Practical Guidance on Science and Engineering Ethics Education for Instructors and Administrators: Papers and Summary from a Workshop December 12, 2012

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PRACTICAL GUIDANCE ON SCIENCE AND ENGINEERING ETHICS EDUCATION FOR INSTRUCTORS AND ADMINISTRATORS

Papers and Summary from a Workshop
December 12, 2012

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Cameron H. Fletcher, Co-Editor
Rachelle D. Hollander, Co-Editor

Joint Advisory Group to the Center for Engineering, Ethics, and Society (CEES)
and the Online Ethics Center (OEC)

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On December 12, 2012, the Center for Engineering, Ethics, and Society (CEES) at the National Academy of Engineering (NAE) held a workshop on "Practical Guidance on Science and Engineering Ethics Education for Instructors and Administrators." This workshop was part of the University of Illinois at Urbana-Champaign project (NSF No. 1045412) to develop a national online resource on ethics in science, mathematics, and engineering, which was funded by the National Science Foundation. The workshop was supported by Contract/Grant No. 1013801 between the National Academy of Sciences and the University of Illinois at Urbana Champaign.

NAE staff prepared the discussion summaries and session introductions and they have been reviewed according to procedures approved by the NAE report review process.

Participants at the workshop prepared the workshop papers and modified them for this publication. The bibliography of suggested resources was compiled from the suggestions of the workshop participants. Publication of signed work signifies that it is judged a competent and useful contribution worthy of public consideration, but the data, interpretations, findings, and conclusions in such publications are those of the authors and do not purport to represent the views of the council, officers, or staff of the NAE or the organizations or agencies that provided support for the project.

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William Kelly, American Society for Engineering Education (ASEE)

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In addition to the reviewers, the JAG wishes to thank the project staff. Vivienne Chin managed the committee's logistical and administrative needs, making sure the workshop ran efficiently and smoothly. NAE senior editor Cameron H. Fletcher edited the authored papers and the summary sections written by CEES program officer Frazier F. Benya. Benya also assisted in planning the workshop, coordinated with the authors on their submissions, edited the proceedings, led the response to review, and managed the development of the publication. CEES associate program officer Simil Raghavan participated in planning the workshop and in workshop discussions. She also assisted in developing the report. NAE senior program officer Janet Hunziker managed the review process. CEES director Rachelle Hollander planned the workshop, reviewed and edited the entire proceedings, and oversaw the project from start to finish.

Lastly, the JAG would like to extend a special thanks to C. K. Gunsalus and Michael Loui from the National Center for Professional and Research Ethics (NCPRE) at the University of Illinois at Urbana-Champaign for collaborating on the workshop planning and publication, and for contributing to the discussion at the meeting. NCPRE supported and co-sponsored the workshop through the Ethics CORE project, which was funded by the National Science Foundation (#1043289), so we also thank the staff members that worked on that project and at NCPRE.

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1

Introduction

C.K. GUNSALUS
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Over the last two decades, colleges and universities in the United States have significantly increased the formal ethics instruction they provide in science and engineering. For the sciences, the impetus came from two federal mandates. In 1992, the National Institutes of Health (NIH) began requiring instruction in responsible conduct of research for NIH trainees. In 2010, the National Science Foundation (NSF) began requiring instruction in the "responsible and ethical conduct of research" for all undergraduate students, graduate students, and postdoctoral scholars supported on NSF grants awarded in 2010 and later. For engineering, the impetus for ethics education started in 1997, when ABET (formerly the Accreditation Board for Engineering and Technology) adopted Engineering Criteria 2000 (EC2000) for accrediting engineering programs (ABET 2011). EC2000 required graduates to demonstrate "an understanding of professional and ethical responsibility." Although ABET criteria had by 1985 included "an understanding of the ethical characteristics of the engineering profession" (Harris et al. 2005), EC2000 added assessment of student outcomes in professional ethics as well as other outcomes in engineering education.

Today, academic programs in science and engineering have incorporated instruction in ethics. In this they resemble programs in medicine and law, although instruction in science and engineering ethics may begin in undergraduate programs. Medical and law schools socialize students into their professions' values and responsibilities. Ethics instruction in these schools covers professional obligations that go well beyond ordinary moral obligations of honesty and fairness. For example, law students learn that they must disclose potential conflicts of interest when they engage clients, and they learn the boundaries and rules of attorney-client privilege and how to handle client funds.

Similarly, science and engineering programs socialize students into the values of scientists and engineers as well as their obligations in the conduct of scientific research and in the practice of engineering. The values of science include commitments to objectivity and truth. The values of engineering include commitments to safety and efficiency. While everyone has an obligation to avoid endangering other people, engineers have a special obligation to promote the "safety, health, and welfare of the public," as stated in the Code of Ethics of the National Society of Professional Engineers (NSPE 2013). Junior scientists learn the special obligations of researchers. For example, when a manuscript is submitted for publication in a peer-reviewed journal, the reviewers must keep the contents of the manuscript confidential—they must not share the manuscript's ideas with others.

In addition to teaching the special obligations of scientists and engineers, ethics instruction can prepare students for challenges that might arise in their professional lives. Ethics education programs typically help students develop the skills to recognize ethical problems, to reason about conflicts between important values, and to evaluate possible actions to address those problems. For example, students can learn how to negotiate practical solutions to disputes over authorship and intellectual property.

Beyond preparing practitioners for their specific professional obligations, medicine, law, science, and engineering all recognize that their practitioners have the power to affect the lives of many people in significant ways. An engineer's design decision can determine whether an automobile passenger survives an accident. A scientist's report can influence the development of public health policies or the drafting of environmental regulations. A lawyer's contract can change the ability of a company to hire and retain employees. A surgeon's skill can affect whether a patient lives or dies. Professionals who have such great power should understand that they also have great responsibilities. Physicians are responsible for the health of their patients. Engineers are responsible for the safety of the devices and systems that they design. Scientists and other researchers are responsible for the integrity and trustworthiness of their reports of their work, because others both within and outside the research community rely on the accuracy of the reports to build on their results. In short, education programs for future physicians, lawyers, scientists, and engineers should help students learn their professional and ethical responsibilities.

Instructors and administrators have struggled to meet federal mandates and accreditation requirements for ethics education in science and engineering. Technical requirements in the curricula crowd out time for ethics discussions. Demands for publication, research funding, disciplinary teaching, and professional service leave faculty members with little time or incentive to master the teaching of ethics in science and engineering, and few science and engineering professors have felt comfortable teaching about such ethical issues. They sometimes have sought help from experts in other academic fields, particularly philosophers, to collaborate in teaching science and engineering ethics. Ethics education should not be conducted solely by persons who do not know the professional standards of scientific research and engineering practice, however.

To assist faculty and administrators who plan and deliver ethics education programs in science and engineering, the Online Ethics Center of the Center for Engineering, Ethics, and Society (CEES) at the National Academy of Engineering provides access to literature and information, case studies and references, and discussion groups on ethics in engineering and science. Focusing on ethical problems that arise in the work of engineers and scientists, it serves practitioners, educators and students, and individuals interested in professional and research ethics. The Center serves those who are promoting learning and advancing the understanding of responsible research and practice in engineering.

The National Center for Professional and Research Ethics (NCPRE), founded in 2010 at the University of Illinois at Urbana-Champaign, strives to create communities of responsible research and professional practice. At NCPRE instruction in professional and research ethics is considered an essential aspect of career development for emerging professionals as well as practicing scholars, scientists, and engineers. NCPRE's centerpiece project is Ethics CORE, a national online ethics resource center that was initiated with funding from the National Science Foundation.

In December 2012, CEES and NCPRE collaborated on a workshop on Practical Guidance on Science and Engineering Ethics Education for Instructors and Administrators. Supported by the National Science Foundation (grant SES 1045412), the workshop sought answers to the following key questions: What goals are appropriate for ethics education programs in science and engineering? Should these programs cover issues of social policy in addition to issues of individual responsibility? How should ethics be taught? How can institutions support ethics programs and assess their effectiveness? The workshop focused on four key areas:

- goals and objectives for ethics instruction,
- instructional assessment,
- institutional and research cultures, and
- development of guidance checklists for instructors and administrators.

The workshop organizers commissioned papers from leading experts to summarize current research knowledge in these areas. At the workshop, these experts presented their papers, which informed the discussions among the participants. This report presents the edited papers and a summary of the discussions at the workshop.

Ethics CORE and the Online Ethics Center are designed to support faculty and administrators by collecting and providing access to resources such as teaching materials and best practices. In addition to these resources, we hope this workshop report will help readers implement effective ethics education programs in science and engineering.

References

ABET. 2011. History. Available at the ABET website: www.abet.org/History/; accessed June 11, 2013.

Harris CE, Pritchard MS, Rabins MJ. 2005. Engineering ethics: Overview. In: *Encyclopedia of Science, Technology, and Ethics*, ed. C. Mitcham. Detroit: Thomson Gale. Pp. 625–632.

NIH (National Institutes of Health). 1992. Reminder and update: Requirement for instruction in the responsible conduct of research in national research service award institutional training grants. *NIH Guide for Grants and Contracts* 21(43).

NSF (National Science Foundation). 2009. NSF's Implementation of Section 7009 of the America COMPETES Act. Federal Register 74(160). Available online at http://edocket.access.gpo.gov/2009/E9-19930.htm; accessed June 11, 2013.

NSPE (National Society of Professional Engineers). 2013. NSPE Code of Ethics for Engineers. Available online at www.nspe.org/Ethics/CodeofEthics/index.html; accessed June 11, 2013.

2

Goals and Objectives for Instruction

The first session of the workshop examined the goals and objectives for instruction in two areas of ethics education: responsible conduct of research and social responsibility. The first speaker, Michael Kalichman, is director of the Center for Ethics in Science and Technology at the University of California at San Diego. His background is in the neurosciences, but over the last two decades his work has focused on the goals, content, and methods for teaching research ethics. In 1999, with support from the Office of Research Integrity at the Department of Health and Human Services, he created the online Resources for Research Ethics Education, which provides information and resource listings on topics in research ethics, on educational settings, and on tools for discussion (http://research-ethics.net/). In his paper, he addresses the question of what and how to teach students about research ethics by examining what the goals of research ethics education are, as determined by examining federal regulations, and then arguing for what they should be. He suggests alternative principles, goals, and outcomes for teaching of research ethics, arguing that emphasis should be placed on doing something, not everything; increasing time spent in conversations about ethical challenges; meeting the different educational needs of different disciplines; and focusing efforts to improve the community, not just individuals.

The second speaker, Ronald Kline, is the Bovay Professor in the History and Ethics of Professional Engineering at Cornell University, where he holds a joint appointment between the Science and Technology Studies Department and the School of Electrical and Computer Engineering. His research and teaching focus on the history of technology, engineering, and information technology, and the history of engineering ethics and of the social responsibility of scientists and engineers. Kline explores historical beliefs in the scientific and the engineering professions to examine the balance of priorities for topics in research ethics, specifically focusing on the lack of attention to social responsibility in research ethics and science compared to the emphasis it is given in engineering. He concludes with recommendations for correcting the imbalance that has left social responsibility out of many educational efforts in science. First, he proposes addressing directly the imbalance in attention to social responsibility when teaching students. Second, he suggests incorporating the literature from science and technology studies into research ethics because it can help to question the sharp boundary between science and engineering and their responsibilities. Lastly, he argues for expanding the material on social responsibility in the National Academy of Sciences' report *On Being A Scientist*.

Why Teach Research Ethics?

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"Would you tell me, please, which way I ought to go from here?"
"That depends a good deal on where you want to get to," said the Cat.
"I don't much care where —" said Alice.
"Then it doesn't matter which way you go" said the Cat. (Lewis Carroll, 1865)

This analysis begins with an assumption: As teachers of research ethics we care about the outcomes of our teaching. As is true for other types of teaching, for experimental science, for the practice of engineering, and for Alice in Wonderland (Carroll 1865), it is paramount to know where we want to go (i.e., our outcomes) before deciding how to get there. To offer some provisional guidance on where we want to go, both empirical findings and theoretical arguments will be reviewed.

Goals Based on Federal Requirements

Analysis of research and engineering ethics education goals in the United States should begin with a recognition that before the announcement of federal requirements for training in responsible conduct of research (RCR), research ethics courses, workshops, and seminars were rare. Since the announcement of the first National Institutes of Health (NIH) requirement (NIH 1989), NIH requirements have expanded (NIH 1992, 2009), the National Science Foundation (NSF) introduced an RCR requirement (NSF 2009), and increasing numbers of graduate training programs and even entire institutions are requiring RCR training independent of sources of funding.

Given that much of existing ethics education in science and engineering is in response to these federal requirements, the question of goals might be first addressed by reviewing the goals of the requirements. However, while the various announced federal requirements (NIH 1989, 1992, 2000, 2009; NSF 2009) speak to varying degrees about the means (e.g., topics to be covered, how many hours, who is responsible for complying with the requirement), none explicitly ties those means to the intended ends. NIH (1989) opens with the statement that "A fundamental aspect of research is that it be conducted in an ethical and scientifically responsible manner," leaving the implicit assumption that the required RCR instruction will achieve this goal. NIH (1992) seeks only "that all NRSA [National Research Service Award] supported trainees are provided an opportunity for training in the responsible conduct of research." The Public Health Service (NIH 2000) articulated clear and ambitious goals ("promoting the responsible conduct of research and discouraging research misconduct and questionable research practices through education and awareness"), but also only implies that RCR education should, can, and will make this all possible. Furthermore, while this requirement was the most explicit of all, it was suspended just two months after being announced (NIH 2001). The updated NIH requirement (NIH 2009) is highly prescriptive about what *should* be done for RCR training, but only implies the intended outcomes by defining RCR as

> the practice of scientific investigation with integrity. It involves the awareness and application of established professional norms and ethical principles in the performance of all activities related to scientific research.

Finally, NSF (2009) does little more than call for "appropriate training and oversight in the responsible and ethical conduct of research."

In short, the published requirements for RCR education provide more insight into the intended means than the ends (goals) to be met or aspired to. This is to be contrasted with the criteria for accrediting engineering programs, which have emphasized outcomes rather than methods since adoption in 2000. Three of the current accreditation criteria (Engineering Accreditation Commission 2012, p. 3) are directly relevant to the ethical practice of engineering:

> (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability…
> (f) an understanding of professional and ethical responsibility…
> (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

Decreased Research Misconduct

Although the federal RCR requirements provide limited insight into intended goals or outcomes, there is good reason to believe that they were put in place as a response to research misconduct.

In the 1980s, allegations of research misconduct involving top US scientists—for example, David Baltimore (Kevles 1998) and Robert Gallo (Crewdson 2003)—caused considerable concern not only in the scientific community but even in the public domain. Principals in both of the named cases were called to testify before a subcommittee of the House Committee on Energy and Commerce chaired by Representative John Dingell (Kevles 1998; Crewdson 2003). In 1989, Walter Schaffer, NIH's newly assigned research training officer, was charged with coordinating the development of an educational requirement for the NRSA program. Schaffer's recollection (personal communication, 2012) is that

> a few high visibility misconduct cases…may have precipitated discussions related to training and education in the responsible conduct of research. These discussions and the fact that several institutions had already instituted apparently successful training modules led to the issuance of the notice in the NIH Guide to Grants and Contracts [NIH 1989].

With the 2009 update, it is clear that the NIH continues to believe that RCR education is an important part of graduate and postdoctoral research training. Similarly, the NSF requirement was plausibly promoted in part as a reaction to a perceived increase in research misconduct cases.

Increased Responsible Conduct of Research

Although a specific focus on decreased research misconduct may have been a motivating factor in crafting federal requirements for RCR education, this isn't explicitly clear in the text of the requirements. Yet both the NIH and the NSF requirement clearly speak to the need to teach RCR. Consistent with this goal, Claudia Blair (personal communication, approximately 1996), former director of the NIH Institutional Affairs Office, noted that an important factor in developing the RCR education requirement was that past NIH trainees reported that they weren't taught key aspects of their responsibilities (e.g., authorship, use of animal and human subjects) and that this was not likely to change unless such education was required of research faculty.

What, then, should be the goals for our teaching? One possibility is to simply meet the requirements to provide RCR education. But how clear are those requirements about what is expected? At present, the two prominent federal requirements for RCR education are those of the NIH and NSF. The NIH requirements, as summarized recently (NIH 2009), appear to be far more explicit than those of the NSF (2009), which simply states that "appropriate training" should be provided for "undergraduates, graduate students, and postdoctoral researchers who will be supported by NSF to conduct research." In contrast, the NIH requirement gives much more detail about how teaching should be done, while not explicitly stating what the teaching is intended to do (Table 1).

A superficial review of the nine topics shown in Table 1 might suggest that NIH has in fact been very specific about what should be taught. But a list of topics is not a curriculum. For example, what does it mean to teach about "collaborative research including collaborations with industry"? Is it important to explain the risks of collaboration? Highlight published guidelines on collaborations? Address regulatory controls, including material transfer and intellectual property agreements? Explain possible conflicts in academic-industry collaborations? Provide advice on how to negotiate a collaboration? Review examples of great successes in collaboration? Or great failures? Identify possible causes of failed collaborations? Teach negotiation skills? Change attitudes about the advantages or disadvantages of collaborating with others? Produce students who will engage in more collaborations? Or fewer collaborations? Clearly it is not possible to cover all of this if, for example, the NIH guidelines nominally call for 9 topics to be covered in just 8 hours, leaving less than an hour for each topic.

TABLE 1 Topics recommended to be included as proposed in iterations of NIH requirements for RCR instructions.

NIH (2009)	NIH (2000)	NIH (1992)	NIH (1989)
conflict of interest—personal, professional, and financial	conflict of interest and commitment	conflict of interest	conflict of interest
data acquisition and laboratory tools; management, sharing and ownership	data acquisition, management, sharing, and ownership	data management	data recording and retention
responsible authorship and publication	publication practices and responsible authorship	responsible authorship	responsible authorship

research misconduct and policies for handling misconduct	research misconduct	policies for handling misconduct	institutional policies and procedures for handling allegations of misconduct
policies regarding human subjects, live vertebrate animal subjects in research, and safe laboratory practices	human subjects, research involving animals	policies regarding the use of human and animal subjects	policies regarding the use of human and animal subjects
mentor/mentee responsibilities and relationships	mentor/trainee responsibilities	n.a.	n.a.
collaborative research including collaborations with industry	collaborative science	n.a.	n.a.
peer review	peer review	n.a.	n.a.
the scientist as a responsible member of society, contemporary ethical issues in biomedical research, and the environmental and societal impacts of scientific research	n.a.	n.a.	professional standards and codes of conduct, bioethics, research conduct, the ideals of science

n.a., not addressed

Improved Ethical Decision Making

In addition to the goals of decreasing research misconduct and increasing responsible conduct, there is a third possibility favored by many. The requirements for research ethics courses do not cite ethical decision-making skills as the goal of such teaching, but this is an objective often highlighted (e.g., many of the questions for this workshop focus on ethical decision making). The word "ethics" does not appear in the body of the original NIH requirements (NIH 1989, 1992), but the 1992 keywords include "Ethics/Values in Science & Technol[ogy]." The more recent update (NIH 2009) includes the words "ethics" or "ethical" eight times, in the context of "ethical behavior," "ethical issues," "ethical principles," and "professional ethics." And the 2009 NSF requirement mentions "ethical conduct of research." Arguably both requirements are referencing something more than research misconduct, but it isn't made clear whether the goal of promoting ethics means that the trainees are presumed to have deficits in knowledge, skills, attitudes, or perhaps all three.

