsf.gov/oirm/bocomm/bo/bfa_updates_handout2final_27may08.pdf*.

to ethics via this broader impacts mechanism, because it's going to affect them in a very serious way."

Throughout the discussions, meeting participants noted that organizations that fund research and employ scientists and engineers encourage interdisciplinary work and teamwork. However, they also noted that academic incentives for advancement favor individual work. Thus, these incentives should be revised to acknowledge and reward collaborative and cooperative efforts. Professional societies, government funding organizations, and universities can cooperate on workshops to promote ethics, prizes for outstanding ethical leadership, and changes to the tenure process that reward outstanding mentors, for example.

Several workshop participants described substantial barriers to the development of new incentives and suggested that change would be more likely in the long run if faculty achievements in professional ethics activities were incorporated into tenure decisions. In the meantime, recognition for collaborative and cooperative work could be reinforced by prizes given by organizations for outstanding ethical leadership or graduate and postdoctoral workshops in science and engineering ethics sponsored by the National Academies and other professional societies.

Overall, the workshop participants indicated that ethics mentoring and education should include interactions between scientists and engineers and the larger environment in which they work, and should include discussions of how the environment affects, and sometimes changes, research and professional practices. As an example of these interactions, Mark Frankel, AAAS, noted how conflicts of interest can pose challenges to issues of authorship. Some time ago, he said, only researchers and professional organizations paid attention to authorship issues.

However, with today's complex funding arrangements for research, the issue of authorship has taken on a much broader relevance.

Many attendees agreed that values, such as shared standards and transparency, can promote public trust in the work and intentions of scientists and engineers. These values, they said, should be topics of discussion in science and engineering ethics programs. These values provide an overall coherent focus for these activities. However, they also pointed out that differences between science and engineering, as well as field-specific differences within them, should also be taken into account in research ethics activities. This is especially important because many scientific and engineering research projects today involve researchers from different disciplines and subfields, which might have different standards. The differences and similarities should be identified and, if necessary, justified. As one participant indicated, these differences may reflect ethically acceptable differences, with similar underlying ethical values that require discussion to resolve. Standards for authorship credit provide an example. Numerous participants commented that these particularities can limit the utility of generic communications, or rules meant to cover numerous fields. They also noted that ethics education in electronic or lecture formats, which are limited to one-way communication, are less effective because they do not allow for the kinds of deliberation and discussion of ethical problems and practices that can create shared standards and transparency.

Attendees discussed how research on interactions between science, engineering and the larger social context, whether approached from the point of view of science and technology studies, social and behavioral sciences, history, philosophy, or social ethics, can shed light on the ethical implications of the organization of scientific and engineering work and how ethical considerations arise in the everyday work of scientists and engineers. They also noted the

importance of leadership from the science and engineering communities (e.g., the National Academies, AAAS, and scientific and engineering societies in specific fields) in raising the visibility of these issues.

Some discussants pointed out that research on the interactions between science and engineering and the larger social environment can not only help to identify ethical considerations relevant to conducting research; but it can also identify other aspects of professional conduct that can influence whether junior scientists and engineers continue in career paths that include research and teaching or decide to pursue other career goals. For instance, acknowledging and ameliorating factors that result in hyper-competition in a department may raise retention rates; a seminar led by a faculty member from a small college may demonstrate the desirability of an alternative pathway.

3
Ethics Education in Science and Engineering

APPROACHES TO ETHICS EDUCATION

Workshop participants generally agreed that a major goal of ethics education is to encourage faculty and students to question the decisions, practices, and processes around them so they can make better informed decisions and help shape a community of which they want to be part. In the "Pierre-example" in the textbox, has Pierre been taught about the importance of documenting his decisions and considered what the codes of ethics at various corporations might tell him about the desired procedures?

> Since I direct an RCR course, I like to start with cases. We have got Pierre here . . . a postdoctoral fellow . . . trying to get a job . . . about to go to a national meeting to present his work. He has been told that the representative from the company he wants to work for will be there. Some of his data points he thinks are questionable, so he thinks about leaving them out. . . . Are we helping Pierre make the right decision?
> *Wendy Reed Williams, The Children's Hospital of Philadelphia*

Some attendees pointed out that most graduate students and postdoctoral fellows currently learn research practices primarily through ad hoc, informal exposures in their individual laboratories, rather than through formal training. These ad hoc approaches are unlikely to be effective, they said, and therefore the expectations of ethical conduct and beneficial outcomes on the part of professional societies, employers, government funding agencies, and the public are unlikely to be met.

Several participants said that a consistent approach to ethics education and mentoring would make it easier for students and faculty to meet academic and professional standards and employer expectations. Others said the focus of formal training should go beyond professional ethics and research practice to the development of competencies in analyzing how social and technical factors interact. At that point, they said, faculty and postdoctoral and graduate students would have the skills to evaluate the cultures of organizations and the institutions where they were employed.

> Once you get outside the context of universities, there is very little sort of collective framework—collective venues for ethics talk. . . . We need to think about how we can change . . . institutions like weapons labs, industries, and so on . . . so that people have venues where they feel it is okay to talk through these issues .
> *Hugh Gusterson, George Mason University*

Charles Huff, St. Olaf College, reported results of research that had involved numerous collaborators and sources of support. The researchers, he told the group, decided that, rather than examining individual ethical decisions, they would take a performance-based approach (one looking at the progression of a career over time) to the question of developing an ethically exemplary career in computing.

Huff analyzed two major types of morally exemplary individuals in computing, those oriented toward craft (e.g., those concerned with computer accessibility for disabled users) and those oriented toward reform (e.g., those concerned with computing and privacy). These types, he said, represent different moral ecologies (i.e., environments in which individuals can develop ethically exemplary careers). Characteristics in a "model" of ethical performance over time include "moral ecologies, individual personality, relevant skills and knowledge, and the integration of morality into the individual self."