Success in Meeting Goals

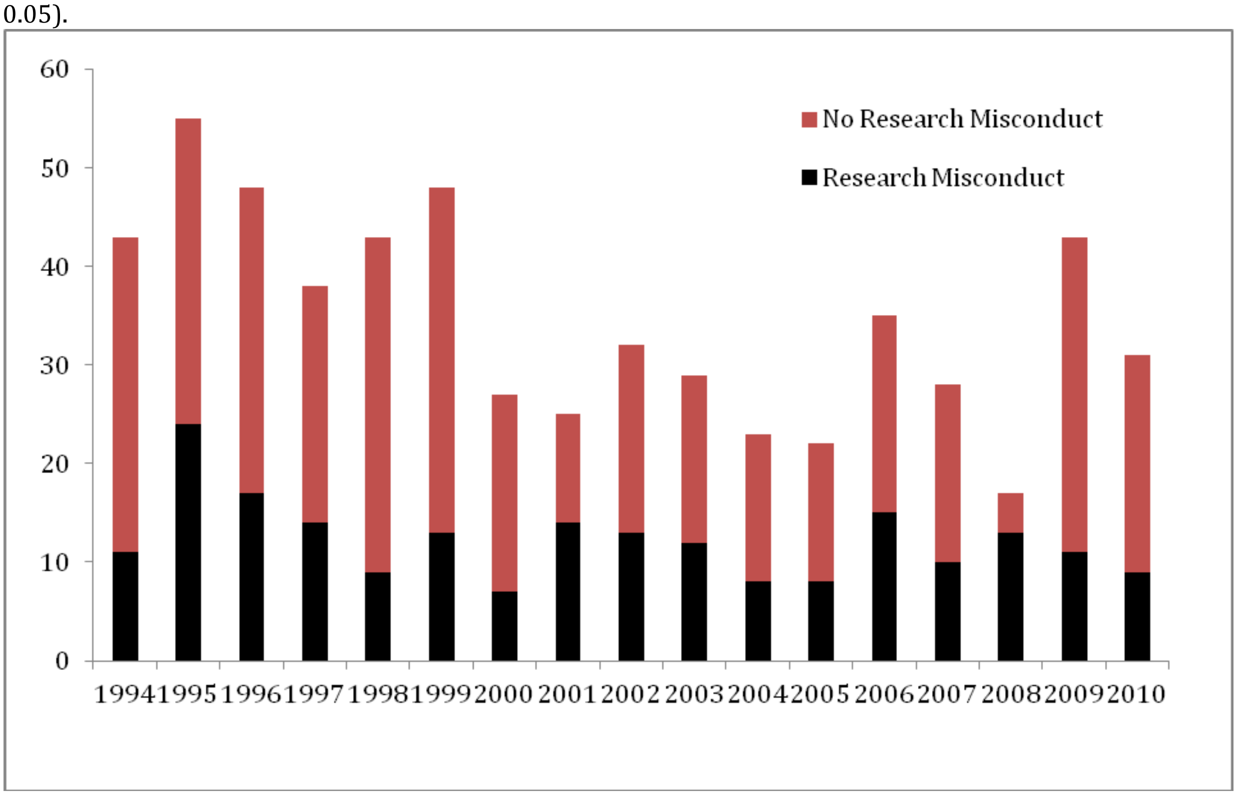
Either directly or by inference, a case can be made that the goals of federal RCR requirements include decreased research misconduct, increased responsible conduct of research, and improvements in ethical decision making. These are admirable goals, but it is important to determine whether they are in fact realistic outcomes for adult training programs that last nominally 8 hours (the floor set by the NIH requirement), and only in rare cases may be as much as 30 hours (e.g., the UC San Diego course on Ethics and Survival Skills in Academia).

Decreased Research Misconduct

Unfortunately, if decreased research misconduct is the goal, there is little evidence of success. And if research misconduct is assumed to be intentional, knowing, or reckless misrepresentation (e.g., fabrication, falsification, or plagiarism), then it is fair to ask whether it is realistic to think that a typical research ethics course (of 8 hours or even 30 hours), much less a workshop (of as little as 1 hour) could somehow change someone who would lie, cheat, or steal into someone who would not.

The proposition that RCR courses might dissuade students from committing research misconduct is problematic in at least two ways. First, statistically speaking it would be an overwhelming task to find evidence of an impact for an individual course because the rate at which cases of research misconduct are reported, investigated, and publicly announced is so low. It is therefore necessary to rely on national averages across diverse, isolated, and ad hoc courses. Second, despite over 20 years of RCR courses, there is no evidence that the courses have had any impact nationally on findings of research misconduct (Kalichman 2009). Although, as shown in Figure 1, the number of allegations (which includes all cases whether or not there was a finding of research misconduct) decreased during the period 1994–2010 ($p < 0.05$), the trend for research misconduct findings is *not* statistically significant ($p > 0.05$), notwithstanding a spike among Office of Research Integrity closed cases in 1995. This should not be surprising. As noted above changing someone's character certainly seems an overly ambitious goal for a short-term RCR course.

FIGURE 1 Annual closed cases for allegations of research misconduct as reported by the Office of Research Integrity (ORI 2012) for the period 1994–2010. By linear regression, the total number of allegations per year fell during this period ($p < 0.05$), but findings of research misconduct show no trend either up or down ($p > 0.05$).



Improved Ethical Decision Making

One view of the NIH requirement was that its goal was to produce more ethical scientists (Elliott and Stern 1996, p. 347):

> When the National Institutes of Health mandated training in ethics, the expectation was that funded organizations do what they could to produce ethical scientists: — that is, scientists who were committed to performing their work in a responsible manner. But, of course, no training grant can produce "ethical scientists" any more than it can produce "successful scientists." What ethics training can do is to identify a narrow scope of skills and knowledge that students should learn. Through evaluation, ethics professors can then decide if these skills and knowledge have been learned.

To the extent that the goal is to improve the skill of ethical decision making, as opposed to moral development, Elliott and Stern (1996) make the case that this measure is amenable to teaching and evaluation. That said, ethical decision making is an interesting goal in that bad decision making might result from one of two circumstances: (1) a failure of character (e.g., someone who is readily willing to lie, cheat, or steal to achieve desired ends) or (2) someone of good character who lacks the necessary knowledge or skills to make good choices. Few people would argue that even the most remarkable of typically brief training programs could correct a character deficit in children (Kohn 1997), much less adults. And even if it could, one would hope that the number of people of such poor character is a very small fraction of researchers. On the other hand, if the assumption is that most researchers are of fundamentally good character but lacking in the skill or knowledge to make good choices, then this might be an ideal target for RCR training programs.

Many studies have successfully demonstrated that teaching students ethical decision making skills can result in statistically significant, positive results (e.g., Bebeau 2002; Bebeau et al. 1995; Mumford et al. 2008), but this is not always the case (e.g., Drake et al. 2005; Heitman et al. 2001; Schmaling and Blume 2009). A meta-analysis of published studies (Antes et al. 2009) showed frequent examples of improvement, but unfortunately the improvement was modest. Antes and colleagues (2010) reviewed much of the literature on effectiveness of RCR education and found that the results overall have been equivocal at best (p. 519):

> These findings indicated that RCR instruction may not be as effective as intended and, in fact, may even be harmful. Harmful effects might result if instruction leads students to overstress avoidance of ethical problems, be overconfident in their ability to handle ethical problems, or overemphasize their ethical nature.

In fairness, it is worth asking whether these modest findings are an effect of averaging results from both courses taught with best practice pedagogies and those based, for example, on lecture alone. While it is reasonable to expect that the type of pedagogy does matter, the studies that have been conducted are almost invariably based on case-based discussions or other approaches that promote active learning and engagement. In short, the modest success of these courses is plausibly not the result of pedagogical failures alone.

In any case, if modest, but positive, changes are possible, this may be sufficient reason to teach RCR courses. However, that view might be tempered by knowing that most people, including most of those who now teach RCR courses, never had such training. Does this absence of training mean they lack the capacity to make good ethical decisions? That is certainly possible, but seems unlikely. And if it is unlikely, then it is fair to ask why scores improve if adult students already have the ability to make good decisions? One simple possibility is that the artificial nature of asking students to address fictitious or real cases in an "ethics" class results in improvement largely because before the class the students didn't know what the instructor was looking for (e.g., writing a detailed explanation of who has what at stake and considering ethical principles in choosing among competing possible actions). That doesn't mean they would have made bad decisions on their own, it simply means they don't yet know how their answer will be scored. This is an important distinction and could easily be tested by giving a new group of students a case for analysis and randomly assigning them to receive either no further instruction or guidance on what should be included in their analyses. It is worth considering the possibility that the second group would show a modest improvement not unlike that found for RCR courses (Antes et al. 2009).

Increased Responsible Conduct

If decreased research misconduct and improved ethical decision making are not realistic goals for RCR courses, then what remains? Both the NIH and NSF have labeled their requirements as *RCR* requirements. Therefore it is reasonable to assume that an intended outcome is an increase in the responsible conduct of research. What that means for NSF is not clear, but by inference from the list of topics for the NIH requirement (Table 1), the intention appears to be that researchers, engineers, and others should learn some set of facts about those topics. This begs many questions about which facts should be covered and whether all topics listed are equally appropriate to all kinds of scientists and engineers. However, it is reasonable to ask whether there is evidence that RCR courses can increase such knowledge.

Unfortunately, once RCR knowledge is reduced to testable facts, there are few things that might be asked, and they might not be terribly interesting (e.g., "What does IRB stand for?" or "Is plagiarism an example of research misconduct?"). Given these limitations, studies of the impact of RCR teaching on factual knowledge and on self-reported behaviors and perspectives have shown only modest effects (Antes et al. 2009; Elliott and Stern 1996; Powell et al. 2007; Schmaling and Blume 2009), no effects (Drake et al. 2005; Kalichman and Friedman 1992), or even negative effects (Anderson et al. 2007; Eastwood et al. 1996).

Current Goals for RCR Education

RCR requirements were likely created in the hope of decreasing research misconduct, but there is no evidence that simply meeting the requirements has had or will have an impact on research misconduct. Whether the requirements are interpreted as calls to decrease research misconduct, increase RCR, or increase ethical decision making, it is clear that the texts of the requirements do little to link particular methods or approaches to achieving those goals. NSF (2009) has given no guidance other than a mandate to provide "appropriate training and oversight in the responsible and ethical conduct of research," and the NIH (2009) emphasizes expectations of what should be done (e.g., topics to be covered, hours of instruction, faculty involvement) rather than any particular outcome. In the absence of compelling evidence linking training programs to these outcomes, it is fair to conclude that the actual goals remain undefined.

Instead of relying only on federal requirements to inform goals for research ethics education, it might be useful to review how teachers of research ethics view the purposes of their teaching. The corresponding array of "goals" for teaching research ethics is vast (Kalichman and

Plemmons 2007); just a few examples are summarized in Table 2. By inference, probably the only consistent goal is to meet the requirements to provide RCR education. Ironically, as noted above, those requirements are rooted in a goal (decreased research misconduct) that is probably out of reach of most, if not all, courses.

TABLE 2 Selected examples of the wide variety of goals expressed by RCR instructors surveyed in 2003 and 2004 (Kalichman and Plemmons 2007).

Knowledge	Trainees should have information about • data management, animal subjects, human subjects, conflicts of interest, authorship, publication, peer review, collaboration, mentoring, research misconduct, and whistleblowing • uneven power situations, vulnerable populations • copyrights, patents (especially in terms of life forms and genetics) • where to find help
Skills	Trainees should know how to • make ethical decisions • think critically • manage stress • work in a multidisciplinary research team • resolve conflicts
Attitudes	Researchers will recognize that • research is often characterized by ethical dilemmas that are not simple but are amenable to mitigation or resolution • open communication with others is a part of RCR • regulations were developed in response to real problems
Behavior	Researchers will • model the highest standards of scientific conduct • engage in more effective communication with others

Criteria for Goals

It may, therefore, be of value to think differently about this. Historically, in the absence of requirements for RCR education, relatively little was done formally. Then, in the face of increasing requirements, RCR education programs, approaches, and resources grew dramatically from 1989 to the present. Although the resulting options vary widely in terms of what is done (Mastroianni and Kahn 1998; Kalichman and Plemmons 2007) and what goals are pursued (Kalichman and Plemmons 2007), they typically meet the requirement to do *something*. From a cynical perspective, that might be seen as enough. However, from a more practical perspective, perhaps the requirements should not be seen as an end in themselves (i.e., to comply) but as a means to do something that has real value to the scientific enterprise. Specifically, perhaps there are goals that are particularly worth pursuing and that would also meet the federal requirements. If so, what features would be desirable for those goals?

A provisional list of criteria for goals worth pursuing was one of the challenges addressed at an NSF-funded meeting at Asilomar (in Pacific Grove, CA) in March 2012. The conference convened 18 leaders in RCR education, a program evaluator, and 5 graduate students. While agreement was not always unanimous, the following summarizes a consensus about criteria worth considering for optimal goals for RCR education (listed in order of importance and priority):

1. ***Important:*** The goal should address something that is particularly relevant (***important***) to the ethical or responsible conduct of science.
2. ***Deficient:*** Some things that are important may not in fact be lacking. The goal should address something that needs improvement or correction because it is ***deficient***.
3. ***Independent:*** Even if something is important and deficient, it could be secondary to some other goal. Meeting the goal should be ***independent*** of first needing to meet other goals.
4. ***Amenable to Intervention:*** Even if something is important and deficient, we may have no realistic way to repair that deficit. The goal should be something for which we have, or we could reasonably produce or acquire, an ***intervention*** that would enable us to make a change.
5. ***Measurable:*** It is possible that there is something that we can change by intervention that is both important and deficient, but we have no means to assess our impact. The goal should be something for which we have the tools for defining ***measurable*** outcomes. [NOTE: Measurable outcomes can also include qualitative findings. The key is to have something credible to convince ourselves and others that there is some value added because of our efforts.]
6. ***Magnitude:*** It is possible that there is something that we can change by intervention that is important, deficient, and measurable, but the magnitude of our impact might be too small to be considered cost effective. The goal should be something for which we can produce a change of sufficiently large ***magnitude***.
7. ***Feasible:*** Even if something reasonably meets all of the above criteria, it may not in fact be practical or feasible in the research environment because of the amount, type and availability of resources required or because of the characteristics of the research environment. The goal should be something that is ***feasible***.

Suggested Principles, Goals, and Outcomes

Mindful of the above criteria for goals worth pursuing, taking into consideration past studies of research ethics education outcomes, and reflecting on anecdotal experiences of research ethics teaching, the following are suggested principles, goals, and outcome measures for research and engineering ethics teaching.

Principles

1. The entire community of scientists and engineers benefits from *diverse, ongoing options* to engage in conversations about the ethical dimensions of research and engineering.
2. Specific topics or materials aren't important. The number of possibilities is endless. The point is to do something, not everything.
3. Different members of the community of scientists and engineers and different disciplines are likely to require different goals, content, and approaches to ethics education.

Goals and Outcomes

A logical extension of the principles noted above is that the ultimate goals of research ethics courses should focus on the community and not on individuals. More specifically, the point is not that individuals should meet some nominal standard (i.e., leaving open the possibility that someone could "test out" of the "ethics requirement"). Instead, the question is what sorts of outcomes might one look for with individual students that logically might serve the larger community goal. Table 3 illustrates four such goals and proposed corresponding outcome measures.

TABLE 3 Goals and outcome measures for trainees in responsible conduct of research (RCR) or responsible conduct of engineering (RCE) courses.

Goals for Trainees	Outcomes to be Measured
• Engage in conversations with peers and mentors about ethical challenges of research and/or engineering	• Time spent in conversations about ethical challenges to conduct of science
• Know rules, issues, options, and resources for RCR and/or RCE*	• Ability to identify places, people, and/or other resources to help in addressing ethical challenges to conduct of science
• Understand the purpose and value of ethical decision making	• Self-reported disposition to research ethics
• Have a positive disposition (or at least not a negative disposition) toward lifelong learning about RCR and/or RCE	

*Including at least some reflection on each of four domains: (1) conduct of research (e.g., truth in reporting, mitigating bias); (2) protections for subjects of research (e.g., animal and human subjects); (3) interactions with colleagues (e.g., collaboration, peer review, mentoring); and (4) social responsibility (e.g., considering public interest in choice of projects, communicating with the public).

Conclusion

A prerequisite for effectiveness in ethics education for scientists and engineers is to be clear about the goals of that education. Based on data and experience, a case can be made that those goals should not reside solely in attempting to decrease misconduct, in an isolated course or program, nor in "one size fits all" approaches to topics to be covered and approaches to be used. Instead, a suggested beginning point is goals that emphasize increased conversations about responsible conduct; increased awareness of rules, issues, options, and resources; a clear understanding of the meaning of "ethical decision making"; and an acceptance of the importance of lifelong learning about responsible conduct.

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References

Anderson MS, Horn AS, Risbey KR, Ronning EA, DeVries R, Martinson BC. 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.

Antes AL, Murphy ST, Waples EP, Mumford MD, Brown RP, Connelly S, Devenport LD. 2009. A meta-analysis of ethics instruction effectiveness in the sciences. *Ethics and Behavior* 19(5):379–402.

Antes AL, Wang X, Mumford MD, Brown RP, Connelly S, Devenport LD. 2010. Evaluating the effects that existing instruction on responsible conduct of research has on ethical decision making. *Academic Medicine* 85(3):519–526.

Bebeau MJ. 2002. Influencing the moral dimensions of professional practice: Implications for teaching and assessing for research integrity. In: Steneck NA and Sheetz MH, eds. *Proceedings of the First ORI Research Conference on Research Integrity*. Rockville MD: Office of Research Integrity, Department of Health and Human Services. pp. 179–187. Available online at www.ori.hhs.gov/documents/proceedings_rri.pdf.

Bebeau MJ, Pimple KD, Muskavitch KMT, Borden SL, Smith DH. 1995. *Moral Reasoning in Scientific Research: Cases for Teaching and Assessment*. Bloomington: Indiana University Press.

Carroll L. 1865. *Alice's Adventures in Wonderland*. London: MacMillan and Co.

Crewdson J. 2003. *Science Fictions: A Scientific Mystery, a Massive Cover-up and the Dark Legacy of Robert Gallo*. New York: Little, Brown & Co.

Drake M, Griffin P, Kirkman R, Swann J. 2005. Engineering ethical curricula: Assessment and comparison of two approaches. *Journal of Engineering Education* 94:223–231.

Eastwood S, Derish P, Leash E, Ordway S. 1996. Ethical issues in biomedical research: Perceptions and practices of postdoctoral research fellows responding to a survey. *Science and Engineering Ethics* 2:89–114.

Elliott D, Stern JE. 1996. Evaluating teaching and students' learning of academic research ethics. Science and Engineering Ethics 2:345–366.

Engineering Accreditation Commission. 2012. Criteria for Accrediting Engineering Programs: Effective for Reviews During the 2012-2013 Accreditation Cycle. Baltimore: *Accreditation Board for Engineering and Technology* (ABET). Available online at www.abet.org/uploadedFiles/Accreditation/Accreditation_Process/Accreditation_Documents/Current/eac-criteria-2012-2013.pdf.

Heitman E, Salis PJ, Bulger RE. 2001. Teaching Ethics in Biomedical Science: Effects on Moral Reasoning Skills. Investigating Research Integrity. *Proceedings of the First ORI Research Conference on Research Integrity*. pp. 195–202.

Kalichman MW. 2009. Evidence-based research ethics. *American Journal of Bioethics* 9(6&7):85–87.

Kalichman MW, Friedman PJ. 1992. A pilot study of biomedical trainees' perceptions concerning research ethics. *Academic Medicine* 67:769–775.

Kalichman MW, Plemmons D. 2007. Reported goals for responsible conduct of research courses. *Academic Medicine* 82(9):846–851.

Kevles DJ. 1998. *The Baltimore Case: A Trial of Politics, Science and Character*. New York: W.W. Norton.

Kohn A. 1997. How not to teach values: A critical look at character education. *Phi Delta Kappan* 78(6):428–439.

Mastroianni AC, Kahn JP. 1998. The importance of expanding current training in the responsible conduct of research. *Academic Medicine* 73(12):1249–1254.

Mumford MD, Connelly MS, Brown RP, Murphy ST, Hill JA, Antes AL, Waples EP, Devenport LR. 2008. A sensemaking approach to ethics training for scientists: Preliminary evidence of training effectiveness. *Ethics and Behavior* 18:315–346.

NIH [National Institutes of Health]. 1989. Requirement for Programs on the Responsible Conduct of Research in National Research Service Award Institutional Training Programs. *NIH Guide* 18(45):1. Available online at http://grants.nih.gov/grants/guide/historical/1989_12_22_Vol_18_No_45.pdf.

NIH. 1992. Reminder and Update: Requirement for Instruction in the Responsible Conduct of Research in National Research Service Award Institutional Training Grants. *NIH Guide* 21(43). Available online at http://grants.nih.gov/grants/guide/notice-files/not92-236.html.