Understanding these complexities, workshop attendees pointed out, leads to understanding the limitations of approaches to ethics education that focus only on individual decision points. Training in the skills and knowledge necessary to address particular ethical issues in research can provide guidance for an analysis of particular situations but cannot inoculate individuals against questionable practices. Understanding the complexities encourages an ethics perspective that goes beyond compliance toward ethical ideals.

> We need to think about peoples' moral . . . and ethical commitments in a larger picture of the different kinds of moral careers that people might structure for themselves. …. "I do this because I'm just that kind of an engineer.". . . moral creativity [is] particularly important in design issues. How do you come up with designs that satisfy multiple constraints, many of them . . . social constraints?
> *Charles Huff, St. Olaf College*

Materials submitted by Huff and workshop participant Stephanie Bird, an independent consultant in research ethics and leader of the lunchtime discussion of the ethics scenario, identified skills and knowledge that should be developed in ethics education. The required skills include:

- Recognizing and defining ethical issues.
- Identifying relevant stakeholders and socio-technical systems.
- Collecting relevant data about the stakeholders and systems.
- Understanding relevant stakeholder perspectives.
- Identifying value conflicts.
- Constructing viable alternative courses of action or solutions and identifying constraints.
- Assessing alternatives in terms of consequences, public defensibility, institutional barriers, etc.
- Engaging in reasoned dialogue or negotiations.
- Revising options, plans, or actions.

Both Huff and Bird stressed that ethics education should address both domain-specific and general content areas. Domain-specific areas might include issues of privacy or safety, access, intellectual property, methods of data collection and analysis, and technical knowledge of constraints and opportunities**.** General content might cover appropriate ethical guidelines, characterization of socio-technical systems, ethical argument, and ethical dissent and whistle-blowing.

Science and engineering students require both skills and knowledge to make ethical decisions. Many participants pointed out, however, that skills and knowledge are not sufficient if the individual does not have the personal and social motivators that encourage praiseworthy behavior. Environments must be structured to reward individuals who demonstrate ethical behavior.

CHARACTERISTICS OF EFFECTIVE ETHICS EDUCATION

Workshop participants noted that NSF, the National Institutes of Health (NIH), and the Office of Research Integrity all fund projects in research ethics. Successful strategies for teaching research ethics generally include required (rather than optional) participation in ethics education, active participation by relevant faculty, and interactive and recurring programs. Programs must also be tailored to meet the needs of researchers in specific fields. The specifics of biomedical ethics education, for example, do not translate directly to other fields, just as the

> I have some strong—from my experience in industry—strong beliefs in how ethical issues can be discussed. . . . There are rules, but much of the learning happens in highly ambiguous case studies where groups of practitioners sit around a table and enrich the discussion by [describing] how they would have approached the solution to that case example.
> *Paul Citron, Medtronic (retired.)*

specifics of ethics education for laboratory chemistry do not translate directly to field biology, ecology, archaeology, or engineering.

In his presentation during Panel I, Joseph Helble of Dartmouth noted that students entering graduate school face many challenges. They are no longer searching for "the right answer," he said, but for new answers. Advisors and senior students in their new laboratories usually have established ways of doing things and expectations that their junior colleagues may not understand, especially if they have not taken courses in research procedures. Faced with pressure to produce, students may go along with procedures that make them uncomfortable, or they may cut corners to come up with timely results. Campus-wide ethics training can prepare students to face these ethical difficulties, he said. In addition, such a campus-wide program or set of activities can improve an institution's competitiveness with funding agencies—an example of "doing well by doing good."

In a small group discussion on the second day of the meeting, participants identified additional challenges that ethics activities and programs may face. Faculty members may not believe the programs are needed; students may be faced with inconsistencies between formal ethics training and lab cultures and investigators' priorities; faculty may lack expertise or feel uncomfortable about teaching ethics; institutions may lack resources to support ethics activities; and instructional methods must be appropriate for the target audience.

In addition, several participants pointed out, in presentations and discussions, that working with graduate students and postdoctoral fellows from other countries raises particular questions: whether students from other countries understand the content of ethics training; how teachers can learn from and accommodate students from different backgrounds; and how diversity among graduate students and postdoctoral fellows can improve learning opportunities and outcomes.

In Session III (Outreach and Assessment), Joseph Whittaker, Morgan State University, pointed out that the lack of data on what works, what doesn't work, and what has had mixed results has impeded the development of programs that build on prior successes and avoid prior failures. Some courses meet with student satisfaction and achieve intellectual goals, he said, but the content, techniques, and long-term outcomes of those courses are not assessed or measured.

Participants in discussions also flagged several areas for improvement. First, they recommended looking beyond classroom learning and individual conduct to broad programs that teach the importance of integrity by stressing shared standards, such as transparency in research, and indicators of meritorious practices. Second, universities should establish rewards for faculty members who participate in ethics education and use metrics to measure individual and institutional changes. Third, professional societies should play a more active role in establishing and promoting ethical standards. They might, for instance, establish ethics columns in their newsletters and journals, as some organizations and employers have done successfully.

4
Models and Resources in Ethics Education

The material in this chapter is based primarily on presentations and discussion during and after Session II, *Pedagogical Methods and Materials*. Presenters and respondents were asked to address the following issues:

> There is quite a variety of both methods and materials in effect. More than a few consortia provide online tutorials; conferences are common. What kinds of contents and range of techniques are in use? What are their strengths and their limitations? Whom do they reach, and with what results? What information do we have that enables us to judge their merits? What's missing?

The moderator of this session was planning committee chair John Ahearne, and speakers were Julia Frugoli, associate professor, Department of Genetics and Biochemistry, Clemson University; Kelly Laas, librarian, Center for the Study of Ethics in the Professions, Illinois Institute of Technology (IIT); Caroline Whitbeck, professor emerita, Case Western Reserve University and founder of the Online Ethics Center; and Sara Wilson, professor, Department of Mechanical Engineering, University of Kansas. Respondents were Jason Borenstein, director of Graduate Research Ethics Programs and Co-Director of the Center for Ethics and Technology at Georgia Institute of Technology; J. Britt Holbrook, assistant professor, Department of Philosophy and Religion Studies, University of North Texas; and Simil Raghavan, a graduate student then completing her dissertation in the Department of Biomedical Engineering, Johns Hopkins University.[7]

[7] Dr. Raghavan completed her Ph.D. requirements in fall 2008.

Kelly Laas reminded participants that in 1980 the Hastings Center project on teaching ethics education in colleges and universities concluded that programs should have five goals: stimulating the moral imagination; recognizing ethical issues; developing analytical skills; eliciting a sense of moral obligation and personal responsibility; and tolerating and resisting disagreement and ambiguity. As indicated below, more recent projects have extended and refined, but not diminished the value of, those goals.

In his research, Charles Huff of St. Olaf College distinguishes between decision-oriented approaches to teaching ethics and approaches that are intended to develop ethical behavior over the course of an entire scientific or engineering career. Research by Michael Mumford, University of Oklahoma, identifies strategies for engaging students, postdoctoral fellows, faculty, and administrators in developing knowledge and skills to respond to ethical challenges.

The presenters agreed that institutions and researchers need a menu of programs, ranging from university-level to in-lab, informal, bench-level interactions, from which they can select the type of program most appropriate for their circumstances. In addition, as participants reminded each other throughout the workshop, institutions and researchers need guidance that is easy to follow and not overly time consuming. Several suggested that checklists might be an efficient way to call attention to ethical parameters in research practice (such as lab guidance about authorship and credit requirements), but others noted that a list would always leave out some important issues.

In this session, the presenters described instructional approaches to ethics education and provided examples and suggestions about materials appropriate for different fields or disciplines and different audiences. They indicated a range of pedagogies in courses and workshops: face-to-face and online; lectures and guest lectures; case discussions led by faculty or by students in

small or large groups; case writing; video cases; formal debates; and reflective journal writing among them. In addition, participants reiterated the importance of having support for ethics activities and materials development from the National Academies, Council of Graduate Schools (CGS), and AAAS, as well as from professional societies, individual institutions, and institutional groups.

INSTRUCTIONAL APPROACHES

Julia Frugoli explained that her university (Clemson University) sponsors ethics education in the form of both courses and workshops. The former can be most useful for students, she said, and the latter for faculty. Workshops, especially if they are offered throughout the year, can reach more people and more departments than in-course ethics material. Both address similar topics, but courses can explore more of those topics in depth.

At Clemson, the genetics and biochemistry departments have a required, for-credit course on professional-development skills in the molecular sciences for all incoming graduate students. The course addresses many topics, such as lab rotations and mentoring issues, lab notebooks and graphical presentations, peer review, and research ethics. Frugoli noted that the professional-development approach reinforces the idea that faculty and students are professionals, not just individuals "alone in the lab." Although few faculty members attend the classes, some take part when students ask, for instance, for examples of lab notebooks to take to class for discussion.

Students can also improve professional practices. For instance, in Frugoli's department students produced electronic notebooks tagged by date; faculty members subsequently showed an interest in adopting that procedure. The department has also sponsored one-day workshops for faculty and students, who received certificates for participating.

The courses and workshops at Clemson can meet NSF and other training-grant guidelines, and students have indicated that they liked both types of activities, although for different reasons. At the present time, however, participation in a workshop is not required. Thus the people who participate may not be those who most need this type of training. Sara Wilson of the University of Kansas pointed out differences between engineering and science to which ethics education must be sensitive. Kansas offers an introductory course for graduate students in a number of related scientific fields in chemistry, pharmacology, and nursing that focuses on science topics, such as data integrity and appropriate reporting of statistical methods. Another course, for bioengineering graduate students, emphasizes appropriate engineering analysis, computational error, and model sensitivity. However, because engineers conduct research both in "science mode" (hypothesis-driven, often experimental) and engineering mode (design, forensics, modeling), they must address issues in both areas. By the same token, scientists operating in "engineering mode" might find a focus on engineering topics useful. Each course is offered for one credit.

> We really want to get to . . . having [ethics or professional development] integrated into all kinds of programs, from the lab meeting to core courses, as a module or part of a discussion group, to what your thesis incorporates . . . like a section on . . . ethical and social implications."
> —*Julia Frugoli, Clemson University*

Wilson then compared topics related to (1) RCR in both science and engineering with topics related to (2) RCR and practice in engineering alone. Topics in the first category would include data integrity, appropriate reporting of statistical methods, conflicts of interest, publication and openness, allocation of credit, authorship practices, confidentiality, fabrication, falsification, plagiarism, mentorship, and the use of human/animal subjects. Topics in the second category would include all of those, particularly in the engineering-in-science mode, as well as topics

specific to engineering, which, she said, can be divided into three groups: (1) professional practice and business, (2) design, and (3) modeling.

Topics in the *professional practice and business* group include: working within areas of competence; client/employer/agent relationships and avoiding conflicts of interest; business practices; public statements; and licensure. Topics in the *design* group include: goals and trade-offs; human health and welfare considerations in the design of devices, structures, and constructs; global and social impacts of engineering design; appropriate engineering analysis (expecting the unexpected); and codes and standards. Topics in the last group, *modeling*, include: assumptions; validation; computational error and model sensitivity; and extrapolation.

Caroline Whitbeck, Online Ethics Center, noted that research supervisors are critical to the articulation of standards in their fields. Although some ethical questions are multi- or transdisciplinary, she said, some are discipline-specific and require different answers for different fields. In addition, new standards, norms, or values sometimes have to be developed in response to new conditions or problems, or even disciplines.