NIH. 2000. PHS Policy on Instruction in the Responsible Conduct of Research (RCR) Announced December 5. Available online at http://grants.nih.gov/grants/guide/notice-files/NOT-OD-01-007.html.

NIH. 2001. Notice of suspension of "PHS Policy on Instruction in the Responsible Conduct of Research." February 22. Available online at http://grants.nih.gov/grants/guide/notice-files/NOT-OD-01-020.html.

NIH. 2009. Update on the Requirement for Instruction in the Responsible Conduct of Research. November 24. Available online at http://grants.nih.gov/grants/guide/notice-files/NOT-OD-10-019.html.

NSF [National Science Foundation]. 2009. Responsible Conduct of Research. Proposal and Award Policies and Procedures Guide. Part II – Award and Administration Guidelines, p. IV-3. Available online at www.nsf.gov/pubs/policydocs/pappguide/nsf10_1/nsf10_1.pdf.

ORI [Office of Research Integrity]. 2012. *Annual Reports*. Rockville MD: Department of Health and Human Services. Available online at http://ori.hhs.gov/annual_reports.

Powell S, Allison MA, Kalichman MW. 2007. Effectiveness of a responsible conduct of research course: A preliminary study. *Science and Engineering Ethics* 13(2):249–264.

Schmaling KB, Blume AW. 2009. Ethics instruction increases graduate students' responsible conduct of research knowledge but not moral reasoning. *Accountability in Research* 16:268–283.

Balancing Priorities:
Social Responsibility in Teaching Responsible Conduct of Research

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In this essay I draw on the history of engineering and research ethics, specifically the way priorities in these disciplines were established in the United States, to discuss how we should teach social responsibility in research ethics. Following Deborah Johnson (1992, p. 21), I use the term "social responsibility" in the sense of having a moral obligation "to protect the safety and welfare of society."[1] I focus on one obstacle in teaching this aspect of research ethics: the long-standing belief that social responsibility is not the primary concern of scientists because they produce basic knowledge rather than technology. In this view, scientific knowledge is seen as neutral, neither good nor bad, and those who apply this knowledge, mainly engineers, should bear the primary social responsibility for its use (see, e.g., the 1999 newspaper statement by physics Nobel laureate Leon Lederman cited in McGinn 2010, p. 8; Shuurbiers 2011, p. 770).[2]

This long-held belief in the neutrality of scientific knowledge and the ideal of pure science, which amounts to a social agnosticism of science, has been roundly criticized by historians, sociologists, and philosophers of science and technology. But my experience teaching research ethics at Cornell has shown me how persistent this belief still is. It comes up regularly in the classroom and in discussions with science faculty. Unfortunately, this impediment to teaching social responsibility is reinforced by the literature on how to teach research and engineering ethics. Engineering ethics prioritizes the public's health, safety, and welfare, while research ethics prioritizes the ethical conduct of research. The literature in these fields sends the message that social responsibility—the duty to protect the public—is not the main concern of scientists.

Conflicting Priorities in Science and Engineering Ethics

This inversion of priorities has been evident in research and engineering ethics since the professionalization of these fields in the 1970s and 1980s. Codes of ethics, textbooks, and the National Academies booklet *On Being a Scientist*—all show this striking distinction.[3] The fields

[1] Johnson argues that engineers have an individual role responsibility, rather than a responsibility emerging from a social contract between the engineering profession and the public. The social responsibility of researchers would seem to come under the category of "responsibility-as-accountability," identified by Michael Davis (2012, p. 15).
[2] Schuurbiers (2011, p. 770) comments on the "'neutrality view' of social responsibility" and cites previous authors who argue that the "social responsibility of researchers should include critical reflection of the socio-ethical context of their work."
[3] Although the journal *Science and Engineering Ethics*, established in 1995, publishes articles that focus on the traditional priorities in the field of engineering ethics and the traditional priorities in the field of research ethics,

list similar ethical issues, but invert their priorities (see Box 1). The order of priority varies somewhat in the various codes of ethics issued by the professional engineering societies, e.g., between the lean code of the Institute of Electrical and Electronics Engineers (IEEE) and the expansive code of the National Society of Professional Engineers (NSPE), which is regularly enforced. There are also some differences in priorities between the latest (2009) editions of *On Being a Scientist* and *The Responsible Conduct of Research* (by Adil Shamoo and David Resnik). But the basic distinction on how social responsibility is valued in these fields holds and has held since I published an article on this subject in 2005 (Kline 2005). The public's health, safety, and welfare are the first priority in engineering ethics, but the lowest priority in research ethics.

BOX 1

Priorities in Research and Engineering Ethics

<u>Main Issues in Research Ethics</u>
- Integrity of research
- Credit and authorship
- Conflicts of interest
- Welfare of subjects, experimenters, and environment
- Social implications of research

<u>Main Issues in Engineering Ethics</u>
- Public's health, safety, and welfare, including the environment
- Being a faithful agent of the employer
- Conflicts of interest
- Credit (e.g., intellectual property provisions)
- Integrity of reports

Sources: Committee on Science, Engineering, and Public Policy, National Academy of Sciences, National Academy of Engineering, Institute of Medicine (2009); Shamoo and Resnik (2009); Martin and Schinzinger (2005); and Herkert (2000).

How do we account for this inverted priority and why does it matter for teaching the responsible conduct of research? I maintain that the inverted priority is a cultural obstacle to teaching social responsibility in research ethics and that understanding its history—how it came about—shows why this cultural belief has such a strong hold on ethicists, students, and researchers alike. Understanding this history helps us to identify ways to improve our methods of teaching social responsibility in research ethics.

Creating Priorities in Engineering and Research Ethics

I have argued elsewhere that the reason for the inverted priorities in engineering and research ethics is best understood by considering the responses of professional societies to accidents in

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thereby reinforcing these disciplinary boundaries, it also publishes a large number of articles that cover the social responsibility of research as I have defined it here, as evidenced, for example, by the article by Schuurbiers (2011) which I discuss at the end of this essay.

engineering and scandals in science.[4] These responses were supported by the centuries-old belief that science values fundamental knowledge in order to understand nature, while engineering values the design of artifacts in order to improve the lives of people. This belief ignores the long history of the hybridity of science and technology—the difficulty of drawing sharp boundaries between science and engineering in the past and in the present.

The Catalysts: Catastrophic Accidents and High-Profile Fraud

I'll focus here on the responses of professional societies to accidents and scandals. In the 1970s, charges of research misconduct and dangerous technology grew into public scandals about "fraud" in science and amoral calculation in engineering. Accounts of scientific scandals and engineering disasters filled newspapers, calling forth responses from the scientific and engineering communities and from social scientists and philosophers. This outcry helped create the fields of research ethics and engineering ethics, as well as programs in science, technology, and society (Mitcham 2003a,b).

Engineering ethics was transformed by a litany of engineering disasters in the 1970s and 1980s. A short list would include the unsafe design of the Bay Area Rapid Transit (BART) system; the amoral cost-benefit analysis in designing the gas tank of the Ford Pinto; the crash of a DC-10 airliner due to a cargo door opening after takeoff and the crash of a second DC-10 due to an engine falling off during takeoff; the partial meltdown of a nuclear power plant at Three Mile Island; the collapse of a fourth-floor walkway in the atrium of the Hyatt Regency Hotel in Kansas City; the Union Carbide disaster in Bhopal, India; and the space shuttle Challenger accident. These disasters form the corpus of the standard historical cases taught in engineering ethics. The earliest cases, the Pinto gas tank and BART in the early 1970s, spurred changes in the codes of ethics of engineering professional societies. The Engineers' Council for Professional Development, an umbrella group, rewrote its code in 1974 to state that the engineer "shall hold paramount the safety, health, and welfare of the public." Other engineering societies followed suit. The revision aimed to assure the public that engineers, if not their managers, were socially responsible. The IEEE also wrote a new code of ethics in 1974, based on its involvement with the BART case (Kline 2001/2002, pp. 15–16; Davis 2001).[5]

In science, scandalous cases of fraud helped define the field of research ethics. Perhaps the book that did the most to publicize this issue was *Betrayers of the Truth*, published by science journalists Bill Broad and Nicholas Wade in 1982. In the previous year, Al Gore, then a young congressman from Tennessee, held congressional hearings on Fraud in Biomedical Research; as chair of the Investigations and Oversight Subcommittee of the House Committee on Science and Technology, he drew on cases reported by Broad and Wade in the journal *Science*. Other congressional bodies followed suit in the 1980s. In 1988, Representative John Dingell, chair of the House Committee on Energy and Commerce, held hearings on Fraud in NIH Grant Programs (Broad and Wade 1982, chap. 1; Gold 1992–1993, vol. 2, chap. 6; Kevles 1998, pp. 101–108).

The scientific community responded to the publicity surrounding these cases by conducting investigations, issuing reports, and publishing educational materials. The first edition of *On Being a Scientist* appeared in 1988. In 1992, the National Research Council defined misconduct as "fabrication, falsification, and plagiarism in proposing, conducting, and reporting research." The National Academies established a Panel on Scientific Responsibility and the Conduct of

[4] This section is based on Kline (2005, pp. xxxvi–xxxviii), which gives a more detailed history.
[5] Davis argues that the original codes, dating back to the late 19th century, stressed social responsibility.

Research, which issued a two-volume report, *Responsible Science: Ensuring the Integrity of the Research Process*, in 1992–1993 (Committee on Science, Engineering, and Public Policy; National Academy of Sciences, National Academy of Engineering, Institutes of Medicine 1992–1993, vol. 1, p. 5; 2009, p. 15; Gold 1992–1993; Mitcham 2003a, p. 277; Whitbeck 1995, p. 201). The cold fusion controversy in 1989, the David Baltimore case in biomedicine in 1991, and the fabrication of research results on organic semiconductors by physicist Jan Hendrik Schön at Bell Labs in the late 1990s kept the topic of fraud in the news and before the scientific community (Lewenstein 1992; Kevles 1998; Levi 2002).

Ethical Conduct of Research versus Social Responsibility

The third and most recent edition of On Being a Scientist (2009, p. 3; emphasis in the original) carries on the tradition of prioritizing the ethical conduct of research over its social consequences. The booklet's introduction cites the duty "to act in ways that serve the public" as one of three main obligations of the scientist—the first two are obligations to other researchers and to oneself.[6] It also says that science directly affects the health and well-being of individuals and is used to make policy on social issues such as climate change and stem cell research. But the duties to society as a whole merit only one of the 12 topical sections, "The Researcher in Society" (see Box 2); the first page of this short section describes the duties of the researcher to the public, the second presents a historical case (Committee on Science, Engineering, and Public Policy 2009, pp. 29–43, 48–49). That case, however, is not about protecting the public's health and safety, which is the first priority in codes of engineering ethics. Rather, the case is about the researcher's duties in playing a public role as a scientist.

BOX 2

Topics Covered in *On Being a Scientist* (2009)

Advising and Mentoring
The Treatment of Data
Mistakes and Negligence
Research Misconduct
Responses to Suspected Violations of Professional Standards
Human Participants and Animal Subjects in Research
Laboratory Safety in Research
Sharing of Research Results
Authorship and the Allocation of Grants
Intellectual Property
Competing Interests, Commitments, and Values
The Researcher in Society

Source: Committee on Science, Engineering, and Public Policy (2009), pp. xvii–xviii.

[6] One could argue that the duty to protect human subjects of research is a social concern and thus a social responsibility.

In the historical case, Arthur Galston, a graduate student in the early 1940s, found that a synthetic chemical enabled crops to grow in colder climates. After the war, he learned that military researchers had turned his work into the defoliant Agent Orange, which was sprayed on forests during the Vietnam War. At a meeting of the American Society of Plant Physiologists in 1966, Galston testified about the long-term toxic effects of Agent Orange. He sent a copy of his report to President Lyndon Johnson and later met with President Richard Nixon's science advisor, Edward E. David Jr., who recommended in 1970 that the spraying of Agent Orange be stopped. The case concludes by quoting Galston that he used to think a scientist could simply refuse to work on a project that had risky health effects, but that it wasn't that simple. "The only recourse," he concluded, "is for a scientist to remain involved with it [the project] to the end" (Committee on Science, Engineering, and Public Policy 2009, p. 49).

It's a good case study, but the general discussion accompanying it gives a mixed message. *On Being a Scientist* states that researchers "have a professional obligation to perform research and present the results of that research as objectively and as accurately as possible" ((Committee on Science, Engineering, and Public Policy 2009, p. 48).[7] Yet when they become public advocates of science, their colleagues and the public may view them as "biased." Nevertheless, they have the "right to express their convictions and work for social change, and these activities need not undercut a rigorous commitment to objectivity in research." This section tends to reinforce the sharp boundary drawn between science and politics, which historians and sociologists of science have questioned for some time. The implication is that objective research will always lead to good results, whereas advocacy is always suspect and has to be justified.

The section ends by saying that the

> values on which science is based—including honesty, fairness, collegiality, and openness—serve as guides to action in everyday life as well as in research. These values have helped produce a scientific enterprise of unparalleled usefulness, productivity, and creativity. So long as these values are honored, science—and the society it serves—will prosper. (Committee on Science, Engineering, and Public Policy 2009, p. 48)

The sentiment is an honorable one, but it does not consider whether the researcher has an obligation to avoid harming the public. It assumes deterministically that these good values of science lead to good technology which leads to good social results. It ignores the historical evidence that many research projects have not led to good social results, including the case of Agent Orange that illustrates this section of the booklet. Because this is a historical case, rather than a hypothetical one, there are no questions asking readers about the ethics of Galston's actions throughout this episode, alternative paths he might have taken, or the responsibility of other researchers in this case. Readers miss the opportunity to consider what the social responsibilities of scientists are while they are conducting research. Monitoring is a worthy value, but so is reflection on possible consequences while conducting research—and the latter is more expected of engineers than of scientists.[8]

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[7] On the difficulty of separating politics from science, see Hackett et al. (2008), Part III.

[8] The view that the main social responsibility of scientists pertains to their public role in giving expert testimony, making statements to the public, and advocacy has most likely been shaped by post–World War II cases of the scientist in the public eye, beginning with the movement of the atomic scientists.

Suggestions for Practical Guidance

This brief analysis of the history and present state of priorities in research and engineering ethics, and my experience teaching these subjects at Cornell, prompt me to suggest some practical guidance about how to improve our teaching of social responsibility in research.

Specific Suggestions

First, I propose addressing head-on the inversion of priority toward social responsibility in research and engineering ethics. My observation when I taught an NSF-required session on research ethics for undergraduate students doing research in nanoscience and technology during the summer at Cornell is that they respond well to this approach. Their puzzlement that engineers are expected to privilege public health and safety while scientists are not leads them to reflect on their own expectations of research and their status in the university laboratories. They see the hybridity of science and engineering in the labs because nano research is conducted by both scientists and engineers, often in the same building. Being young, they are also idealistic and very interested in the social implications of their research. I try to balance the attention I give to the conduct of research and its possible consequences. The main way I've done this is to introduce the inversion of priorities about social responsibility, discuss a case or two along the lines of those on research conduct in *On Being a Scientist*—though I tend to use more detailed cases—and discuss in-depth a current social concern about nanoscience and technology, such as the toxicity of nano products or the creation of surveillance bots.

My second suggestion is to bring literature from science and technology studies—the history, sociology, and philosophy of science and technology—to bear on research ethics. One value of that approach is to question the sharp boundary drawn between science and engineering in the cases we use (see Kline 2001/2002).

Third, I strongly recommend expanding the material on social responsibility in the booklet *On Being a Scientist* and giving it a higher priority in the next revision. Including a statement on the obligation to protect the public's safety and welfare should be considered, as well as explicit statements about the duties of social responsibility during the conduct of research. I suggest adding a hypothetical case study on this aspect of social responsibility to balance the current historical case on the public role of the scientist. One might go further and devote two sections to social responsibility: one on the conduct of research and one on interactions with the public. That would send the message that social responsibility involves attending to large-scale social consequences as much as it does the obligation to care for the welfare of both experimenters and human subjects of research.

Resources and Examples

While writing this paper, I looked for an existing case that would exemplify what I had in mind about teaching the broad social responsibility of conducting research. In the six volumes of cases on graduate research ethics, edited by Brian Schrag at the Association for Practical and Professional Ethics and published from 1997 to 2002, I found one case on obligations to the public (Schrag 2001). In this case, Tom, a postdoc, is conducting research on the pH levels of a region's lakes, and thinks that the high acidity levels, which are killing off the fish, are probably caused by emissions from nearby electrical power plants. A second, five-year research project is planned to determine the cause of the acid rain. Tom meets with Susan, a member of a local environmental group, who asks him to downplay the uncertainties in his research and state that he believes the power plants are causing the acid rain. Tom consults Richard, a senior research scientist on the project, who also believes the power plants are probably the cause of the acid rain. But Richard cautions Tom against getting involved with advocacy of this sort because he could tarnish his scientific reputation by seeming to be nonobjective and biased since the second five-year study of the cause of the acid rain has not been conducted. The case asks, What should Tom do in this situation, in which his moral obligations to the norms of science and to saving the lakes are in conflict?

This hypothetical case provides a good alternative to the historical case in the Researcher in Society section in On Being a Scientist. But it still addresses only the researcher's public role. What we need are new cases that address the social implications of ongoing research, such as that in nanoscience.

In fact, I think current research in nanoethics may be an important avenue in which to explore how to teach social responsibility in the conduct of research. This well-funded area is a vibrant one. The NSF has established a National Nanotechnology Infrastructure Network, which includes social and ethical implications in its research agenda. And in 2005 the NSF funded two Centers for Nanotechnology in Society (at Arizona State University and the University of California at Santa Barbara), whose charge also includes ethical issues. These centers have explored many ways of educating researchers and the public about ethical issues of nanoscience and technology. Nanoethics, a new scholarly journal, was launched in 2007.

I'll comment on two recent projects that integrate social responsibility in research ethics.[9] In 2010, Robert McGinn proposed some brief ethical guidelines for nano researchers (McGinn 2010, pp. 1–2). These covered the existing microethics issues of laboratory safety, intellectual property rights, and integrity of data; the existing mesoethics issue of dealing with the public; and the new macroethics issues of accepting social responsibility for protecting the safety and welfare of the public. One of his ethical responsibilities, for example, states that "if a NT [nanotechnology] researcher has reason to believe that her or his work will be applied to society so as to create a risk of significant harm to humans, he or she has an ethical responsibility to alert appropriate authorities about the potential danger." This duty is similar to a provision that has long been part of engineering codes of ethics. Essentially what McGinn has done is to merge research and engineering ethics for researchers working in nanoscience and technology. Although he does not ground his guidelines in the extensive scholarship in research and engineering ethics, his attempt to merge these fields moves in the right direction, in my view (McGinn 2010, p. 9).[10]

A more radical project is to integrate concerns about social responsibility into the early stages of research and development (R&D) through a method called "midstream modulation." One variant of this approach, "laboratory engagement studies," embeds an ethicist in the laboratory to help researchers reflect on the "social responsibilities of their research practices." Proponents of this approach refer to it as a form of learning, as researchers learn about the socioethical context of their work upon being prompted to reflect on it by the "embedded ethicist." Daan Schuurbiers recently described his experiences with this type of intensive engagement with a small number of

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[9] Most scholarly research on nanoethics, however, does not address research practices. See McGinn (2010, p. 2) and Lewenstein (2006).

[10] McGinn cites the NSPE code of ethics regarding the requirement for the engineer to be a faithful agent of the employer and to hold paramount the public's health, safety, and welfare (notes 18 and 19, p. 4), but does not do so for his other ethical responsibilities. On the issue of macro-micro ethics in engineering, see Herkert (2005) and Kline (2010).

researchers at two biotechnology laboratories, one at Delft University of Technology in the Netherlands and one at Arizona State University. Both labs researched the production of alternative resources and fuels. Schuurbiers concluded that this engagement helped to make "broader socio-ethical issues more *visible* in the lab" and "encouraged research participants to critically reflect on these broader issues. Contrary to their initial claims, participants came to acknowledge that broader socio-ethical dimensions permeated their research" (Schuurbiers 2011, pp. 769, 786). One could not ask for much more than that when teaching social responsibility in research ethics.

Conclusion

These are just a few of the ways that the obstacle of the social agnosticism of science can be overcome to teach social responsibility in research ethics. Although this agnosticism is reinforced by the standard literature in engineering and research ethics, which was shaped by responses to scandals and accidents of the 1970s and 1980s, we live in a new era of nanoscience, biotechnology, and other emerging fields in which the hybridity of science and engineering is evident. I'm not advocating that social responsibility should be the number one priority in research ethics. I'm suggesting that we rebalance the priorities in that field to recognize that the traditional view of the relationship between science and engineering is untenable. If that is true for researchers in science and engineering, it should also be true for those of us who teach them ethics.

References

Broad W, Wade N. *Betrayers of the Truth*. New York: Simon and Schuster.

Committee on Science, Engineering, and Public Policy; National Academy of Sciences, National Academy of Engineering, Institutes of Medicine. 1992–1993 *Responsible Science: Ensuring the Integrity of the Research Process*. Washington: National Academy Press.

Committee on Science, Engineering, and Public Policy, National Academy of Sciences, National Academy of Engineering, Institute of Medicine. 2009. *On Being a Scientist: A Guide to Responsible Conduct in Research*, 3rd ed. Washington: National Academies Press.

Davis M. 2001. Three myths about codes of engineering ethics. *IEEE Technology and Society Magazine* 20(3):8–14.

Davis M. 2012. 'Ain't No One Here but Us Social Forces': Constructing the Professional Responsibility of Engineers. *Science and Engineering Ethics* 18:13–34.

Gold BD. 1992–1993. Congressional activities regarding misconduct and integrity in science. In: *Responsible Science: Ensuring the Integrity of the Research Process*, Committee on Science, Engineering, and Public Policy; National Academy of Sciences, National Academy of Engineering, Institutes of Medicine. Washington: National Academy Press.

Hackett EJ, Amsterdamska O, Lynch M, Wajcman J, eds. 2008. *Handbook of Science and Technology Studies*, 3rd ed. Cambridge, MA: MIT Press.

Herkert J. 2000. Engineering ethics education in the USA: Content, pedagogy, and curriculum. *European Journal of Engineering Education* 25:303–313.

Herkert J. 2005. Ways of thinking about and teaching ethical problem solving: Microethics and macroethics in engineering. *Science and Engineering Ethics* 11:373–385.

Johnson D. 1992. Do engineers have social responsibility? *Journal of Applied Ethics* 9:21–34.

Kevles DJ. 1998. *The Baltimore Case: A Trial of Politics, Science, and Character*. New York: W.W. Norton.

Kline RR. 2001/2002. Using history and sociology to teach engineering ethics. *IEEE Technology and Society Magazine* 20(4):13–20.

Kline R. 2005. Research ethics, engineering ethics, and science and technology studies. In: *Encyclopedia of Science, Technology, and Ethics*, ed. Carl Mitcham, vol 1, pp. xxxv–xli. New York: MacMillan.
Kline R. 2010. Engineering case studies: Bridging micro and macro ethics. *IEEE Technology and Society Magazine* 29(4):16–19.
Levi BG. 2002. Investigation finds that one Lucent physicist engaged in scientific misconduct. *Physics Today*, November, p. 15.
Lewenstein B. 1992. Cold fusion and hot history. *Osiris*, 2nd series, 7:135–163.
Lewenstein B. 2006. What counts as a "social and ethical issue" in nanotechnology? In: *Nanotechnology: Implications for Philosophy, Ethics, and Society*, eds. Joachim Schummer and David Baird. Singapore: World Scientific.
Martin MW, Schinzinger R. 2005. *Ethics in Engineering*, 4th ed. New York: McGraw-Hill.
McGinn R. 2010. Ethical responsibilities of nanotechnology researchers: A short guide. *Nanoethics* 4:1–12.
Mitcham C. 2003a. Co-responsibility for research integrity. *Science and Engineering Ethics* 9:273–290.
Mitcham C. 2003b. Professional idealism among scientists and engineers: A neglected tradition in STS studies. *Technology in Society* 25:249–262.
Schrag B, ed. 2001. A pHish tale. *Graduate Research Ethics: Cases and Commentaries*, vol. 5. Bloomington: University of Indiana. Available online at www.onlineethics.org/Resources/Cases/pHish.aspx.
Schuurbiers D. 2011. What happens in the lab: Applying midstream modulation to enhance critical reflection in the laboratory. *Science and Engineering Ethics* 17:769–788.
Shamoo A, Resnik D. 2009. *The Responsible Conduct of Research*. Oxford: Oxford University Press.
Whitbeck C. 1995. *Ethics in Engineering Practice and Research*. Cambridge UK: Cambridge University Press.

Discussion

The group began with a discussion of the potential effect of terminology on ethics education. C.K. Gunsalus suggested that it might be better to frame the educational goals around developing expert decision-making or problem-solving skills in research rather than referring to it as ethics, which can imply a character trait rather than a learned skill. Julia Kent reinforced this point by reporting that in research by the Council of Graduate Schools, graduate students had responded more favorably to the idea that ethics training was about learning skills rather than knowing what was right or wrong. The group also mentioned possible issues associated with use of the term "professional" when discussing research ethics because not all scientists or engineers may consider themselves to be professionals.[11]

Michael Davis noted that the term social responsibility had origins in business and in that context, it typically refers to doing good whereas when used in research it is often about not doing harm. He argued that by not emphasizing the harm aspect of social responsibility educators were making the issues less dramatic and less significant than they actually are, and he urged educators to talk openly about the harm aspect. Ronald Kline posited that use of the term *responsible conduct of research* reinforces the separation between research ethics, engineering ethics, and their incorporation of social responsibility because the word "conduct" does not often encompass the broader issues of health, safety, and welfare of the public. He also noted that the distinctions between these two areas of ethics, conduct and social responsibility, are increasingly less clear in the research world because research often involves both basic science and engineering in the same lab.

Audience members discussed the possible impact of a profession's goals on the views of scientists and engineers toward research ethics and responsible conduct. Joe Herkert pointed out his concern that because their professions' stated purpose is to provide a social good, scientists and engineers may feel that their actions are, by definition, already ethical. Stephanie Bird commented that the fields of science and engineering, and the students in them, often have internalized views of social responsibility that include a professional goal to provide benefits to society, but added that, although these views are engrained or embedded in the teachings and discussions within the field, they are not explicitly stated in education. Michael Davis observed that scientists and engineers differ in their underlying goals: scientists, he suggested, generally want to find knowledge or truth, whereas engineers are more interested in finding out something that is useful.

Returning to the notion of ethics education as training for expert decision making, Michael Kalichman argued that education should not be about providing students with a list of facts and rules that need to be learned, because that could end up being a large list of items; rather, educators should be encouraged to just *do something* relating to certain key issues in research ethics. Felice Levine reinforced this view, commenting that educators need to teach a mode of

[11] In the case of engineers however, the ABET Engineering Accreditation Commission does consider accredited programs to be leading to the *professional* practice of engineering. Accreditation Policy and Proceedure Manual (APPM), 2013-2014, II.E.3.c. http://www.abet.org/DisplayTemplates/DocsHandbook.aspx?id=3146.

reasoning and that it does not matter as much what the topics or exemplars are in the curriculum. She stressed that what is important is that the students remember how to reason about issues associated with the work they are doing and the persons they work with, how to conceptualize their problems, and how to make tough judgment calls. Stephanie Bird made the point that the people with the best understanding of research ethics are those that regularly or frequently consider the implications of their work on both the small and large scale, and that this phenomenon reinforces the importance of using case studies as a way to develop reasoning skills because they allow students to practice considering the implications of actions.

3

Goals and Objectives for Instructional Assessment

The second session examined the goals and objectives of instructional assessment for ethics education in classrooms and in programs or centers. While the first two sessions of the workshop separated educational goals and assessment goals, speakers in this session and in the discussion afterward emphasized the importance of integrating the two in practice.

The first speaker was Michael Davis, a senior fellow at the Center for the Study of Ethics in the Profession and professor of philosophy at Illinois Institute of Technology. His work covers professional ethics, codes of ethics, and social contracts. His book *Engineering Ethics* (Ashgate, 2005) specifically addressed the professional ethics of the engineering field, and his educational research has focused on how to integrate ethics into technical courses. In his paper Davis begins by examining the meanings of “science and engineering ethics education” and “instructional assessment,” and then describes types of assessment, with a focus on generalized summative assessment. He concludes that to improve assessment across multiple classes, we need to define a set of instructional objectives for ethics education in engineering and science, as has already been accomplished for responsible conduct of research.

Heather Canary and Joseph Herkert gave the second talk. Canary is an assistant professor in the Department of Communications at the University of Utah. Her research has focused on graduate ethics education and she has infused ethical considerations into her teaching of communications. Herkert is the Lincoln Associate Professor of Ethics and Technology in the School of Letters and Sciences at Arizona State University. He is also part of the ASU Consortium for Science, Policy, and Outcomes. His teaching and research has focused on engineering ethics and the social implications of technology. Canary and Herkert have collaborated on two projects, which they describe in their paper and presentation, on integrating ethics into graduate science and engineering curriculum and on creating macroethics modules for online courses. Both projects included assessing the impact of their educational efforts. In their paper they describe the difficulties of assessing ethics education across programs or centers and call for the definition of a clear set of objectives for instructors. They also describe useful methods for conducting assessment across centers or programs. They conclude with guidance for instructors, arguing for instructors to take instructional design seriously; to consider what goals are most appropriate for each instructional effort; to use the content, context, and goals to determine the assessment plan; to make use of experts to fine-tune assessment methods; to also make use of informal assessments; and to make use of existing resources.

Instructional Assessment in the Classroom
Objectives, Methods, and Outcomes

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Given that this workshop is concerned with providing "practical guidance on science and engineering ethics education" and my assigned subject is "instructional assessment in the classroom," I should, I think, begin by making clear what I mean by "science and engineering ethics education." Like most important terms, that one seems to have different senses for different people, and some of the differences can affect what gets assessed.

Ethics Education

"Ethics" typically carries one or more of three senses in discussions of "ethics education." In one sense, "ethics" is just another word for "morality," that is, those standards of conduct that apply to all moral agents—don't lie, keep your promises, help the needy, and so on. When educators talk of "character," "integrity," or "virtue" while talking of "ethics," it is generally this first sense of "ethics" they have in mind. In another sense, "ethics" names a field of philosophy, that is, the attempt to understand morality as a reasonable undertaking. Ethics in this sense is also called "ethical theory" or "moral philosophy." When philosophers claim expertise in "ethics," this is the "ethics" referred to. In a third sense, "ethics" consists of special (morally permissible) standards of conduct that apply to members of a group simply because they are members of that group. It is in this sense that research ethics applies to researchers and no one else, engineering ethics to engineers and no one else, and so on. I shall hereafter use "ethics" exclusively in this third sense (reserving "morality" for the first sense).

Education in ethics—in the special-standards sense—can have many objectives.[1] But, for the purposes of this workshop, the educational objectives that can reasonably be supposed assessable

[1] See, for example, the list in Hollander and Arenberg (2009, pp. 12–13):

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

N.B. Hollander has informed me that she thought of these as an ethical decision procedure rather than as a set of course objectives.

in a classroom (or similar academic setting, such as a lab or field site) seem to belong to one of three categories:

- *Ethical sensitivity*. This is the ability to identify ethical issues in context, for example, to see that a certain source of research funding may create a conflict of interest.
- *Ethical knowledge*. Some ethical knowledge is propositional ("knowing that"); for example, knowing that one's conduct is governed by law, institutional regulation, and professional code. And some ethical knowledge is skill; for example, knowing how to use an ethical decision procedure or file an ethics complaint on a university's website.
- *Ethical judgment*. This is the ability to design a plausible course of action for the ethical issues identified, using relevant ethical knowledge.[2]

Many educators are tempted to add a fourth objective: *increasing ethical commitment*, that is, increasing the relative frequency with which students conduct themselves as engineers or scientists should—before or after graduation. While I believe, or at least hope, that ethics education can increase ethical commitment, there are at least two reasons not to address that objective here. The first is that obtaining relevant information in an academic setting is not easy. The best tool available for assessing commitment is a survey in which students report their perceptions of their own conduct or the conduct of those around them.[3] Such a survey may give a reasonably good indication of academic atmosphere—but there is (alas!) no evidence that it reveals much, if anything, about actual conduct.

The other reason not to try to assess increased ethical commitment in the classroom is that we (teachers of research ethics, engineering ethics, or the like) are primarily interested in what students do after graduation, that is, the effect of ethics education over a lifetime. We would have failed if, while conducting themselves properly in the classroom, our students became monsters upon leaving. Yet, once they leave the classroom, we are in an even worse position to learn much about their conduct than while they were in the classroom. Of course, over several decades, employers are likely to develop the sense that graduates of certain programs are more trustworthy than others. That is, in fact, an important way to assess what goes on in the classroom. Unfortunately, no one today seems willing to wait that long to assess the success of ethics instruction, so that slow method is (in practice) not available.

Nevertheless, we need not, I think, be apologetic about our inability to assess ethical commitment from what goes on in the classroom—or even from what goes on in the university as a whole. Ethics education is no worse off in this respect than education in the technical side of engineering, mathematics, or science. We can give students tools but we cannot guarantee that they will use them, much less how they will use them. For example, we cannot say whether an engineering student who has done well in first-year chemistry will, after graduation, ever use what he has learned about chemistry—even on problems where it might be helpful.[4] When it comes to assessment, ethics should not be held to a higher standard than other academic subjects.

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[2] What is sometimes called "moral imagination" is an aspect of either sensitivity or judgment, depending on whether the term is understood as referring to the ability to appreciate the consequences of one's choice (sensitivity of a sort) or the ability to invent alternatives to the choices with which one has been presented (part of judgment).
[3] Donald McCabe has done substantial research of this sort; see, for example, McCabe et al. (2002). For similar research directly related to science ethics, see Martinson et al. (2006).
[4] Of course, an engineer who doesn't use chemistry when he should may soon be out of a job; but the same should be true of an engineer whose conduct on the job is obviously inconsistent with the ethics she learned in school.

Kinds of Assessment

My subject is instructional assessment in the classroom. The term "instructional assessment" is another ambiguous term. It might refer to assessment of (a) the instructor, (b) the instruction (that is, the course presentation, content, assignments, and grading), or (c) the outcome of instruction. Departments routinely assess instructors by visiting classes, looking at course materials, and surveying students. I have nothing to add to the common wisdom on that subject.[5] Assessing instruction, though closely related to assessing instructors, has a different emphasis, especially when the instruction is the same across two or more instructors (as in, for example, a multisection course). Though I do have something to say about assessing instruction, my focus here will be on assessing the *outcome of instruction*.

Such instructional assessment may be either criterion-based or improvement-based. Criterion-based assessment seeks to determine how close students are to some ideal or set level, such as a certain sort of proficiency. In contrast, improvement-based assessment seeks to determine how much students have learned during some period (such as between the first day of class and the last). Both criterion-based assessment and improvement-based assessment assume the existence of right and wrong answers—or, at least, better and worse answers. Pretests and posttests are the hallmark of improvement-based assessment; a single test at the end of the semester is the hallmark of criterion-based assessment.

Some assessing of instructional outcomes goes on during instruction. This is what education professors call "formative assessment." Formative assessment belongs as much to instruction as to assessment. So, for example, if I ask a student a question to which she should know the answer, her answer should tell me whether she knows something she should know. If, once she has given the answer, I reveal my assessment (as I should), I thereby inform her of her status or progress in the course, for example, the need to learn something she thought she knew. A student's failure to answer correctly also gives me a reason to change how I present the relevant material; her success, a reason to leave it as it is. That is another use of formative assessment, guiding instruction.[6]

Much assessment of instructional outcome is not formative in this way. Going on at the end of the course or is done during the course solely for the purpose of a final grade, it is what education professors call "summative assessment." There are at least two kinds of summative assessment, what might be called "local" and "generalized."

Local Assessment

Local assessment is done for the purposes of a particular course, for example, an idiosyncratic exam given for the purpose of assigning a final grade in a single section of a single course. Generalized assessment is designed to allow comparison across several sections, courses, or programs, whether to assess the instructor, course, or students. The Stanford Achievement Tests are perhaps the classic examples of generalized assessment tools; the Defining Issues Test (DIT-2), the equivalent for moral development.

In principle, local assessment of ethics education is easy. An instructor need only ask questions that give students the opportunity to reveal what the class has taught them. If the class is supposed to have increased their ethical sensitivity, then they should do better picking out

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[5] For a good summary of the common wisdom, see Suskie (2004).

[6] For more on formative assessment, see William et al. (2004), Stiggins and Chappuis (2012), and Keefer and Davis (2012).

certain ethical issues in a case at the end of the semester than at the beginning. If the class is supposed to have increased ethical knowledge, its members should reveal more ethical knowledge at the end of the course than at the beginning, for example, when explaining the ethical issues they identified or justifying the course of action they have chosen. If the class is supposed to improve ethical judgment, then students should do better at the end of the course than at the beginning when they try to resolve an ethical issue, for example, by proceeding in a more orderly way and making better use of the information provided.

In practice, local assessment is harder than I just made it sound, especially for instructors used to assessment using numerical problems. There are at least two barriers to instructors engaging in local assessment of ethics. The first is the difficulty of developing course-specific ethics questions. This barrier gets lower every year, as textbooks and websites provide more cases that can be taken directly or at least used as a model.[7] The second barrier is grading. It also presents less difficulty than it used to. There are now "grading rubrics" that break down the grading process into several manageable stages.[8] Instructors no longer need develop their own from scratch.

Whenever educators discuss assessment, they are likely to debate the relative merits of qualitative and quantitative assessment. By "qualitative assessment," I mean assessment in terms of qualities, such as "better" or "should have said something about harm to third parties." By "quantitative assessment," I mean assigning a number or its equivalent to represent the assessment.[9]

I have never understood this debate—at least when the focus is what is practical in a classroom rather than what is merely logically possible. Both sides seem to have missed the obvious: Most, perhaps all, of what can be done without numbers in a classroom can be done with them (for example, by adding comments).[10] The practical question is usually whether it is worth the time to work out the protocol for assigning numbers. It is generally not worth the time if the number of students to be assessed is small. As the number of students grows, quantitative assessment becomes ever more attractive (faster, cheaper, and more convenient, though at the expense of certain information).[11]

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[7] See, for example, Ethics Education Library, http://ethics.iit.edu/eelibrary/ (accessed October 12, 2012).

[8] See, for example, Sindelar et al. (2003) and Keefer (2012).

[9] For this purpose, letter grading is a kind of *quantitative* assessment (since it allows averaging and other operations characteristic of cardinal numbers).

[10] Of course, a lot of information, especially information useful for formative assessment, can be lost in the switch from qualitative to quantitative assessment *if* comments are ruled out. Comments tend to become impractical as the testing population grows relative to resources.

[11] One reviewer objected:

> Davis says that he never understood the controversy between quantitative and qualitative assessment, and that qualitative assessments can be turned into numbers using rubrics. Actually, some qualitative assessments cannot be "quantitized." For example, qualitative assessment can document changes in students' conceptual understanding or professional identity. In these cases, the qualitative assessment yields detailed descriptions of the different ways in which students understand particular concepts, and the different ways in which students think of themselves as scientists or engineers or researchers. A comprehensive assessment effort may use mixed methods, that is, a combination of quantitative and qualitative data, collected in a planned, thoughtful way. The practice of collecting different kinds of data is called "triangulation."

While I agree with what the reviewer said, I do not think it a criticism of what I said. On the one hand, "triangulation" is just a fancy term for comparing results of several instruments. Triangulation can be useful whether the results compared are from qualitative instruments, quantitative instruments, or some mix. On the other hand, qualitative assessment cannot "document" change in student's conceptual understanding (or anything else) unless it *measures*

It is perhaps unnecessary to note an important difference between most actual assessments and the ideal assessment of educational psychology. Most educators cannot verify the reliability of a test before using it. Many do not even use the same test twice. They generally judge a test to be reliable if it gives results within the range they are used to. An educator assumes the results to be valid if the test sorts students in something like the way he has already sorted them. (If he has doubts he can ask a colleague for a second opinion.) This is, of course, assessment's equivalent of folk wisdom, not science. But, given the resources available, folk wisdom is generally an educator's best guide. And for many of us, especially those who teach subjects like philosophy, this folk wisdom is probably at least as good a guide as educational psychology can now provide even with unlimited resources (though, in principle, educational psychology should be able to do better).