In all of these cases, supervisors play a critical role in helping graduate and postdoctoral students identify requirements for good practice and interpret the behavior of others. Whitbeck believes that, although experienced investigators often have a "sophisticated understanding of how to behave. . . [they] may not know how to talk about what they have learned." Therefore, programs to assist faculty and assess mentoring activities are also important.[8]

Simil Raghavan, Johns Hopkins University, expanded on that idea. She described an annual faculty retreat sponsored by her department, during which students lead discussions on case studies they have developed. The program has two parts. In the first part, students meet in small

[8] Whitbeck describes a method of involving supervisors, focused on 10 topics for the responsible conduct of research at *www.onlineethics.org/cms/13008.aspx*.

groups to discuss the cases; in the second part, each group presents a case to the entire department for discussion. This activity provides students with "memorable interactions," she said, although questionable positions are not always challenged, especially if they are advocated by high-status faculty members.

INSTITUTIONAL APPROACHES

Dartmouth University

In Session I, Joseph Helble, Dartmouth, described the university-wide ethics program for graduate students at his university. The program, which began in 2004, was developed in collaboration with Dartmouth's Ethics Institute. It includes a broad-based ethics training course for all new science and engineering students. The course begins during orientation and continues throughout the term. Faculty and senior graduate students act as facilitators during orientation, which encourages community building. In the ethics course, instructors use a case-based approach, focused on issues of professionalism, mentoring, data collection, and authorship.

After taking the course, a majority of graduate students surveyed reported having a clearer understanding of their ethical responsibilities and insight into issues that they had not previously considered. The survey results also indicated that the program promotes a strong sense of community among graduate students. Dartmouth is currently tracking the incidence of honor-code violations to see whether the program has made a difference in this regard. The initial data are positive, but determining their significance will require comparison with data for several more years.

Helble reported that program weaknesses include the lack of cases relevant to some fields, a lack of interest on the part of some students, and difficulty in demonstrating the relevance of

some concepts to students who have not yet begun working in laboratory or research environments. In addition, some international students, who have been educated in academic environments in which getting the right, praiseworthy solution is the highest priority, do not understand problems related to sharing and copying from other students. Helble asked how such ideas can be challenged without appearing to demean other cultures.

University of Oklahoma

Michael Mumford of the University of Oklahoma described a two-day, 16-hour course developed by his research team. The course, which is separate from normal coursework, focuses on what these researchers call "sensemaking" in ethical decision making—an approach that uses case studies, social reinforcement through interactive, cooperative learning emphasizing the social nature of ethical problems, and strategies to help students identify and think through them.

> We are not teaching people ethics. .. . We have to cover too many fields. Rather, we are teaching them strategies by which to construct a viable response.
> *Michael Mumford, University of Oklahoma*

Students are encouraged to recognize the dimensions of problems, ranging from their origins to their relevant values; to seek outside help; to question their own judgment; to deal with emotions; to anticipate the consequences of actions; to analyze personal motivations; and to consider the perspectives of others. This course, which is being taught to graduate students in all departments on the Norman campus, requires a significant commitment of university resources.

Council of Graduate Schools

Daniel Denecke of the Council of Graduate Schools in Washington, D.C., described ongoing projects sponsored by the council. In 2004, CGS began an RCR project, with a grant from the

Office of Research Integrity and received a grant from NSF for a second project in 2006. The goal of both projects is to develop a cadre of knowledgeable graduate deans, as well as to gain experience in best practices for the start-up and institutionalization of ethics education in graduate schools. CGS will document its results, so that they can be adopted by others. A third project that began in 2007 focuses primarily on biomedical and behavioral sciences and emphasizes comprehensive approaches to promoting and institutionalizing scholarly integrity and a national dialogue on resources and models for ethics education among senior administrators in the nation's graduate schools.[9]

In the first project, the Council of Graduate Schools identified several "best practices" for start-up activities: (1) establishing an advisory board that includes core research faculty; (2) providing public forums; (3) offering two-tiered instruction (both disciplinary and trans-disciplinary); (4) addressing ethical reasoning and deliberation; (5) making RCR training mandatory; and (6) developing and conducting multilevel assessment (e.g., on both individual and institutional change).

In the second project, CGS identified "best practices" for institutionalizing programs on campuses. These practices included: (1) identifying differences between student and faculty perceptions of training in ethics and ethical climate; (2) using survey data to motivate the proposed activities/programs; (3) linking to mandatory requirements and/or documenting the completion of training; and (4) scanning available resources for gaps when developing

> You don't want to send the message this is just about bad people . . . behaving badly . . . But it's about setting the . . . bar high for scholarship to be encompassing right conduct. . . . And that's part of . . . mentorship too.
> —*Daniel Denecke, Council of Graduate Schools*

[9] For information on the CGS activities, see ***http://www.cgsnet.org/Default.aspx?tabid=336***.

new content in-house.

Persistent challenges for ethics education and mentoring for graduate students and postdoctoral fellows, Denecke said, include faculty buy-in, professional development for students, and assessments of academic climate. Support from graduate deans is essential for these initiatives. In project documents, the Council of Graduate Schools uses the language of scholarly or research integrity to discourage a "compliance mentality" and encourage an understanding of research integrity as the way things are done.

Workshop Discussions

One theme that emerged in discussions throughout the workshop was the need for institutional change. Charles Huff of St. Olaf College had pointed out that many people who want to do the right thing need resources, including best practices and recommendations for measuring progress. Measurements should assess organizational structures and processes, he said, and the results may lead us to ask questions, such as whether the moral imperative to include underrepresented groups, for instance, is based on the rights of individuals or on the potential to change research environments and institutions for the better.

Another reason for institutional change, according to J. Britt Holbrook of the University of North Texas, is the difficulty of linking instruction in research ethics to tenure. Holbrook noted that incorporating ethical considerations in the criteria for NSF funding might encourage that linkage.

A number of participants argued that programs on ethics and science, technology, and society on a broader level than research practice should also be recognized. Holbrook described a Ph.D. Plus option in nanotechnology and society at Arizona State University for which

engineering Ph.D. students add a chapter to their dissertations about the societal implications of their work. In fact, he said, humanitarian service is now included in numerous undergraduate and graduate engineering programs.[10]

As many participants noted, all of these additions and changes to the curriculum require trade-offs. Reaching many students or covering many topics may come at the expense of in-depth examination of the issues—"trade-offs of quality for quantity." Some of them pointed out that large numbers of students can participate in online training, but, given limited time and resources, fewer can participate in face-to-face interactions. Others noted, however, that the online training might not be as effective because of the absence of direct interaction and limited exposure to the material. In addition, all of these alternatives need better assessment methods.

In the opinion of Joseph Whittaker, Morgan State University, advocates for ethics activities and programs must acknowledge these quality-control issues. He believes that to be effective future programs must do the following:

- Expand "trainer of trainers" capabilities.
- Facilitate benchmarking, that is, finding, learning, and adopting best practices.
- Develop centralized information databases to encourage/facilitate knowledge transfer, sharing, and implementation.
- Consider ethics knowledge an asset, and promote it as a product or service that the university provides.
- Identify challenges and barriers to training, implementation, and knowledge sharing.

Given their particular circumstances, Whittaker suggested that responsible institutions assess their current culture or state of environment; determine how their leadership, strategies, and

[10] Linda Abriola, NAE Member, Dean, School of Engineering, Tufts University and Kevin Passino, Electrical and Computer Engineering, Ohio State University described programs at their schools at the NAE CEES Workshop on Engineering, Social Justice, and Sustainable Community Development, October 2-3, 2008, at the National Academy of Sciences.

demographics impact the practice, choices, and information-transfer initiatives that affect ethics practices; identify the best approaches—a grand design or small, scalable, progressive start-up; develop plans that maximize existing resources; and determine if better results would be achieved with coordinated governance or oversight.

INSTRUCTIONAL RESOURCES

On Being a Scientist, a publication of the National Academies (now in its third edition), is a welcome resource, particularly for faculty and students in the natural and physical sciences and engineering. Another basic resource is *Advisor, Teacher, Role Model, Friend: On Being a Mentor to Students in Science and Engineering* (National Academy Press, 1997).[11] The AAAS Program on Scientific Freedom, Responsibility and Law has produced many publications and videos on scientific integrity and maintains an online AAAS-NAS compilation of resources on research integrity.[12] Participants provided citation resources before the meeting.[13] During the workshop, participants also mentioned two other types of resource: train-the-trainer and ethics-across-the-curriculum activities. Noted among these programs were the annual Teaching Research Ethics workshops at Indiana University.[14]

Workshop speaker Kelly Laas of IIT addressed the issue of electronic resources. She noted that students find blogs, wikis, and social networking sites most useful, but faculty members need websites to help them quickly find resources for teaching students. Practitioners may find an interactive case-discussion site (e.g., *www.ethicscasediscussions.org*) most useful.

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[11] Available at *http://www.nap.edu/catalog.php?record_id=5789*.
[12] *http://www.aaas.org/spp/sfrl/projects/research_integrity/scientific_integrity/*. This resource is being transferred to the CGS Scholarly Integrity project; it will be available at *http://www.scholarlyintegrity.org/Resources.aspx*.
[13] The list is available at *http://www.nae.edu/?ID=10430*.
[14] *http://poynter.indiana.edu/tre/*.

Lass indicated that to stimulate students to develop the intellectual, social, and emotional resources they will need to recognize and respond to ethically challenging professional circumstances, online environments should put users in active roles, helping them to use their knowledge and skills in life-like situations. Online resources should also put students in contact with others on sites where they can discuss and share ideas, and they should encourage students to seek out answers and find new resources (e.g., through online tutorials, case libraries, or ethics resource centers).

Online tutorials, such as CITI (Collaborative Institutional Training Initiative)[15] and the Columbia University online training modules,[16]Lass said, can quickly and effectively convey information to busy students and researchers. Tutorials can also promote the creation of "ethics communities." The OpenSeminar in Research Ethics,[17] for example, has initiated a blog.

However, maintaining and updating these sites has been difficult. Laas noted that online resource sites could be improved if materials were indexed in various ways (e.g., by ethical issue, discipline, cases, or audience) and if site managers continue to solicit new case studies and materials to update their sites.[18] As a result of the America COMPETES Act, demand for online resources may increase, especially for well-organized databases of available ethics materials, developed syllabi and full texts of readings, experts or experienced instructors in RCR and science and engineering ethics, and an online discussion forum for information exchange among

[15] Found at ***www.citiprogram.org*** , the CITI Program is a subscription service that provides research-ethics education to the research community. To participate, learners must be affiliated with a CITI participating organization.

[16] ***http://www.fhcrc.org/science/education/courses/research_ethics/training/online/.***

[17] ***http://openseminar.org/ethics/screen.do.***

[18] For a general resource on research ethics and engineering ethics, see ***www.onlineethics.org***. For a resource on bioethics, see ***http://www.ethicshare.org/.*** Codes of ethics for many scientific and engineering societies are available at ***http://ethics.iit.edu/codes/coe.html***. For general background as well as a wide range of materials on ethics and ethical controversies, see ***http://ethics.sandiego.edu/***.

instructors. In addition, all of these sites should incorporate new technologies and content as they become available.

Laas pointed out, and numerous participants agreed, that new technologies and learning evolve together. Online resources must not only solicit new material and review the quality and relevance of uploaded material, they must also find ways to shorten retrieval time and allow users to personalize their sites. She suggested that educators develop ways to facilitate searches for materials most relevant to a discipline, problem, role (e.g., student, teacher, or employer) and promote interactive learning environments.

5
Assessment and Evaluation of Ethics Education and Mentoring

The following background questions provided a context for Session III, *Outreach and Assessment*:

> Are relevant and important materials and techniques reaching the appropriate audiences? Who are the appropriate audiences, and are there useful feedback loops from them to the developers of materials, techniques, and guidance? Are the audiences able to adapt or adopt these resources? What efforts might improve access, use, and feedback and improvement? What kinds of assessment have been developed, make sense, or should be encouraged for the future? What have we learned, and what do we need to learn?