I take more seriously the related debate concerning the relative merits of "objective" and "subjective" assessment. Of course, no assessment is strictly objective. Even with the use of a machine-graded multiple-choice test to assess thousands of students, the test itself will be the work of a few individuals, incorporating their biases. About all that can be done about the subjectivity of tests is to reduce it to a minimum, beginning with techniques that shield the assessors from knowledge of whom they are assessing. That shield is the greatest merit of so-called objective tests, especially if machine graded. But much the same effect can be achieved for subjective tests by having a panel of various experts assess the questions, looking for bias both in the choice of question and in the range of answers identified as correct, not looking at the student's name until the test (or other assessment instrument) is graded, using a grading rubric, and using multiple graders, training them for the work, and checking their grading now and then. Since there is a substantial literature on the design of objective tests for use in the classroom, I'll say no more about it here (see, e.g, Osterlind 1997).

Generalized Summative Assessment

That is enough about local assessment. For our practical purposes, the chief problem is *generalized* summative assessment in the classroom of instructional outcomes for ethical sensitivity, knowledge, and judgment. It is the chief problem in large part because, while demand for such assessment seems to be growing, we (teachers of ethics) do not yet know how to do it well.[12]

There are at least three approaches to such assessment. One approach is surveying students concerning their perception of what they have learned.[13] While such surveys can show that students noticed the ethics, liked it (or not), and thought they learned something useful (or not), they cannot answer the question, "What did they *in fact* learn?" Students may or may not be good judges of what they have learned.

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change (for example, by counting the increased use of certain terms or concepts). Those measures can be, and generally are, rendered as numbers. (Consider how Kohlberg scored his original test of moral development.) Without some sort of scoring, one has only a pile of papers and one's impressions, nothing so formal as documented changes.

[12] I say this regretfully, I should add. For purposes of doing a good job of teaching engineering or science ethics, the important topic is not summative assessment but formative.

[13] For an example of what such a survey might look like (and what sort of results one might get), see Davis (2006), esp. 726–727.

The second approach is one or more standardized tests. Whether objective or subjective, the standardized tests must in practice overcome at least three impediments: time, relevance, and comparability.

The first impediment, *time*, should come as no surprise. It is hard to develop a reliable *generalized* test of sensitivity, knowledge, or judgment that requires much less than an hour to administer. To track achievement in all three dimensions—sensitivity, knowledge, and judgment—course by course, with pretests and posttests, the cost in class time is likely to be a minimum of six hours, that time devoted to testing in addition to whatever testing is otherwise required, say, the usual midterm and final exam.[14] This first impediment cannot, it seems, be overcome by online testing outside of class. The evidence is that the percentage of students taking (or finishing) such a test online will be substantially lower than the percentage if the test were taken in class. Even when classes are quite large (such as a typical undergraduate engineering class at a large university), the rate of online response can be low enough to make the test results more or less meaningless for instructional assessment (Borenstein et al. 2010, especially p. 395).[15]

The second impediment, *relevance*, may seem a bit more surprising. Relevance is several related problems. One concerns judgment. The DIT-2 is often used to assess *ethical* judgment, although it was designed to assess development of *moral* judgment. There is, it is true, reason to suppose a relationship between moral and ethical judgment, but that relationship has yet to be shown, much less quantified. A group at Georgia Tech is now developing the equivalent of the DIT-2 for engineering; another is doing something similar at Purdue.[16] Once there is a reliable test of ethical judgment, one sensitive enough to pick up changes from semester to semester, we (teachers of ethics) should know what relation engineering ethical judgment has to what the DIT-2 measures. Whatever we learn from that, we will probably need a similar test for the sciences—perhaps even for each of the major sciences—if only to understand the connection (or disconnection) between moral judgment and ethical judgment in the sciences.[17]

The problem of relevance for assessment of ethical sensitivity and ethical knowledge is, I think, more difficult than for assessment of ethical judgment. There seems to be a natural law governing tests of sensitivity and knowledge:

> The more general the test, and therefore the more useful for comparing across courses, the less able it is to register much about the ethics that students learned in a particular course and, therefore, the more likely to register "nothing learned"; the more specific the test, and therefore the more useful for registering what students learned in a particular course, the less useful for comparison across courses. (Davis and Feinerman 2012, p. 358)

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[14] Yes, that would be more than a tenth of a typical semester course (3 hr/wk × 15 wk = 45 hr).

[15] This evidence comes from undergraduate classes in which the online test, though not required, was clearly relevant to course content. The response rate might well be substantially lower if the test looked largely unrelated to the course (as it might look, for example, in a technical course, graduate or undergraduate). Of course, if students were paid a nonnegligible sum to take (and complete) such a test, relevant to the course or not, and paid significantly more if their effort was scored "serious," the response rate might be much better. Certainly, paying students is worth a try.

[16] Borenstein et al. (2010). Purdue has yet to publish; I know of the work there only because the group is using me as a consultant.

[17] Work on such a test is also under way. See, for example, Mumford et al. (2008).

So far, I know of no one who has developed a test of ethical sensitivity or knowledge both (a) general enough to produce comparable results across a wide range of courses and (b) specific enough to measure much of what was actually learned in a particular course.[18] Indeed, in my experience (and the experience of those I have consulted), tests that even try to be general enough to cover many courses tend to be quite long—with most questions irrelevant to most courses. Students are therefore likely to feel that taking such a test is a waste of time—as well as irrelevant to the course in which they are enrolled. The instructor is likely to agree, and therefore be unwilling to impose such a test on students. These results, being negative, seem to have gone largely *un*published.

That brings me to the last impediment to generalized testing for sensitivity and knowledge: *comparability*. Suppose, for example, that we have a reliable test of ethical sensitivity, one that can be used in any class and is capable of picking up changes in most. Still, the score in one class may correspond to sensitivity to safety; the same score in another course, to sensitivity to bias in data collection; and the same score in a third class, to sensitivity to sexual harassment. The raw scores are, in effect, giving the count for apples in one class, oranges in another, and bananas in a third.[19]

Now, it may seem that all that is needed to solve this problem of comparability is a weighted count of generic fruit. But to provide a weighted count we would need to answer questions such as, "How important is learning about safety compared with learning about avoiding unbiased data or responding to sexual harassment?" Since it is unlikely that the answers to such questions can be both useful and noncontroversial, I think we need to work around such questions rather than answer them directly. The easiest way around is by institutional arrangements. Since I have a little more to say about classroom assessment, I will save my views on working-around for the conclusion.

The third approach to generalized assessment in the classroom is still experimental (Davis and Feinerman 2012). It works like this. There are course-specific pretests and posttests designed to measure relative improvement in a class—in sensitivity, knowledge, judgment, or some combination of these. Each class has its own idiosyncratic test, with ethics questions based on the specifics of what was taught. Those questions are integrated into ordinary exams. In each class, each student's posttest score is divided by the student's pretest score, yielding a single number (rather like a grade point) that can be compared with that of other students in that class or other classes. This approach avoids the impediments of time and relevance, but adds to the instructor's burdens, since the instructor must prepare and grade the tests' ethics components (just as she prepares and grades the technical components). More important, I think, the approach does no more to solve the comparability problem than the second approach does.

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[18] There are actually two problems here. The harder one is developing such a test that is useful across all the sciences or all fields of engineering (or all fields of engineering *and* science). The easier problem is to develop such a test useful across one science or one field of engineering. But even that easier problem has yet to be solved and seems likely to run up against my natural law.

[19] This statement of the problem assumes that ethical sensitivity, like ethical knowledge but unlike ethical judgment, must be taught piecemeal. While I think this is largely true, it is at least possible that raising one sort of ethical sensitivity (say, to sexual harassment) might raise ethical sensitivity more generally. That is an empirical question I do not wish to prejudge. I also do not wish to prejudge the question of how large an effect that might be (if it exists).

Conclusion

The way around the problem of comparability is, I think, not to worry about it classroom by classroom. The design of a generalized test is much easier if its purpose is to measure whether students have learned certain specified things by the end of their academic career. That is, we educators need to define a body of instructional objectives—the specific ethical sensitivities, ethical knowledge, and level of judgment a graduate should have. We already have that for some sciences (for example, the eleven or twelve items required for adequate instruction in Responsible Conduct of Research).[20] We need something that specific for engineering as well. ABET's criteria, though helpful, are still too general.[21]

Once the instructional objectives are defined, the institution (or some group of institutions) can develop a way to measure the degree to which students have achieved the ethical sensitivities, knowledge, and judgment desired—or, at least, measure their progress in that direction. That assessment tool might be anything from a machine-graded multiple-choice test to a rubric-guided scoring of student portfolios. (Developing such an instrument should be much easier than developing anything that has to work in a wide variety of classrooms.) Each program could then devise a curriculum designed to ensure that its students achieve a certain score on that generalized summative assessment. Individual courses could be evaluated on whether they contribute what they are supposed to contribute to the overall curriculum, for example, by using the course-specific third approach or just by checking to see how well graduating students in their program do on the appropriate questions. There is no need to decide how important each course's share of the job is.

Notes

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References

[20] There are, of course, sciences (or parts of sciences) that that list of topics may not fit, for example, action research, fieldwork in anthropology, and historical research into the recent past.

[21] The list of engineering topics might look something like this:

1. The public health, safety, and welfare
2. Candor and truthfulness (including fabrication, falsification, and incomplete disclosure of data)
3. Obtaining research, employment, or contracts (credentials, promises, state of work, and so on)
4. Conflicts of interest
5. Data management (access to data, data storage, and security)
6. Cultural differences (between disciplines as well as between countries and religions)
7. Treating colleagues fairly (responding to discrimination)
8. Responsibility for products (testing, field data, and so on)
9. Whistle blowing (and less drastic responses to wrongdoing)
10. Accessibility (designing with disabilities in mind)
11. Authorship and credit (coauthorship, with faculty, students, and nonacademics)
12. Publication (presentation: when, what, and how?)
13. National security, engineering research, and secrecy
14. Collaborative research
15. Computational research (problems specific to use of computers)
16. Confidentiality and privacy (personal information and technical data)
17. Human and animal subjects research in engineering (including field testing)
18. Peer review
19. Responsibilities of mentors and trainees

Borenstein J, Drake MJ, Kirkman R, Swann JL. 2010. The Engineering and Science Issues Test (ESIT): A discipline-specific approach to assessing moral judgment. *Science and Engineering Ethics* 16:387–407.

Davis M. 2006. Integrating ethics into technical courses: Micro-insertion. *Science and Engineering Ethics* 12:717–730.

Davis M, Feinerman A. 2012. Assessing graduate student progress in engineering ethics. *Science and Engineering Ethics* 18:351–367.

Hollander R, Arenberg CR, eds. 2009. *Ethics Education and Scientific and Engineering Research*. Washington: National Academy of Engineering.

Keefer MW. 2012. The importance of aligning assessment, instruction, and curricular design in professional ethics education. *CORE Issues* 1. Available online at http://nationalethicscenter.org/content/article/178.

Keefer M, Davis M. 2012. Curricular design, instruction, and assessment in professional ethics education: Some practical advice. *Teaching Ethics* 12:81–90.

Martinson BC, Anderson MS, De Vries R. 2006. Scientists' perceptions of organizational justice and self-reported misbehaviors. *Journal of Empirical Research on Human Research Ethics* 1:51–66.

McCabe D, Trevino LK, Butterfield KD. 2002. Honor codes and other contextual influences on academic integrity. *Research in Higher Education* 43:357–378.

Mumford MD, Connelly S, Brown RP, Murphy ST, Hill JH, Antes AL, Waples EP, Devenport LD. 2008. A sensemaking approach to ethics training for scientists: Effects on ethical decision-making. *Ethics and Behavior* 18:315–339.

Osterlind SJ. 1997. *Constructing Test Items: Multiple-Choice, Constructed-Response, Performance and Other Formats*. Norwell, MA: Kluwer Academic.

Sindelar M, Shuman L, Besterfield-Sacre M, Miller R, Mitcham S. 2003. Assessing engineering students' abilities to resolve ethical dilemmas. *Proceedings of the 33rd Annual Frontiers in Education* 3 (November 5–8): S2A 25–31.

Stiggins RJ, Chappuis J. 2012. *An Introduction to Student-Involved Assessment for Learning*. Boston: Pearson.

Suskie L. 2004. *Assessing Student Learning: A Common Sense Guide*. San Francisco: Jossey-Bass.

William D, Lee C, Harrison C, Black P. 2004. Teacher developing assessment for learning: Impact on student achievement. *Assessment in Education Principles Policy and Practice* 11:49–65.

Assessing Ethics Education in Programs and Centers
Challenges and Strategies

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Assessment is generally one of the most difficult and controversial aspects of research and educational programs and projects. In the case of science and engineering ethics research and education, it is all the more difficult because interest in assessment in this area is relatively recent and methods developed in other contexts are not always readily transferable.

This paper draws on some of the literature on assessment in science and engineering ethics as well as our own experiences in conducting two NSF-funded research projects: "Integrating Microethics and Macroethics in Graduate Science and Engineering Education: Development and Assessment of Instructional Models" (here called "MicroMacro"; Herkert et al. 2009; Canary et al. 2012) and "Developing and Assessing Macroethics Modules for the Collaborative Institutional Training Initiative (CITI) Responsible Conduct of Research Courses" ("MacroCITI"). Our experience with assessment in ethics centers is limited; we draw instead on our leadership and participation in the ethics-across-the-curriculum program sponsored by the Lincoln Ethics Teaching Fellows Program of the Arizona State University (ASU) Lincoln Center for Applied Ethics (Herkert 2011).

First we discuss challenges in assessing ethics education in programs and centers, and then strategies to address them. We end with practical guidance gained from our review and experiences.

Assessment Challenges

Published accounts of assessment attempts identify several challenges inherent to assessing ethics education in academic centers and research programs (e.g., Antes et al. 2009; Davis and Feinerman 2012; Herkert et al. 2009). The difficulties arise from multiple content areas and goals represented in academic/research programs and centers as well as multiple modes of education used across contexts. However, research and experience also indicate methods for addressing these complications.

One challenge is that a collection of activities that constitute an entire academic/research program or center inevitably covers different content and represents different strategies for content delivery. For instance, centers might take a multidisciplinary approach to ethics, with faculty weaving ethics education into their specific disciplinary courses. Although general ethical issues might be similar across disciplines, ways in which those issues surface likely are radically different. That is, a materials engineer working in a laboratory needs to be aware of conflict of interest issues just as a practicing civil engineer does, but such issues emerge differently in academic labs than they do in consulting engineering practice.

Similarly, ethics education programs typically draw on faculty, students, and other participants across time and interests, all of which constitute contextual differences. Any center or program assessment efforts must take these disciplinary and contextual differences into account. For example, Davis and Feinerman (2012) noted that incorporating ethics in different engineering courses at two universities required assessment that would be specific enough to tap what students learned and at the same time broad enough to apply across instructional contexts. Assessment strategies constructed too broadly do not effectively measure anything, or simply tap what would be considered "common knowledge." On the flip side, those constructed too narrowly for specific courses or delivery modes cannot be compared across contexts.

A second assessment challenge is how to tap differing foci and goals represented by components of programs and centers. Antes and colleagues (2009), in their meta-analysis of ethics education in science, point to the necessity of matching assessment criteria to instructional goals. Although that might seem obvious, it is not always apparent or easy to find ways to assess the actual goals or outcomes of ethics education because of the many possible foci of such efforts. More specifically, entire programs or centers might include an array of goals and outcomes that are not all accomplished in any one context or endeavor. One program activity might focus on ethical decision making and another on understanding standards for ethical behavior.

In an attempt to discern the most relevant issues as well as the most effective strategies for teaching ethics in the sciences, the Antes et al. (2009) meta-analysis distilled potential moderating variables—such as instructional context, instructional activities, and student characteristics—that influence outcomes of such instruction. These elements influence what is assessed as well as best ways to assess learning and outcomes. The authors' analysis points to the importance of carefully designing ethics educational contexts that are interactive, incorporate content about domains of ethical behavior (e.g., conflicts of interest, authorship), and include several types of instructional activities. Antes and colleagues also note that few published studies of ethics instruction constitute rigorous research projects that provide enough information to compare results across studies. Our experiences in our NSF-funded studies and in preparing this paper lead us to concur with that conclusion.

Our initial effort (the MicroMacro project) to conduct the type of rigorous study of ethics education recommended by Antes and colleagues (2009) took these challenges and issues into account. As we report in two papers (Canary et al. 2012; Herkert et al. 2009), we took great care to design alternative modes for teaching about social and ethical issues encountered at both the individual level ("micro ethics") and the collective level ("macro ethics" or "social responsibility"). We sought input from experts from across the United States to identify realistic and relevant instructional goals.

The earlier paper (Herkert et al. 2009) discusses the rather lengthy process involved in developing goals and outcomes that would be both realistic and assessable. One step in that process involved a three-day workshop with about 20 people participating in several in-depth sessions about micro- and macroethical issues important for students to consider (see Herkert et al. for a complete account of issues, goals, and outcomes discussed). An example of a micro issue identified during the workshop is "professional norms such as objectivity, transparency, accuracy, and efficiency" (Herkert et al., p. 7), and an example of a macro issue, "ways to envision the possible social implications of research" (Herkert et al., p. 7). An in-depth discussion of the relative merits of teaching micro- and macroethics is beyond the scope of this paper; we refer the reader to our earlier conference proceedings (Canary et al. 2012; Herkert et al. 2009).

One workshop session was devoted to assessment, and resulted in new ideas for matching assessment approaches to instructional goals. After the workshop, the research team met to refine workshop ideas into manageable instructional goals and realistic student outcomes that we could assess across both different instructional models and the entire research project. We worked as a team and with input from a panel of experts to develop multiple assessment strategies that would reliably and validly evaluate learning and achievement of the identified goals. We discuss those strategies in the next section.

Another set of assessment challenges arose during the MicroMacro project and again in our second project, MacroCITI. Results of the MicroMacro project pointed to clear benefits of integrating macro- and microethical issues in graduate ethics education. Students in instructional models in that program demonstrated gains in knowledge of ethical standards, ethical sensitivity, and ethical judgment (Canary et al. 2012). However, many institutions rely solely on CITI for ethics education for graduate students.

CITI, managed out of the University of Miami, provides online ethics education programs for multiple disciplines and multiple purposes (e.g., human subjects, responsible conduct of research). But no CITI module is dedicated to the social responsibility aspects of research. Accordingly, we used materials developed for instruction and assessment in the MicroMacro project as a springboard for developing new online instructional materials in social responsibility for CITI. This project presented us with an assessment challenge previously identified by Borenstein and colleagues (2010): the difficulty in assessing online instruction and learning. The online environment is very different from a typical interactive in-person class and response rates for online surveys are dramatically lower than in face-to-face contexts.

Additionally, brief educational experiences such as the new CITI module are not conducive to collecting pre- and posttest data, as was possible in the MicroMacro project. Other ethics programs or centers might have similar instructional contexts, such as field experiences, community engagements, or brief activities. As with the online CITI modules, such nontraditional educational contexts are associated with assessment challenges.

Assessment Strategies

For ongoing research or educational programs, an important aspect of assessment is defining a clear set of objectives among participating instructors. As mentioned above, assessment needs to match the program; even if there are differences across segments of the program, common threads may be assessed uniformly.

For the MicroMacro research program, we determined that all four instructional modes (standalone course, hybrid face-to-face/online course, ethics material embedded in a science course, and lab engagement) would cover data management, conflict of interest, military research, and sustainability. These common threads represent two "micro" issues and two "macro" issues identified in early stages of our project. Content and approaches differed, but all of these areas could be assessed with a quantitative tool. Furthermore, we identified three of the four goals for ethics education outlined by Davis (1999) that would be realistic to achieve and assess in our research program: (1) increased knowledge of relevant standards of conduct, (2) greater ethical sensitivity, and (3) improved ethical judgment.

With the four common content threads and three instructional goals we had a structure for our assessment strategies. We developed quantitative items (true/false, Likert-type scale, and multiple choice) to measure each of the three goals for each of the four content areas. Importantly, we also used existing measures of moral judgment (collaboratively agreed upon as appropriate measures of ethical judgment), a short form of the Engineering and Sciences Issues Test (ESIT; Borenstein et al. 2010), and the Moral Judgment Test (MJT; Lind 2009). Results indicated that our study-specific measure and the MJT did not capture changes in ethical judgment but the ESIT did (Canary et al. 2012).