Felice Levine, executive director, American Educational Research Association, (AERA) moderated this session. Speakers were Melissa Anderson, professor, Department of Educational Policy and Administration, University of Minnesota Minneapolis; Daniel Denecke, head of the Best Practices and Publications Program, Council of Graduate Schools; and Joseph Whittaker, dean, School of Computer, Mathematical and Natural Sciences, Morgan State University.[19] The respondents were NAS member W. Carl Lineberger, professor, Department of Chemistry and Biochemistry, University of Colorado, Boulder; and Charles Huff, professor, Psychology Department, St. Olaf College.

One of the speakers in Session I, Michael Mumford, University of Oklahoma, also addressed the issue of assessment in reviewing the work of his research team, which compared

[19] Brian Schrag, executive secretary, Association for Practical and Professional Ethics, had also been scheduled to make a presentation but was unable to attend.

results from its "sensemaking" training with other kinds of ethics training. Using a case-based pre/post measure, the team found that interactive "sensemaking" instruction had more positive results than some other approaches. Mumford reported that an evaluation of research-ethics courses at a number of research intensive universities showed that instruction given as part of regular classes that did not include interactive activities was generally not effective. In some cases, he said, this kind of instruction even had negative impacts on ethical decision making in four areas of research conduct—data management, the conduct of a study, professional practices, and business practices.

Melissa Anderson, University of Minnesota Minneapolis, reported on her research team's survey of more than 7,000 early and mid-career NIH-funded scientists. Very few of the survey respondents reported that they had engaged in any fabrication, falsification, or plagiarism in the three years prior to taking the survey, but many indicated engaging in questionable research practices. A majority of mid-career scientists reported that they had cut corners or made inappropriate use of funds in those years. For both early- and mid-career scientists, the research indicated significant associations between these questionable practices and environmental factors, such as competitiveness, counter-norms (e.g., secrecy and self-interestedness), and perceived injustices in the research environment.

The survey results also indicated limited positive influence of ethics education on research behaviors, whether the instruction had been given in a separate course or was combined with other research training. The self-reports from early-career NIH-funded scientists even indicated a negative relationship between separate ethics instruction and good data-handling practices.

In addition, the results indicated that the influence of mentoring depended on the type of mentoring. Mentoring focused on research ethics, good practice, and personal assistance was

associated with a decrease in questionable behavior, but mentoring for survival (or how to get ahead in your field) was associated with an increase in questionable behavior.

Anderson recommended that laboratories and other research locations adopt a principle of "collective openness" that would require participants to encourage "anybody at any time [to] ask questions about any . . .work or how it is done . . . [and] raise questions so that mistakes, oversights, and misbehavior will . . . be caught.." Operating in accordance with this principle, she argued, would ensure that research behavior could "stand up to scrutiny" and meet the standards of "scientific integrity."[20]

The next speaker, Daniel Denecke of CGS, reported that the 10 universities that participated in the first CGS project on ethics research (funded by NIH), found assessment to be a difficult challenge because of the difficulty of finding or developing measures of student learning. Denecke said assessments should also measure the institutional climate for integrity (which might explain differences between faculty and student perceptions) and the effectiveness of curricular reforms. The 10 participating universities assessed the effectiveness of efforts to get faculty buy-in rather than student learning.

The eight universities that participated in the second CGS project (funded by NSF), had some features in common, such as online modules, but they also developed their own activities and, especially, their own assessment strategies. Although a comparative assessment for these universities would have been helpful, Denecke said, the short lifespan of the project and the diversity of approaches had made that impossible.

He then described a new project that will have three layers of assessment. Measures of student learning will be left to the institutions, but the other two measures will be based on common instruments, one to assess student and faculty perceptions of cultural changes in their

[20] Readers can find citations to this work at http://cehd.umn.edu/EdPA/People/Anderson.html.

institutions and one to assess how well practices put in place for the project worked during the project and afterward, and to identify mid-course adjustments.

At various times in discussions throughout the meeting, workshop participants remarked that assessments of ethics instruction and mentoring were at an early stage of development, and that determining and adopting appropriate, consistent measures for success would not be easy. Even measures of student satisfaction and pre/post test achievement differentials, which are relatively easy to measure, do not tell if the right things are being measured or whether students can call on what they've learned afterwards, when needed. In addition, many assessment instruments have not been validated, and instructional methods may not always be appropriate for the target audience.

In the general discussion following this session, areas in need of further research, such as a multi-level assessment that would include individual outcomes and institutional changes over the short and long term, were identified. Among the commonly accepted, or at least usable, measures, the group named measures of broad-based faculty and departmental involvement at the institutional level, and measures of improvements in reasoning ability and other skills and knowledge at the individual level.

Some discussion participants noted that new, expanded, or revised programs offered by professional societies and accreditation bodies could provide another kind of measure. Felice Levine of American Educational Research Association suggested that questions might be embedded in ongoing periodic research surveys. For example, NSF could add an ethics question to its graduate student/postdoctoral survey. Several participants suggested that compliance officers in industry and academia might be asked to describe their experiences with different approaches to ethics education and to identify needs for further research.

The group was generally encouraged that attempts at assessment were being made and that the need for assessment has been recognized, if only in response to the new requirements of funding agencies, such as NSF. Many participants noted the urgent need for better assessment tools and a "menu" of choices to guide principal investigators who want to incorporate ethics training into their research programs, including assessments of training programs and "train-the-trainers" programs, to determine their consistency and effectiveness. Some members of one discussion group had floated the idea of national standards or certification but did not have time to pursue the idea in detail. Charles Huff of St. Olaf Collage also mentioned a variety of available measurement tools that might be adapted to ethics education, ranging from tests of personality, to those measuring recognition of ethical issues and knowledge of approaches to their resolution, to organizational ethical climate scales.[21]

[21] http://www.stolaf.edu/people/huff/info/Papers/Good.Computing.P1.doc

6
What's Next?

In the last two sessions of the workshop, Session IV at the end of day one and discussions on the morning of day two, participants reviewed the ideas and themes that had arisen during the first three sessions and identified the issues that merited further attention.