Another approach to assess a common goal across instructional contexts is from the ASU Lincoln Ethics Teaching Fellows Program (Herkert 2011). At the end of the fellowship year, fellows were asked to consider how including ethics content in their courses related to fostering critical thinking skills in their students. Herkert, the program director, thematically analyzed responses and noted the following common themes: linking ethics and decision making, recognizing multiple views, questioning assumptions, and moving away from simple dichotomies. These answers comport with the findings of Antes and colleagues (2009) that the most effective ethics education focused on ethical decision making.

One strategy for ethics education assessment in centers and programs, then, is to include critical thinking or decision making components in the educational experiences and then evaluate the development of those skills. That could be accomplished with case studies, open-ended responses, or quantitative tools such as the ESIT.

Another way to assess changes in students' understanding of ethics, while taking into account the specific content of different contexts in a program or center, is to tailor pre- and posttests to each context. Davis and Feinerman (2012) noted the importance of such tailoring. Pre- and posttest surveys can ask students to define, describe, or discuss the focus of the course. For instance, as an outcome of the ASU Lincoln Ethics Teaching Fellowship, Canary redesigned a Communication in Leadership course, using an ethics lens to cover issues throughout the semester rather than in discrete units. Students wrote their personal definitions of "leadership" at the beginning of the semester and again on the last day of class. A comparison of answers revealed more nuanced understandings of leadership, including its ethical dimensions, at the end of the course (Canary 2011).

We did a similar assessment in the MicroMacro project. At the beginning of each participating course and again during the last week of the semester, students were asked, "How do you view your role in society as a scientist or engineer?" Preliminary results did not identify dramatic differences between answers before and after instruction, with the exception of one new theme, "to be socially responsible in contributions," that emerged in the posttest. However, we are conducting a more detailed analysis of language used in answers to determine whether there are more nuanced differences between time periods and instruction groups.

Another assessment strategy for centers is to conduct systematic analyses of project or annual reports from center personnel. For instance, the ASU Lincoln Ethics Teaching Fellowship required each fellow to provide a final report to the Lincoln Center. These reports included each fellow's major activities as well as personal reflections and evaluations of future contributions to ethics education that might result from those activities. Such reports could be thematically analyzed across programs or centers to distinguish between effective and ineffective educational activities.

Simple metrics can also be useful in assessing the work of centers. The Lincoln Ethics Teaching Fellows Program, for example, uses the total number of students exposed to ethics education through new and revised courses created by the teaching fellows. Voluntary studies of ethics education commonly suffer from small numbers of student participants and low response rates (Canary et al. 2012; Davis and Feinerman 2012); this type of metric might be one way of describing potential impact of programs and centers.

There will be advantages and disadvantages to any assessment tool. No single tool can do everything, so the best idea is to incorporate a variety of assessment tools. Qualitative, open-ended questions as well as targeted, quantitative items will capture different aspects of educational experiences and development.

Additionally, certain tools or strategies are more appropriate for assessing particular goals in particular settings. For example, we determined that our goals for the MacroCITI project were limited to increasing (1) knowledge of standards and issues and (2) ethical sensitivity. Because of the national, online nature of the study we determined that those goals would be best assessed using only quantitative measures. We used some items developed in the MicroMacro project and developed new ones specific to the instructional materials created for the MacroCITI project.

As Antes and colleagues (2009) pointed out, it is also important to consider the instructional process. There are several ways to do this. For example, the MicroMacro project included open-ended questions for students to identify best and worst instructional methods used in their instructional models. We also used several existing scales that measure instructor-student communication and classroom climates (see Canary et al. 2012 for description of these measures). These strategies would be less useful for online instructional environments, of course. However, it is interesting that, in our MicroMacro project, students in the hybrid course demonstrated the highest posttest scores of all instructional groups in measures of their knowledge of relevant standards, ethical sensitivity, and ethical judgment (although the difference was statistically significant only for knowledge). Indeed, 32 percent of participants in that study indicated that using a combination of instructional methods was most effective for ethics/social responsibility instruction.

Clearly there are multiple ways to reach students, engage their thinking about ethics and social responsibility, and guide them toward improving their knowledge, sensitivity, and judgment concerning these issues.

Practical Guidance

By reviewing other published accounts of ethics education assessment and assessing ethics education in two multiyear research programs and an ethics center teaching fellows program, we have garnered experiential knowledge that we share here as practical guidance.

- Take instructional design seriously. Incorporate multiple methods of instruction and varied learning activities, as appropriate for the particular content and context.
- Consider what goals are appropriate for each instructional endeavor and clearly articulate them with center/program faculty.
- Use the content, context, and goals to determine assessment strategies and design assessment tools. For many programs/centers, this will involve the use of multiple strategies to capture multiple foci, contexts, and goals.
- When possible, make use of project workshops and contacts with experts to fine-tune assessment methods. Build such workshops and consultations into program/center budgets.

- Make use of informal assessments as well. Assessment need not always be expensive or time consuming. Informal assessments of center projects can provide valuable information to faculty and administrators.
- When appropriate, use existing resources developed in previous studies. For example:
  - The Engineering and Science Issues Test (Borenstein et al. 2010) measures ethical judgment in research and practice settings.
  - Our MicroMacro project website (www.cspo.org/projects/eese-daim/) provides quantitative measures of knowledge of relevant standards and ethical sensitivity for four content areas frequently addressed in ethics education. It also provides qualitative items to compare students' personal reflections and evaluate the instructional process.

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References

Antes AL, Murphy ST, Waples EP, Mumford MD, Brown RP, Connelly S, Devenport LD. 2009. A meta-analysis of ethics instruction effectiveness in the sciences. *Ethics and Behavior* 19:379–402.

Borenstein J, Drake MJ, Kirkman R, Swann JL. 2010. The Engineering and Science Issues Test (ESIT): A discipline-specific approach to assessing moral judgment. *Science and Engineering Ethics* 16:387–407.

Canary HE. 2011. Using an ethics lens for teaching communication: Focus on small group and leadership communication. *Teaching Ethics* 11(2):25–35.

Canary H, Herkert JR, Ellison K, Wetmore J. 2012. Microethics and macroethics in graduate education for scientists and engineers: Developing and assessing instructional models. *Proceedings of the 2012 American Society for Engineering Education Annual Conference*. Available online at www.cspo.org/projects/eese-daim/publications/ASEE-2012-Paper.pdf.

Davis M. 1999. Teaching ethics across the engineering curriculum. *Proceedings of the Online Ethics Center International Conference on Ethics in Engineering and Computer Science*. Available online at www.onlineethics.org/Education/instructessays/curriculum.aspx.

Davis M, Feinerman A. 2012. Assessing graduate student progress in engineering ethics. *Science and Engineering Ethics* 18:351–367.

Herkert JR. 2011. The Lincoln Teaching Fellows Program at the ASU Polytechnic Campus. *Teaching Ethics* 11(2):1–5.

Herkert JR, Wetmore J, Canary HE, Ellison K. 2009. Integrating microethics and macroethics in graduate science and engineering education: Developing instructional models. *Proceedings of the 2009 American Society for Engineering Education Annual Conference*. Available online at www.cspo.org/projects/eese-daim/publications/ASEE-2009-paper.pdf.

Lind G. 2009. The Moral Judgment Test. Information is available online at www.uni-konstanz.de/ag-moral/mut/mjt-engl.htm.

Discussion

Most of the discussion revolved around an idea raised by Michael Kalichman, who observed that the assessment approaches presented seemed to focus on evaluating whether students had achieved a standard set of skills and he questioned whether that should be the goal of ethics education. He proposed instead that ethics education should provide an environment for discussion, inside and outside the classroom, and it should facilitate more discussion among students and principal investigators. Carl Lineberger observed that what teachers of science and engineering ethics were trying to create among students, and then test that they have learned, is a *persistence of knowledge*, a knowledge that has long-term effectiveness and can spread beyond the individual to change the environment both locally and even internationally.

Kalichman went on to suggest that if ethics education only teaches certain skills or knowledge, then it should be possible, in principle, for a student to test out of the class. This prompted much discussion, with most participants arguing that students should not be able to test out of the class. Stephanie Bird pointed out that allowing students to test out of a class would send the wrong message: it would send a message that there was a limit to what one needed to know about ethics. A few people suggested that students with highly developed skills—those that might otherwise test out of the class—could be engaged as teaching assistants or encouraged to help lead discussions based on their insights, experiences, and perspectives. Bird observed that the involvement of advanced students and postdocs in ethics education can be very important because their thoughts can be more convincing to students than those of faculty.

Michael Davis noted that there was an important distinction between the goals for ethics classes in science and those in engineering because most science students will work in academia, whereas engineers are more likely to work in industry. He said he could understand having an ethics class for scientists that focuses on changing the environment or providing an environment for ethics discussion, but he did not see how this would be valuable to engineers since their working environment is typically outside academia. He concluded that he would be willing to allow an engineering student to test out of an ethics class.

C.K. Gunsalus commented that corporations have been working for some time on improving the ethical climate of their workplaces and that their research could be beneficial to those in academia who are trying to improve the ethical environment at their institutions.

In response to the call for creating an environment for ethics discussion, Joe Herkert reported that in a recent class, students had said they particularly appreciated the opportunity to discuss ethical issues with other students. Heather Canary added that in her research with Herkert they had assessed the environment and its impact beyond the classroom. They did quantitative measurements of classroom dynamics, which included evaluation of how supportive or negative the classroom climate was, instructor argumentativeness (which fosters discussion), instructor verbal aggressiveness (which discourages discussion), and out-of-classroom communication with instructors. They also asked students how often they talked with peers and faculty outside of class and found that higher measures in fostering classroom discussion correlated with higher out-of-classroom discussions, which they called the spillover effect.

The group also discussed the value of formative assessment, in which students participate in evaluating how much they learned. Bird commented that the method had been very effective in a class in which she had participated, where students at the end of the class analyzed their pretest answers for what they had been missing and assessed what they had learned. Julia Kent added that the CGS has used formative assessment in a number of projects, citing its capacity both to make explicit to students the expectations of a course and allow the students to engage in self-assessment, which has been shown to help students develop useful metacognitive skills. Also supporting the call for formative assessment, Felice Levine suggested that it might be worth both discussing the available data about student learning with students and having them assess it. She also proposed asking students at the end of the course how they might (re)design it, explaining that this could emphasize to the students that the educational process was about collective community education rather than just their own individual education.

4

Institutional and Research Culture

The third session explored the role of institutions and the impact of institutional and research cultures on ethics education. The speakers in this session looked beyond the role of individuals and teachers and examined institutional efforts to improve ethics education. They also considered the influence of institutional or research cultures on the success or failure of educational efforts.

The first speaker was Julia Kent, director of Global Communications and Best Practices at the Council of Graduate Schools (CGS). Her research has addressed a broad range of topics in graduate education: scholarly and research integrity, learning assessment, interdisciplinary graduate education, career outcomes for graduate students, professional doctorates, and international collaborations. In her paper she describes strategies and lessons learned from CGS projects, with a focus on two efforts: the Project for Scholarly Integrity (PSI) and a project on Modeling Ethics Education in Graduate and International Collaborations (NSF#1135345). She explains that the aim of the PSI was to define and develop a framework for a comprehensive institutional approach to research and scholarly integrity, and it was pilot-tested by six universities. The goal of the second and on-going project, she states, is to develop institutional modes for preparing graduate students for ethical challenges that arise in international research. She concludes that successful ethics education requires the engagement of institutional leadership to support the goals of individual programs and the incorporation of assessment in ethics education programs.

The second speaker was Brian Martinson, a senior research investigator and director for science programs at HealthPartners Institute of Education and Research (HPIER). His research has focused on research integrity and its relationship with organizational or institutional climates in academic research settings. He also serves on the National Research Council committee charged with revising the 1992 publication, *Responsible Science: Ensuring the Integrity of the Research Process*. In his paper Martinson details the importance of organizational climates in the success of science and engineering ethics education and describes a new assessment tool for evaluating the organizational climate on ethics, the Survey of Organizational Research Climate (SORC). He argues that scientists are susceptible to situational influences and that local organizational cultures can shape the behavior of scientists; the encouraging news, he suggests, is that these cultures are themselves susceptible to improvement through the actions of local organizational leaders.

Institutional Strategies for Effective Research Ethics Education:

A Report from the Council of Graduate Schools

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Introduction and Background on CGS Initiatives

For nearly a decade the Council of Graduate Schools (CGS), an organization devoted to advancing graduate education and research, has worked with US universities to enhance the preparation of graduate students for the ethical challenges and responsibilities of scholarship and research.[1] This work has responded to CGS member institutions' desire to effectively prepare graduate students to conduct research responsibly and to ensure the quality of research conducted at their institutions. CGS's collaborative research with member institutions is also motivated by recognition that the current research environment is creating new challenges for researchers. These include, to name only a few, increasing pressures to produce publications and quantifiable research outputs; the interlinking of research sectors (academic, commercial, government) that may have different expectations about the outcomes of research; and the globalization of research, which requires researchers to navigate different research norms and policies, and to identify situations where norms for research practice may not be transparent (CGS 2012b).

Since 2003 CGS has granted subawards to 22 universities (and worked with an additional 44 affiliate universities and colleges)[2] to create graduate education programs and resources for the responsible conduct of research (RCR). In 2004–2006, through a contract with the DHHS Office of Research Integrity (ORI), CGS worked with ten institutions to develop and test interventions and assessment strategies for the training of graduate students from the behavioral and biomedical sciences in the responsible conduct of research. The results of this project were published in *Graduate Education for the Responsible Conduct of Research* (CGS 2006). In 2006–2008, supported by a two-year grant from NSF, CGS worked with eight institutions to develop interdisciplinary programs in research ethics for students in science and engineering (S&E), a project that resulted in *Best Practices in Graduate Education for the Responsible Conduct of Research* (CGS 2009).

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[1] For an overview of CGS initiatives in the areas of research and scholarly integrity, see www.cgsnet.org/scholarly-integrity-and-responsible-conduct-research-rcr.

[2] Many affiliate universities chose to fund and implement part of their proposed projects. In addition, they joined project activities such as PSI discussions and CGS Annual Meeting and Summer Workshop sessions, and implemented institutional assessment activities using the common assessment tools developed for the project.

Building on the recommendations and lessons learned from these two initiatives and with funding from ORI, CGS launched the Project for Scholarly Integrity (PSI) in 2007.[3] The council worked first with an advisory committee and then with six US universities to define and develop a framework for a comprehensive institutional approach to research and scholarly integrity that was then pilot-tested by the six universities. A monograph on the project, *Research and Scholarly Integrity in Graduate Education: A Comprehensive Approach*, was published along with an online data dashboard (CGS 2012b).

This paper focuses on the institutional strategies used in these projects to develop (1) effective research ethics and RCR education programs on US campuses and (2) resources and tools that may be useful to both administrators and instructors in research ethics programs. Special attention is given to the lessons learned and best practices developed through the Project for Scholarly Integrity, offering successful models for communication and collaboration between graduate schools and other campus leaders and entities such as graduate program directors, college deans, directors of centralized RCR programs, research integrity officers, graduate student organizations, and other stakeholders.

Next, I share the goals of a current CGS project, Modeling Ethics Education in Graduate International Collaborations, funded by NSF's Ethics Education in Science and Engineering (EESE) program (NSF #1135345). This project may be of particular interest to both instructors and administrators of ethics education programs in science and engineering because it addresses a widely recognized gap in research integrity and ethics training for graduate students: the need to prepare graduate students at US institutions to manage the unique challenges and questions that arise in international research collaborations.

The terms "research integrity," "RCR," and "research ethics" are used throughout this paper, each in a specific way. "Research integrity" encompasses a broad range of positive attributes of researchers and institutions that are incorporated in programs, institutional processes, and training methods designed to instill aspirational qualities associated with honesty in research. "RCR" training, an important component of all institutional PSI projects, refers to the Office of Research Integrity's definitions of the term; however, in cases where RCR training was included in programs designed to promote positive qualities of researchers more broadly, "research integrity" is used. "Research ethics" is a broad term that has a variety of uses. In the Project for Scholarly Integrity, it refers to a definition frequently used by educators—the principles that help people adjudicate and make decisions when values may be in conflict. The CGS monograph on the Project for Scholarly Integrity provides more detailed definitions of these terms in the context of the project (CGS 2012b, pp. xvi–xix).

The Role of the Graduate School in Supporting Research Ethics Education

Graduate schools play an important role in fostering interdisciplinary, cross-campus collaboration in research ethics education. The previous CGS projects present examples of how graduate schools have effectively brought together multiple campus units and program faculty with complementary areas of expertise. Graduate deans have provided strong leadership and support in assessing vulnerabilities, identifying needs, and supporting the faculty-led development of curricula and activities targeted to meet those needs and vulnerabilities.

At many partner institutions, collaboration between graduate schools and research ethics and RCR programs have resulted in a hybrid program design. Resources and activities are distributed

[3] Information about the PSI is available online at www.scholarlyintegrity.org/ShowContent.aspx?id=78#.

between centralized sources, on the one hand, and program sources on the other, including coursework and in-lab activities. Such a distributed model of research ethics education provides students with both general and field-specific skills and knowledge, supports sustainability, and furthers campus integration.

The value of this hybrid design is supported by research that calls for closer attention to the role of institutional environments in supporting (or hindering) RCR and research integrity education.. In medical fields, the need to address the institutional systems that foster integrity is well established. In 2002, an influential Institute of Medicine report endorsed an "open-systems model" to conceptualize the dynamic relationship between the different elements of a research organization that contribute to a climate of integrity. The knowledge, attitudes, and behaviors of an institution's members are strongly tied to distinct aspects of organizational structure, such as mission, goals, and strategies for promoting research integrity, as well as the processes used to support those goals through strong leadership, communication, and socialization of members around this issue (IOM 2002).[4] Focusing on units of institutional culture in other S&E fields, Melissa Anderson has argued that greater attention must be given to the ways labs and research groups socialize and reinforce the ethical behaviors of their members, from students to senior scientists (Louis et al. 2007).

CGS projects have been successful because they leverage the support of graduate schools, which can promote culture change at the organizational level as well as in departments and programs where research and research training take place. The CGS experience suggests that this comprehensive, integrated approach to research ethics education is the most effective approach in terms of gaining the broad faculty input necessary to ensure relevance and meet student needs.

The Project for Scholarly Integrity

A Framework for Collaborative Action

The PSI was guided by a *Framework for Collaborative Action* (CGS 2008), developed by a planning committee tasked with identifying core components of an institutional approach to supporting and advancing research integrity in graduate education. The goal of the framework was to support programs that were comprehensive in scope, sustainable, and responsive to a broad range of needs and issues. In the context of the PSI, a "comprehensive" approach went beyond providing training programs that were isolated and/or not reinforced by graduate training in the disciplines.

The planning committee's five-part framework was intended to provide institutions with the flexibility to develop activities that were well suited to the needs of their graduate communities, while also creating a structure of collaboration that would encourage the exchange of ideas and promising practices among institutions. Each institution that submitted a proposal to CGS for funding developed a plan to:

1. *engage* the community in identifying needs,
2. *invite* campus stakeholders to reflect on a plan for action,
3. *act* on those reflections (put the plan into motion, implement project activities),
4. *communicate* to the broader community about activities and their ongoing impacts, and

[4] Thrush et al. (2007, 2011) have used IOM's model as the foundation of a climate survey instrument, a pilot version of which was adopted by all awardees for CGS's current PSI project and administered across all science and engineering fields.

5. *integrate* activities to ensure greatest impact and sustainability.

It is important to note that these steps did not always occur in sequence. For example, integration of PSI activities into program activities and existing university resources was a key part of many projects and was planned and executed throughout the projects, not necessarily as a final step.

Through a competitive award process, an external advisory committee chose six institutions to participate in the project as awardees:

- Columbia University
- Emory University
- Michigan State University
- Pennsylvania State University
- The University of Alabama at Birmingham
- The University of Arizona

The next sections highlight some of the successful strategies used by institutions in the first three areas of collaborative action.

Step One: Engage the Community in Identifying Needs

One of the central goals of the PSI project was to promote the recognition that research integrity is a topic that concerns all members of the graduate community—administrators, faculty researchers and supervisors, graduate students, RCR program directors, and beyond. Working in the context of the Framework, institutional awardees engaged a broad range of campus partners for frank discussions of campus needs. Two Framework principles guided their work: finding opportunities to recognize vulnerabilities in the graduate community and rewarding excellence in upholding high standards and value for research integrity.

Some of the most effective strategies for communicating with campus groups about the importance of research integrity reflected serious consideration of the specific goals of graduate education and the interests of graduate students and faculty. For example, (1) project messages were presented in academic, intellectual contexts, such as an invited speaker series or a faculty-led workshop on ethical issues in research, and (2) the relevance of PSI activities was communicated to specific disciplinary units or programs. These strategies helped institutions emphasize that research integrity requires high-level, learned skills and that it directly impacts the quality of research.

Step Two: Invite Campus Stakeholders to Reflect on a Plan of Action

While institutions used different approaches for organizing their campuswide activities, common strategies included appointing a planning or steering committee with a variety of representatives from across campus, appointing a project director, and creating neutral forums for discussion and evaluation.

Also key to this stage of the process was creating partnerships and alliances that could support the goals of the project in an ongoing way or at key points. Graduate deans and project staff used this stage to both reinforce existing relationships and create new ones. Their reach was quite broad, and included

- coordinators for professional development programs for faculty or students

- student and postdoctoral associations
- ethics centers
- research offices
- research integrity or compliance offices
- interdisciplinary research centers, and
- graduate student associations

These relationships provided a foundation for creating campuswide buy-in for the project and expanding project resources.

Step Three: Put the Plan into Motion (Implement Project Activities)

The implementation phase, focused on educational activities for graduate students, required thoughtful consideration on the part of all institutions. The monograph on the PSI project (CGS 2012b) addresses three concerns taken up by project awardees prior to and during this phase: (1) developing the right curricular content, (2) determining the sequencing of content and pedagogy, and (3) building collaborations to extend the reach of research integrity programs.

One model for curriculum development created by the University of Arizona established a small grants program that invited students to partner with faculty mentors to develop courses and lessons in research integrity. These grants not only provided opportunities for institutions to engage graduate students and faculty but also recognized excellence in research integrity education (awardees were acknowledged in a "Grantees Showcase" and contributed to an online campus repository of RCR resources).

Several other institutions developed required, hybrid programs for research integrity that were led both by faculty in the disciplines and by central research integrity programs. Examples of the ways in which institutions developed and sequenced content are discussed in detail in the CGS monograph (CGS 2012b).

PSI Assessment Activities

PSI awardees administered two assessment tools as part of their institutional projects: a Research Integrity Inventory Survey, which collected data on campus resources and activities, and a prevalidated version of the Survey of Organizational Research Climate (SORC) developed by Lauren Crain, Brian Martinson, and Carol Thrush, working in collaboration with a consortium of awardees composed of three institutions: Michigan State University, Pennsylvania State University, and the University of Wisconsin–Madison (Thrush et al. 2007, 2011). Institutions also worked independently to develop learning assessments appropriate to curricular activities on their campuses.

Findings from the PSI Research Integrity Inventory Survey

The PSI data confirmed findings from the earlier project (CGS 2009): there is a gap between the way program faculty perceive the training they are providing to students in research and scholarly integrity and the training that students say they are receiving.

S&E students receive information through a wide range of activities and resources, such as online training modules, required and elective courses in the program or graduate college, program courses that incorporate research ethics issues (e.g., research methods), orientation programs, workshops, seminars and speaker series. Among individuals responding to the Research Integrity Inventory Survey on behalf of 240 graduate programs or departments, nearly four of every five (78 percent) reported that students in their programs receive information on research ethics issues from advisors and mentors, whereas 50 percent or fewer reported that students receive this information through other means, such as coursework, workshops, or online and print materials. (When we analyzed data for physical sciences, engineering, and mathematics separately, respondents reported that students were three times more likely to receive information through advising and mentoring than through any other modality.)

In contrast, graduate students participating in focus groups for the project reported that they receive much of the information they need about research ethics and integrity from sources other than their advisors and mentors and that, depending on their supervisor, do not always find that the mentoring relationship provides adequate guidance on issues of research integrity.

In the context of international research, some students describe “trial by fire” situations in which collaborative or field research with international partners or in another country involves challenges that have been unanticipated by students’ research advisors in courses, supervision, or the grant project design.[5]

The PSI findings indicate a need to provide graduate students with multiple touch points for research integrity education. A second and more promising finding is that students are eager to receive this preparation. The institutions that participated in the PSI as awardees and affiliates indicate that students are very interested in research integrity education that is delivered both centrally and in departments, especially when these opportunities are tied to their professional development as researchers.

An in-depth analysis of the Research Integrity Inventory Survey and the climate survey, the methods used in administering them, and the assessment results can be found in Part III of *Research and Scholarly Integrity in Graduate Education* (CGS 2012b).

PSI Data Dashboard

As a companion to the PSI monograph (CGS 2012b), CGS has developed a Benchmarking Tool that enables member institutions to compare aggregate data collected by CGS from awardee institutions using data from the two surveys.[6]

Modeling Effective Research Ethics Education in Graduate International Collaborations: A Learning Outcomes Approach

CGS is conducting a project that will result in the development of institutional models for preparing graduate students to confront the broad range of ethical issues that typically arise in international S&E research and educational collaborations.

In April 2012, CGS invited US member institutions to submit proposals that address issues of research ethics and research integrity encountered in international S&E research collaborations and exchanges as well as joint or dual degree programs. The selection criteria encouraged these institutions to also address one or both of two priority areas: (1) those faced by graduate students conducting field research in international settings, and (2) those that international graduate students frequently encounter in US programs.

The project takes an innovative, “learning outcomes” approach to supporting the education and development of graduate students. Learning outcomes, a concept developed and refined in a

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[5] For analyses of PSI survey data and semistructured discussions with S&E students and faculty on multiple campuses, see CGS (2012b).

[6] Information about the dashboard is available online at www.cgsnet.org/benchmarking/best-practices-data/PSI-dashboard.

large body of Scholarship of Teaching and Learning (SoTL) research, are explicit statements of generic skills, abilities, and disciplinary competencies that a student is expected to have acquired by successfully completing a course, a program, or other activities including cocurricular experiences.

Through the research and educational activities of this project, CGS will engage faculty, experts, and universities in (1) defining the discrete knowledge, skills, and behaviors that are especially valued in the careers of scientists and engineers in their fields, and (2) using these desired outcomes to develop curricular content, assess student understanding, and improve educational programs. Such an approach will make it possible to address a well-documented gap in understanding of the outcomes of international research experiences. It will also improve knowledge of the effectiveness of research ethics education in an international context.

The project is intended to enhance the US S&E graduate community's understanding of the effectiveness of different approaches to integrating research ethics education in international collaboration and integrating international issues in research ethics programs. The project will result in three types of resources: (1) five model sets of learning outcomes that identify research ethics skills and abilities for graduate students in international collaboration, addressing issues typical of different disciplinary and international collaborative contexts; (2) at least five case studies that describe how these outcomes are being used to evaluate and enhance both research ethics education and international collaborations at the graduate level; and (3) an online repository of graduate learning outcomes for international collaborations. A CGS template for developing learning outcomes will be shared with US universities and offered for consideration and use to other CGS member institutions, along with a preliminary framework for incorporating a learning outcomes approach into graduate education. Five institutions have been selected to participate in the project: Emory University, Northern Arizona University, the University of Puerto Rico–Rio Piedras, the University of Oklahoma, and Virginia Tech.

Institutions and ethics instructors can find additional resources on the CGS website (under Selected Resources on Research Ethics Education in International Collaborations), organized into six broad categories: Research Ethics Issues in International Collaborations, Research Ethics for US Scholars Abroad, Research Ethics in Graduate Education, Research Ethics Education for International Graduate Students, Integrating and Assessing Research Ethics Education, and Other Resources.

Conclusion

In my overview of the CGS Project for Scholarly Integrity, I have highlighted several key ingredients of characteristics of successful institutional efforts to promote research ethics and RCR education at US institutions.

The first of these is engaging the leadership of institutions to support the goals of individual programs. (This is advice that graduate leaders not only recommended but also, in the context of individual PSI projects, practiced. For example, to gain broader support for their PSI initiatives, graduate deans engaged the office of their university president or the vice president for research.) Seeking the support of the graduate school and other university administrators has proven to be an effective way to generate campuswide support and to construct a thoughtful institutional strategy. A campuswide approach can also be critical to problem solving and overcoming obstacles that one campus program or unit cannot solve on its own, and to finding cost-effective solutions that pool the resources of different groups on campus.

Second, CGS and its project partners learned that assessment is a critical part of any sustainable and effective program in research integrity education. It is particularly important for engaging faculty in the disciplines, whose curricula, research practices, and mentoring habits have great power to reinforce (or undermine) the value of research integrity to their graduate students. *Research and Scholarly Integrity in Graduate Education* describes several examples of the ways in which institutions used results of the common assessment activities to initiate conversations with faculty about graduate student needs.

Program faculty clearly have an important role to play in any comprehensive approach to research ethics education, and it is important for universities to demonstrate the need for their direct engagement and disciplinary expertise.

References

CGS [Council of Graduate Schools]. 2006. *Graduate Education for the Responsible Conduct of Research.* Washington.

CGS. 2008. The Project for Scholarly Integrity in graduate education: A framework for collaborative action. Available online at www.cgsnet.org/ckfinder/userfiles/files/PSI_framework_document.pdf.

CGS. 2009. *Best Practices in Graduate Education for the Responsible Conduct of Research.* Washington.

CGS. 2012a. *Modeling Effective Research Ethics Education in Graduate International Collaborations: A Learning Outcomes Approach*. Washington.

CGS. 2012b. *Research and Scholarly Integrity in Graduate Education: A Comprehensive Approach.* Washington.

IOM [Institute of Medicine]. 2002. *Integrity in Scientific Research: Creating an Environment That Promotes Responsible Conduct*. Washington: National Academies Press.

Louis KS, Holdsworth JM, Anderson MS, Campbell EG. 2007. Becoming a scientist: The effects of work-group size and organizational climate. *Journal of Higher Education* 78(3):311–336.

Thrush CR, Vander Putten J, Rapp CG, Pearson LC, Berry KS, O'Sullivan PS. 2007**. "**Content validation of the organization climate for research integrity (OCRI) survey." *Journal of Empirical Research on Human Research Ethics* 2(4):35–52.

Thrush CR, Martinson BC, Crain AL, Wells JA. 2011. User's manual for the Survey of Organizational Research Climate. Available online at https://sites.google.com/site/surveyoforgresearchclimate/.

Note

This paper includes selected portions of the framework paper that guided the development of proposals to the EESE project, *Modeling Effective Research Ethics Education: A Learning Outcomes Approach* (CGS 2012a), a CGS report prepared for publication by Daniel Denecke and Julia Kent. The author would like to acknowledge the contributions of Daniel Denecke, PI for CGS's PSI and NSF EESE projects, and Jeffrey Allum, a coauthor of the PSI monograph, in the preparation of this paper.

Getting from Regulatory Compliance to Genuine Integrity: Have We Looked Upstream?

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Introduction

My goals for this paper are (1) to discuss the importance of organizational climates as an important backdrop for the success of science and engineering ethics practice and education, and (2) to describe a recently validated climate assessment tool, the Survey of Organizational Research Climate (SORC), that organizational leaders can use to assess their own local climates, to motivate, target, and inform efforts to cultivate integrity in their institutions.

Organizational self-assessment is one form of the "looking upstream" mentioned in the title of this paper. What does it mean to "look upstream" and why might this be helpful for institutional leaders wishing to foster and maintain the integrity of research in their institutions? Among other things, it means looking beyond the individual researcher or scientist to understand the contexts in which they operate. It also implies that efforts to educate individuals in the responsible practice of research, by themselves, represent an incomplete and inadequate response. Some context may help to illustrate the idea.

Let's consider the following propositions from the 2010 report of the Council of Canadian Academies (Council of Canadian Academies and the Expert Panel on Research Integrity 2010, p. 48, Box 3.2):

- Fabrication or falsification of data and plagiarism (FF&P) are rare but serious threats to the integrity of research and represent scientific misconduct as defined by the US government (OSTP 2000);
- Eradicating FF&P is primarily a matter of quickly catching and sanctioning individual "bad apple" researchers who engage in such behavior; and
- This is the primary means of ensuring integrity in research.

Just 25 years ago these statements would have been largely uncontroversial among most leaders of the US science community. That FF&P represent federally defined research misconduct is merely a statement of fact. However, can the assertion of the rarity of such behavior or the subsequent propositions be taken at face value? While some in the science community today would still readily endorse each of these propositions as factual, the accumulation of experience and evidence over the past 25 years has raised questions about their veracity.

Now let's consider a completely unrelated but parallel set of propositions, again from the Council of Canadian Academies report:

- Mesothelioma is a rare but serious type of cancer that often affects the lung;
- Eradicating this type of cancer is primarily a matter of quickly identifying and treating (through surgery, radiation, and chemotherapy) "bad" or damaged mesothelial cells; and
- This is the primary means of ensuring lung health.

While the first proposition here seems incontrovertible, cancer researchers, those familiar with epidemiology, and others will quickly recognize that the second and third statements miss some important factors and should not be taken at face value. These propositions assert a tertiary prevention approach to dealing with mesothelioma that completely overlooks primary and secondary prevention efforts. One can choose to see mesothelioma as a problem of damaged cells in isolation from the systems of which they are a part, but such a limited perspective does not help at all in terms of understanding the etiology, causes, or prevention of such cell damage. One specific problem with this approach is that it misses the fact that environmental exposure to asbestos is a well-established risk factor for mesothelioma. It also misses threats to lung health other than mesothelioma.

A more comprehensive approach to ensuring lung health would include primary prevention efforts, such as population surveillance and screening, as well as reduced exposure to asbestos, tobacco smoke, and other airborne particulates, and would address threats to lung health other than mesothelioma. In other words, an appropriate understanding and response to ensuring lung health requires that one "look upstream" to understand the systemic aspects of the problem, attending to causally implicated environmental exposures and how they might be avoided or mitigated. Once diagnosed, the proper treatment of mesothelioma remains important, but in itself, without the application of other appropriate preventive measures, is an entirely insufficient approach to ensuring lung health more broadly.

In very much the same way, an appropriate understanding of integrity in research and actions to ensure it require that we look upstream. Guarding vigilantly against malfeasant individuals involved in the research process and properly handling cases of FF&P when they are discovered are clearly worthy endeavors—but in themselves insufficient to ensuring integrity in research. In this context, looking upstream means attending to relevant environmental exposures including the social, psychological, and economic conditions in and around the organizations in which researchers work.

One can consider the character of an organization in terms of its ethical culture or climate. In common usage when discussing organizations, the terms culture and climate are often used haphazardly and without clear definition. Yet the nature and meaning of these overlapping, but distinct concepts has been studied and hotly debated for more than 50 years among students of industrial/organizational psychology, and organizational behavior (Landy and Conte 2010). This is not the place to plumb the depths of this conversation, but briefly, in my use of the term organizational climate, I primarily have in mind what Schein would refer to as the first level of organizational culture—the visible organizational structure and processes that represent "artifacts" of the organizational culture (Schein 1991), which itself represents shared but underlying and often unspoken patterns of values and beliefs held by organizational members.

Having started by identifying US government–defined scientific misconduct, it is also useful to briefly consider what we mean by the term "research integrity." I posit that, just as lung health is about more than the absence of mesothelioma, integrity in research must encompass more than just the absence of a small but pernicious set of behaviors (FF&P). One useful definition comes from a 2010 report of the Irish Council for Bioethics (p. 6):

> upholding standards in research refers to the application of particular ethical (and personal) values. Values that cannot, and should not, be separated from the research enterprise. Taken collectively, these core values encompass the concept of research integrity.…

Until fairly recently, the concept of "research integrity" had been largely defined in terms of its absence, with no real consensus statements about what the core values are that encompass the concept. That changed in October 2010 when no fewer than three largely independent but overlapping definitions appeared nearly simultaneously on the world stage. One comes from the report of the Irish Council for Bioethics cited above, *Recommendations for Promoting Research Integrity* (Irish Council for Bioethics, Rapporteur Group 2010). The second comes from a report, also referenced above, of the Council of Canadian Academies, *Honesty, Accountability and Trust: Fostering Research Integrity in Canada* (Council of Canadian Academies and the Expert Panel on Research Integrity 2010). The third definition, from the Second World Conference on Research Integrity, held in Singapore in July 2010, is called *The Singapore Statement on Research Integrity* (Steneck and Mayer 2010). More recently, a fourth definition was put forth by the InterAcademy Council of the InterAcademy Panel, in their November 2012 report, *Responsible Conduct in the Global Research Enterprise: A Policy Report* (InterAcademy Council and IAP 2012). All four definitions are grounded in a statement of core values or principles, all of which will be recognized as values that would be endorsed by most reasonable people as being fundamental.

- From the Irish Council of Bioethics: *Honesty, Reliability and accuracy, Objectivity, Impartiality and independence, Open communication, Duty of care, Fairness, and Responsibility for future science generations*
- From the Council of Canadian Academies: *Honesty, Fairness, Trust, Accountability, and Openness*
- From the Singapore Statement on Research Integrity: *Honesty, Accountability, Professional courtesy and fairness, Good stewardship*
- From the InterAcademy Council report: *Honesty, Fairness, Objectivity, Reliability, Skepticism, Accountability, Openness*

Beyond brief definitions of the listed values, each source identifies best practices that, if observed diligently, represent its specific vision of science conducted with integrity. In each case, these practices are directed largely toward individual scientists and researchers. Importantly, however, each source, to a greater or lesser extent, also identifies institutional responsibilities for ensuring the integrity of research. The 2012 report of the InterAcademy Council provides the most fully articulated list, with specific responsibilities identified for multiple institutional entities, including universities and other research institutions; public and private sponsors of research; and professional societies, journals, national academies of science, and interagency entities (InterAcademy Council and IAP 2012).

With these values in mind, as we define the state of ideal "health" for the science enterprise, we must look upstream to consider the systemic and local institutional factors that influence the extent to which the behavior of scientists evinces such health.

Looking Upstream

So, what *can* leaders of universities and other research institutions do to focus locally on factors that influence the integrity of science? For this we need to consider the local institutional climates within which scientists work. A useful resource for guidance in such an effort is the 2002 US Institute of Medicine (IOM) report, *Integrity in Scientific Research: Creating an Environment That Promotes Responsible Conduct*, to which I will refer as the 2002 IOM report.

The 2002 IOM report explicitly recognized the role of the local environment—the lab, the department, the university—in shaping the behavior of scientists. This is important because, unlike structural issues, the local organizational environment is something over which institutional leaders *do* have some authority and influence. Moreover, as I stated at the outset of this paper, I believe that the organizational settings and climates within which science and engineering ethics education takes place are key to the success of such an endeavor.