The background questions for Session IV, moderated by planning committee member Mark Frankel, AAAS, are provided below:

> What can we conclude about how to develop and implement programs, how to export them, and how to assess their effectiveness? What can we conclude about the development and use of effective methods and materials? What kinds of research, resource development and dissemination, and assessment activities do we need in order to respond more effectively in the future?

The following topics were on the agenda for the concluding session, which was headed by Rachelle Hollander, director of CEES:

> Identify promising materials and practices and provide examples of successful approaches and outcomes, including those that have created bridges between research investigators and scholars and researchers with expertise in relevant domains of science and engineering ethics. Identify gaps in accessible and useful resources and in the knowledge base, and suggest future research, educational innovations, and outreach and dissemination activities.

In both sessions, participants reviewed the topics and summarized major themes that had emerged during the workshop. First, in response to new mandates for ethics education and mentoring, academic institutions, research investigators, faculty, and students have undertaken many new initiatives and collaborative efforts to develop and implement ethics education and

mentoring programs on their campuses. Second, a wide variety of potential resources for ethics education were identified. Third, the measurement of program effectiveness remains an unanswered challenge.

The ideas described below emerged from the workshop presentations and discussions. They are not listed in order of priorities and are not meant to express a consensus.

1. Context Matters.

What has been learned?

Societal rewards influence the behavior of organizations and individuals in ethically desirable and undesirable ways. Therefore, it is unrealistic to teach standards for ethical practice in scientific and engineering research that do not apply to the external environments in which they find themselves. In other words, ethics is not a vaccine that can be administered in one dose and have long-lasting effects no matter how often, or in what conditions, the subject is exposed to the disease agent. Teaching individual students and postdoctoral fellows good professional practices cannot be highly and widely efficacious until academic culture and society also model and reward ethical behavior.

> My fantasy…would be if NSF could… actually ask universities every five years or so to do a self-study of their research practices. It would be amazing.
> *Deborah Johnson, University of Virginia*

What should be done?

Academic administrations should provide evidence that they have established wide-ranging cross-institution programs to stimulate and reward ethically appropriate behavior, particularly in research settings. Professional societies, government funding organizations, and universities can cooperate on workshops to promote ethics, prizes for outstanding ethical leadership, and changes

to the tenure process that reward outstanding mentors, for example. They and other individuals and organizations involved in ethics education in science and engineering should also look for ways to engage prestigious organizations and individuals in promoting these activities and expectations. For instance, laboratory directors might be asked to become members of the board of universities' ethics centers.

2. Learning Matters.

What has been learned?

Successful ethics programs generally require mandatory student participation,[22] involve relevant faculty, use interactive formats and case materials, and are scheduled throughout the year. Best practices include teaching for field-specific standards.

What should be done?

Examples of best practices in ethics education and ethics mentoring should be collected, and a repository or clearinghouse of information about these practices and available materials should be created.[23] Ways should then be developed to disseminate these practices to many colleges and universities. Ethics educators and programs should also develop materials that are easily accessible and indexed for relevant audiences. The international aspects of graduate science and engineering education might require special attention.

[22]Carlin, D. and D. Denecke, *Best Practices in Graduate Education for the Responsible Conduct of Research.* Washington, DC: Council of Graduate Schools, 2008.

[23] NSF has announced its intention to solicit proposals to support the development of a digital library of ethics education resources of this kind; see Federal Register 74:37, 8818-9. NSF Responsible Conduct of Research, February 26, 2009.

NAE member Paul Citron, Medtronic (retired), urged that particular efforts be made to engage employers of scientists and engineers, to ensure that ethics education programs examine ethical issues in non-academic laboratories, government-university-industry cooperative research programs, and other settings engaged in or incorporating results from research activities. Many students and post-doctoral fellows do not become researchers or academics but work in settings influencing and influenced by research. This involvement would also provide a reality check about what industry wants in graduate education.

3. Criteria for Ethics Programs and Activities

What has been learned?

Reports from administrators, faculty members, postdoctoral fellows and graduate students indicate that stand-alone, online programs that students, post-docs, and faculty take on a "pass/fail" basis do not provide an adequate introduction or enough practical experience to prepare them for ethical problems that arise in academic and professional life. Additionally, they indicate that web-based resources that are regularly checked and updated, and part of a broader program can be useful, and that successful activities and programs include ethically relevant perspectives that take account and model different disciplines and professions.[24]

What should be done?

Successful programs have some common features: use of case studies, interactive formats, involvement of research faculty, and clear take-home messages. Even successful programs can be reinforced with supplemental material; and online resources and tools should be identified and

[24] Carlin, D. and D. Denecke, *Best Practices in Graduate Education for the Responsible Conduct of Research.* Washington, DC: Council of Graduate Schools, 2008.

classified to assist academic institutions, professional associations and societies, principal investigators, and faculty, employers, and individuals to develop and implement ethics activities of all kinds. These activities can range from mentoring programs to campus-wide, multi-level educational modules to consideration of materials from symposia that can be adapted and disseminated online or at meetings of professional organizations.

4. Interactivity Matters.

What has been learned?

Students have demonstrated a facility for and an interest in using online resources that are interactive and adaptable to meet their needs.

What should be done?

Online resources targeted to students should have accessible, engaging interfaces to take advantage of students' affinity for new media. Online materials must be updated to reflect changing issues and interests.

5. Mentoring

What has been learned?

Not all types of mentoring activities improve ethical outcomes. For instance, mentoring postdoctoral fellows to be successful in highly competitive environments can encourage unethical behavior.[25]

[25] Anderson, M. S., Horn, A., Risbey, K. R., Ronning, E. A., De Vries, R., and Martinson, B. C. (2007). *What do mentoring and training in the responsible conduct of research have to do with scientists' misbehavior? Findings from a national survey of NIH-funded scientists.* Academic Medicine, 82(9), 853-860.

What should be done?

Institutions and principal investigators should identify ways in which research scientists and faculty or administrators with ethics education responsibilities can work together on mentoring postdoctoral fellows, especially, but also graduate students at the dissertation level. Particular attention should be paid to issues that affect international, minority, and female students and students who satisfy other diversity criteria, such as age or disability. Finally, professional societies and academic associations should establish and update a repository--or repositories--of information about successful mentoring activities and programs that can assist principal investigators and provide a basis for evaluating other mentoring activities and programs in the future.

6. Evaluation

What has been learned?

Attempts to evaluate and improve ethics education for scientific and engineering research and practice are just beginning. However, they do show that even though the immediate results of some programs are positive, circumstances and pressures can overwhelm graduate students, postdoctoral fellows, and junior faculty and researchers and undermine those results.

What should be done?

Agencies with an interest in ethical research should fund a workshop to develop evaluation criteria and measures for ethics education in science and engineering curricula, particularly graduate programs, and for mentoring postdoctoral fellows and last-stage graduate students. These measures should be applicable at the individual and institutional levels. Results from a portfolio of evaluation projects should be disseminated so the findings can be used to modify

ethics education and mentoring practices. In addition, agencies should consider expanding assessment measures to include compliance officers in businesses, as well as academic institutions.

7. Social Responsibility and RCR (Responsible Conduct of Research)

What has been learned?

Approaches to RCR (often considered synonymous with "research ethics") have focused on the internal demands of specific fields of endeavor and professions for standards of practice. The focus is mostly on meeting minimal standards of acceptable practice rather than on exemplary or recommended practices. The teaching of social responsibility in science and engineering has focused mostly on issues arising from interactions between science and technology and society, such as environmental risk, medical and social equity, and computers and terrorism. Not much dialogue has been initiated between the developers of RCR programs and those engaged with issues of social responsibility of science and engineering. Employers, faculty, postdoctoral fellows, and students should be aware of questions arising in both. The larger issues of science, engineering, and technology in society are of great interest to everyone, including junior scientists, engineers, and students.

What should be done?

Educational institutions and federal agencies that support ethics education should encourage and reward programs that develop creative approaches to ethics education and teach the social responsibilities of science and engineering, as well as RCR, that carefully define and explore exemplary practices, and that integrate the issues of social responsibility and RCR.

Appendix

WORKSHOP AGENDA

DAY ONE

8:00 a.m. Continental Breakfast

8:30a.m. Welcome

Dr. John Ahearne, Chair, NAE CEES Advisory Group
Dr. Francisco Ayala, Member, OBAS Committee, COSEPUP

8:45a.m. Statement of Meeting Goals

Dr. Richard Bissell, Executive Director, Division of Policy and Global Affairs, National Research Council (NRC)
Dr. Rachelle Hollander, Director, CEES, NAE

9:00 a.m. Meeting Logistics

9:10 a.m. Introductions of Meeting Attendees

10:00 a.m. Session I: Needs and Issues for Ethics Education in Scientific & Engineering Research

Investigators and students exist in complex research and learning environments that include academic and other organizations such as professional societies, commercial research laboratories, government funding agencies, and peer-reviewed journals. What do these individuals and groups identify as the main impediments to developing effective responsible research programs? Are there conflicting ideas about what these impediments are and what to do about them?

Moderator: Francisco Ayala
Speakers: Joseph Helble, Deborah Johnson, Michael Mumford, Wendy Williams
Respondents: Paul Citron, Hugh Gusterson, Susan Silbey

Short Break

General Discussion

Noon Lunch and Role-Play Exercise "Getting Results"

Facilitator: Stephanie Bird

1:30 p.m. Session II: Pedagogical Methods and Materials

There is quite a variety of both methods and materials in effect. More than a few consortia provide on-line tutorials; conferences are common. What kinds of contents and range of techniques are in use? What are their strengths and their limitations? Whom do they reach, and with what results? What information do we have that enables us to judge their merits? What's missing?

Moderator: John Ahearne
Speakers: Julia Frugoli, Kelly Laas, Caroline Whitbeck, Sara Wilson
Respondents: Jason Borenstein, J. Britt Holbrook, Simil Raghavan
General Discussion

3:30 p.m. Break

3:45 p.m. Session III: Outreach and Assessment

Are relevant and important materials and techniques reaching the appropriate audiences? Who are the appropriate audiences, and are there useful feedback loops from them to the developers of materials, techniques, and guidance? Are the audiences able to adapt or adopt these resources? What efforts might improve access, use, and feedback and improvement? What kinds of assessment have been developed, make sense, or should be encouraged for the future? What have we learned and what do we need to learn?

Moderator: Felice Levine
Speakers: Melissa Anderson, Daniel Denecke, Brian Schrag, Joseph Whittaker
Respondents: Carl Lineberger, Charles Huff

Short Break

General Discussion

5:15 p.m. Review of Sessions I, II and III

What can we conclude about how to develop and implement programs, how to export them, and how to assess their effectiveness? What can we conclude about development and use of effective methods and materials? What kinds of research, resource development and dissemination and assessment activities do we need in order to respond more effectively in the future?

Moderator: Mark Frankel

7:00 p.m. Working Dinner at the Marian Koshland Science Museum

Speaker: Richard Bissell, On Being a Scientist

Informal conversation and continuation of discussion as needed or desired. The workshop planning group will meet at dinner to discuss meeting's progress and assign follow-up duties.

DAY TWO

8:00 a.m. Continental Breakfast

8:30 a.m. Next Steps

This session will draft an initial version of the meeting summary, based on the previous day's discussion and attendees' reflections about it. The workshop summary will identify currently promising materials and practices and provide examples of successful approaches and outcomes, including those that have created bridges between research investigators and scholars and researchers with expertise in relevant domains of science and engineering ethics. It will identify gaps in accessible and useful resources and in the knowledge base, and suggest future research, educational innovations, and outreach and dissemination activities.

Moderator: Rachelle Hollander

Noon Lunch and Follow-On Assignments

2:00 p.m. Adjourn

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