The 2002 IOM report promoted a performance-based, self-regulatory approach to fostering research integrity and made several specific recommendations to institutions seeking to create environments that promote responsible research conduct and foster integrity:

(1) establish and continuously measure their organizational structures, processes, policies, and procedures;

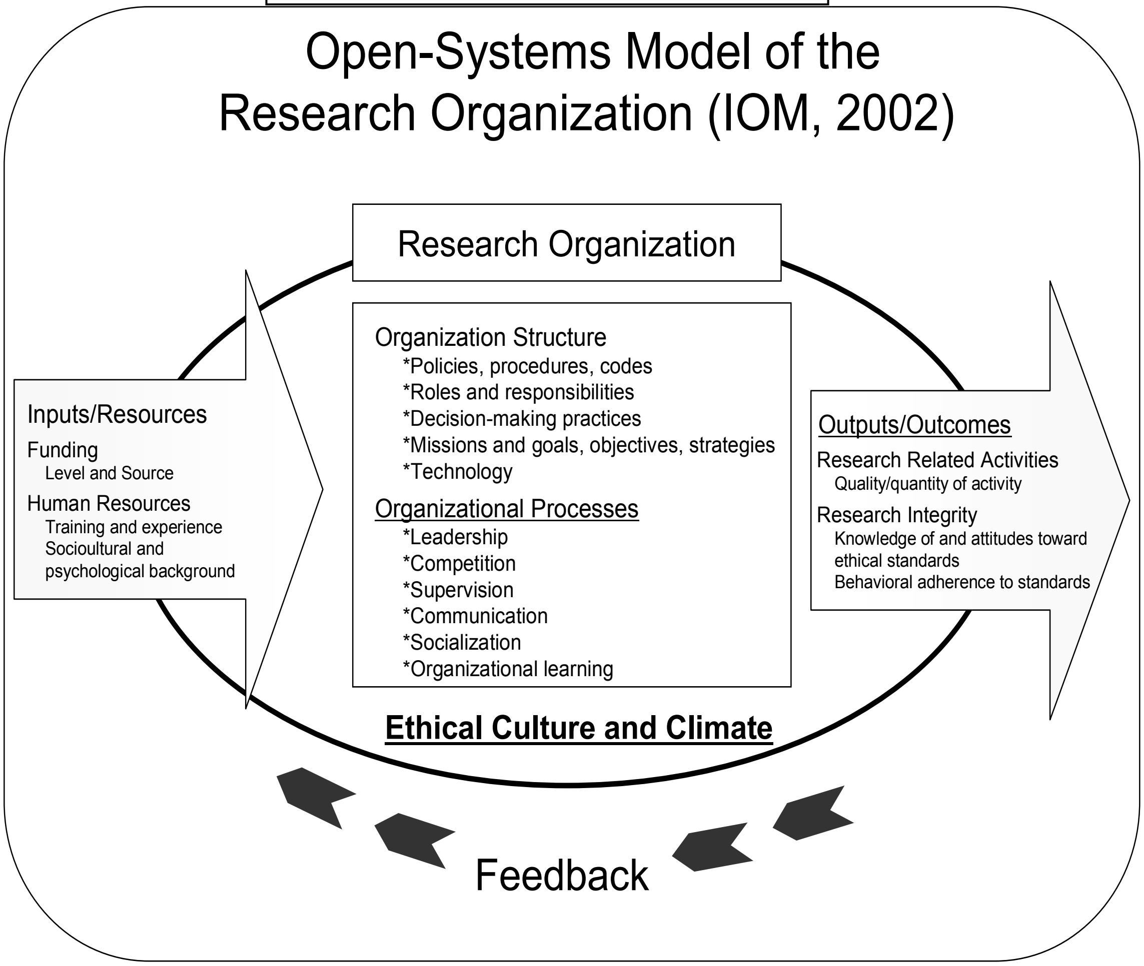
(2) evaluate the institutional environment supporting integrity in the conduct of research; and

(3) use the knowledge gained for ongoing improvement efforts.

These recommendations, along with the conceptual model at the heart of the 2002 IOM report, provide the primary basis and rationale behind the climate assessment tool I describe below, the Survey of Organizational Research Climate, and recommendations my collaborators and I have made for its use in a reporting and feedback system to organizational leaders.

Chapter 3 of the 2002 IOM report includes a conceptual diagram (p. 51) that describes the "open systems model" of the research organization. This model explicitly acknowledges that what happens in organizations is in part a function of the inputs and resources available to them but that an organization's outcomes and outputs—including the quality and integrity of the researchers and their research products—are also a function of the character of the organization itself. The IOM diagram (Figure 1) illustrates a dynamic system that has at its center the climate and culture of the research organization itself. This system takes inputs from the outside world (in the form of human resources, funding stream sources and levels, etc.) and its outputs take the form of both researchers and research-related activities, including the quality of both. I find this framing particularly helpful because it signals to organizational leaders that research integrity, and efforts to ensure it, are key indicators of the quality of their products, not merely boxes to check off to satisfy regulatory compliance requirements. The IOM conceptual framework thus draws attention to the central importance of organizational climates, in terms of structures, processes, policies, and practices.

FIGURE 1 IOM Conceptual Model



Assessment and Feedback Are Effective Mechanisms for Promoting Organizational Change

Since the publication of the IOM report on patient safety in health care, *To Err Is Human* (Kohn et al. 2000), extensive discussions and ongoing initiatives have aimed to shift the practice of medicine away from a culture of "shame and blame" and to create a culture of patient safety in medicine, particularly in hospital settings. Clear parallels exist between such patient safety initiatives and efforts to promote ethical climates in organizations (Fryer-Edwards et al. 2007; Sexton et al. 2006; Dyrbye et al. 2010; Wasserstein et al. 2007).

In a 2010 commentary, Dr. Lucian Leape makes the case for and against three methods for encouraging hospital engagement in safer practices to avoid infections (Leape 2010): *regulation and accreditation*, *financial incentives*, and r*eporting and feedback*. He identifies *reporting and feedback* as the most potent of these, with more equivocal benefits for the other methods. Leape presents the National Surgical Quality Improvement Program (NSQIP), pioneered by the Department of Veterans Affairs in the 1990s, as an excellent example of how such a reporting and feedback system improved clinical care in the VA. In this system, the VA gathered information on the performance of surgical services that was then summarized into self- and comparative performance reports and fed back to the VA surgical services to inform surgeons about their own absolute performance as well as their performance relative to other surgeons. Changes resulting from this process included large improvements in below-average units and systemwide declines in complication and mortality rates (Leape 2010).

I believe that applying this kind of reporting and feedback process can be similarly effective for promoting improvements in research integrity climates at universities and other research institutions. A key distinction is that, unlike the methods focused on compliance with external regulatory forces, such as regulation, accreditation, or the use of financial incentives, the type of reporting and feedback system I propose is grounded in generating the knowledge and motivation that will support genuine self-regulation in organizations.

A Tool for Organizational Self-Assessment: The Survey of Organizational Research Climate (SORC)

At the time of the 2002 IOM report, no gold-standard measures of institutional environments existed to facilitate a proactive, self-regulatory approach to research integrity. Beginning in 2006, partly in response to the IOM report, Carol Thrush and colleagues began developing a survey-based instrument based largely on the IOM's conceptual framework (Vander Putten and Thrush 2006; Thrush et al. 2007). My own collaboration with Dr. Thrush began shortly thereafter, and our subsequent work has led most recently to the development and validation (content, criterion, and predictive validity) of the Survey of Organizational Research Climate, which measures key institution-level factors to deal with threats to research integrity (Martinson et al. 2012; Crain et al. 2012).

The SORC is a self-assessment tool for organizations to gauge employee perceptions of responsible research practices and the state of an organization's research climate. It is appropriate for use in a broad range of fields/disciplines and across multiple positions (e.g., graduate students, postdoctoral fellows, faculty, research scientists). The SORC provides institutional leaders with both baseline assessments of the research integrity climate and metrics to assess aspects of climate that are mutable and/or subject to change in response to organizational change initiatives aimed at promoting research integrity. By focusing on measurement of organizational structures and processes, the SORC is distinct from other recent efforts to measure "ethical work climates," which have focused primarily on tapping the moral sensitivity and motivations of organizational members (Arnaud 2010).

Our primary validation of the instrument was conducted with a sample of faculty and postdocs from academic medical centers at 40 top-tier research universities in the United States. Secondary, external validation data are from the Council of Graduate Schools' Project on Scholarly Integrity, for which a preliminary, prevalidated version of the instrument was used to assess the research integrity climates of seven participating universities (see paper by Julia Kent in this publication).

The SORC consists of seven subscales to assess mutable aspects of universitywide and department-specific climates that might be targeted for change:

- quality of regulatory oversight activities by institutional review boards (IRBs) and institutional animal care and use committees (IACUCs) (3 question items)
- quality and availability of resources pertaining to the responsible conduct of research (RCR) (6 items)
- extent to which research integrity norms exist in departments/centers (4 items)

- extent to which activities take place to socialize researchers into these norms (4 items)
- quality of advisor-advisee relations (3 items)
- reasonableness of research productivity expectations in departments/centers (2 items)
- extent to which factors in the local environment may inhibit research integrity (6 items)

The instrument is sufficiently short (32 question items total) that it can be used in its entirety or, if there are particular areas of interest, specific subscales can be selected for use. The survey measures individual perceptions of responsible research practices and conditions in local environments, as illustrated in the following sample questions:

- How committed are the senior administrators at your university (e.g., deans, chancellors, vice presidents) to supporting responsible research?
- How consistently do administrators in your department (e.g., chairs, program heads) communicate high expectations for research integrity?
- How effectively are junior researchers socialized about responsible research practices?
- How effectively do the available educational opportunities at your university teach about responsible research practices (e.g., lectures, seminars, web-based courses)?
- How respectful to researchers are the regulatory committees or boards that review the type of research you do (e.g., IRB, IACUC)?
- How true is it that people in your department are more competitive with one another than they are cooperative?

The measures themselves do not inform us about individuals' behavior or performance, but from our validation study we know that the measures of climate correlate as expected with self-reported measures of research-related behavior ranging from the ideal to the undesirable (Crain et al. 2012). Moreover, by aggregating individual responses in organizational subunits (e.g., departments), the SORC enables meaningful assessments of group-level perceptions of an organization's environmental conditions.

Feedback of SORC Data to Organizational Leaders

In keeping with the notion that this reporting and feedback system is designed for "internal consumption" of the information, after the collection of responses to the SORC instrument from the appropriate segments of their organizational membership, the data must be summarized and set up for feedback to department chairs, deans, program leaders, and others in organizational leadership positions. Given competing demands on their time and attention, it is important to summarize the data in readily digestible formats. Appropriate aggregation of data by organization and organizational subunit is also necessary to protect the identity of individual respondents.

Table 1 provides an example of a "dashboard" report that might be used to convey the survey results. In this example, we obtained responses from 16 members of department "A," which has been anonymized with respect to both institution and field of study. The rows display the seven climate scales and a score for global climate of integrity. The columns show the department's average scores on the SORC scales and its percentile ranking, providing comparative data for this department relative to others in this institution. The four columns in the right-hand panel of the table present further comparative data, with the relative climate scores for this department compared to the scores of others aggregated across multiple universities.

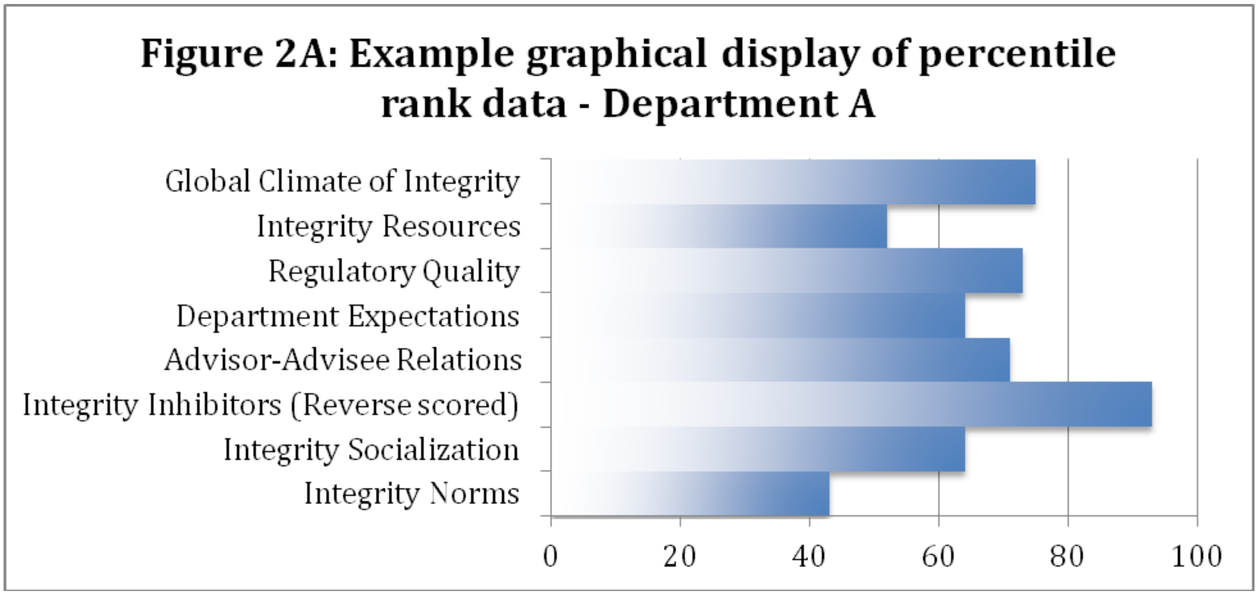
TABLE 1 Example summary report for anonymous "Department A"

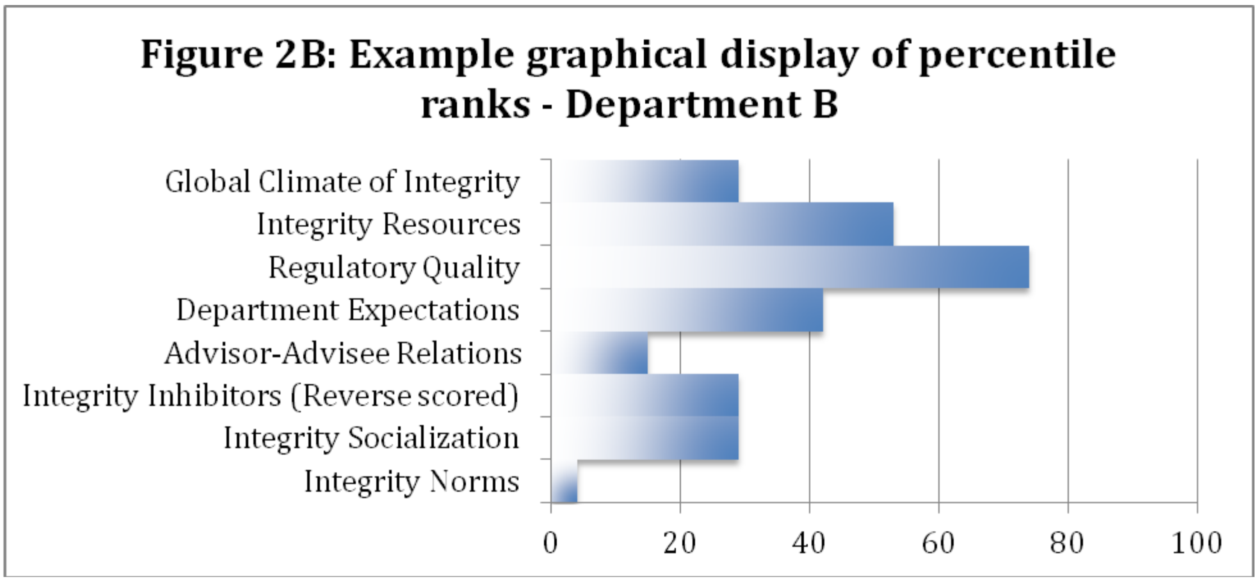
Graduate Program:	**Department A**			Field of Study:			
N of Cases:	**16**			Broad Field of Study:			
	Your Department's Results			**Comparative Results (Relative to Avg)**			
Integrity Climate Scales	Average Score	Percent ≥ 4.5 (Scale of 1-5)	Program's Percentile Rank	All Depts 75th Percentile	Field of Study Average	Broad Field Of Study Average	University Average
Integrity Norms	4.15	16.7%	43	4.28	4.15	4.17	4.17
Integrity Socialization	3.63	15.4%	64	3.73	3.63	3.50	3.52
Integrity Inhibitors	4.42	54.5%	93	4.16	4.42	4.03	3.94
Advisor-Advisee Relations	4.04	21.4%	71	4.06	4.04	3.89	3.90
Departmental Expectations	4.00	35.7%	64	4.04	4.00	3.70	3.83
Regulatory Quality	3.90	28.6%	73	3.91	3.90	3.72	3.72
Integrity Resources	3.43	33.3%	52	3.63	3.43	3.43	3.42
Global Climate of Integrity	4.47	60.0%	75	4.47	4.47	4.26	4.34

Ultimately, we envision a national data repository that would accumulate anonymized data from a large number of institutions, thereby allowing more tailoring of data such that a university or department could receive comparative data specific to similar organizations; for example, a Tier 1 research university might best be compared to other Tier 1 research universities, and a department of chemistry is most appropriately compared to the aggregation of other departments of chemistry.

In addition to the numeric presentation of these data, some leaders may prefer a more graphical/visual presentation of the information. Figure 2 gives such a visually oriented presentation of the percentile-based comparative data for Department A (Figure 2A), as presented in Table 1, and for another anonymized Department B (Figure 2B), whose percentile rankings differ substantially from those of Department A.

Among the valuable aspects of this kind of feedback is the fact that a given organization receives tailored information not only about which aspects of climate are particularly strong or weak for their institution overall but also about which organizational subunits are particularly strong or weak. Such information can help organizational leaders expend their efforts to support research integrity with some specificity and intentional targeting—as opposed to implementing blanket policies or practices that may be both more expensive and less effective. Moreover, to further facilitate such targeting, if an organizational unit scores very low or very high on a particular scale, the leader of that unit can obtain the summary data, appropriately aggregated to protect individual anonymity, for the individual question items comprising that scale.





Conclusion

Misbehavior in science has typically been interpreted as a failing of the individual. But scientists don't behave in a void and are not immune to the influence of the situational imperatives of their positions in the structures of the science enterprise. And while structural and cultural reforms may be needed to address the root causes of a variety of undesirable behaviors, it seems clear that the local organizational climate is an important influence on researchers, and one that is subject to influence by local organizational leaders. Tools are increasingly available to assist organizational leaders in creating and sustaining local research environments that evince genuine research integrity, not just regulatory compliance. Have you looked upstream?

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References

Arnaud A. 2010. Conceptualizing and measuring ethical work climate: Development and validation of the Ethical Climate Index. *Business & Society* 49(2):345–358. doi:10.1177/0007650310362865.

Council of Canadian Academies and Expert Panel on Research Integrity. 2010. *Honesty, Accountability and Trust: Fostering Research Integrity in Canada*. Ottawa, ON. Available online at www.scienceadvice.ca/uploads/eng/assessments%20and%20publications%20and%20news%20releases/research%20integrity/ri_report.pdf.

Crain AL, Martinson BC, Thrush CR. 2012. Relationships between the Survey of Organizational Research Climate (SORC) and self-reported research practices. *Science and Engineering Ethics*. Published online (October 25): 1–16. doi:10.1007/s11948-012-9409-0.

Dyrbye LN, Massie FS, Eacker A, Harper W, Power D, Durning SJ, Thomas MR, Moutier C, Satele D, Sloan J, Shanafelt TD. 2010. Relationship between burnout and professional conduct and attitudes among US medical students. *JAMA* 304:1173–1180. doi:10.1001/jama.2010.1318.

Fryer-Edwards K, Van Eaton E, Goldstein EA, Kimball HR, Veith RC, Pellegrini CA, Ramsey PG. 2007. Overcoming institutional challenges through continuous professionalism improvement: The University of Washington experience. *Acad Med* 82:1073–1078.

InterAcademy Council and IAP. 2012. *Responsible Conduct in the Global Research Enterprise: A Policy Report*. Amsterdam.

IOM [Institute of Medicine]. 2002. *Integrity in Scientific Research: Creating an Environment that Promotes Responsible Conduct*. Washington: National Academies Press. Available online at www.nap.edu/openbook.php?isbn=0309084792.

Irish Council for Bioethics, Rapporteur Group. 2010. *Recommendations for Promoting Research Integrity*. Dublin: Irish Council for Bioethics. Available online at http://irishpatients.ie/news/wp-content/uploads/2012/04/Irish-Council-of-Bioethics-Research_Integrity_Document.pdf.

Kohn LT, Corrigan JM, Donaldson MS, eds. 2000. *To Err Is Human: Building a Safer Health System*. Washington: National Academies Press.

Landy FJ, Conte JM. 2010. *Work in the 21st Century: An Introduction to Industrial and Organizational Psychology*. New York: Wiley.

Leape LL. 2010. Transparency and Public Reporting Are Essential for a Safe Health Care System. The Commonwealth Fund. Available online at www.commonwealthfund.org/Publications/Perspectives-on-Health-Reform-Briefs/2010/Mar/Transparency-and-Public-Reporting-Are-Essential-for-a-Safe-Health-Care-System.aspx#citation.

Martinson BC, Thrush CR, Crain AL. 2012. Development and validation of the Survey of Organizational Research Climate (SORC). *Science and Engineering Ethics*. Published online (October 25): 1–22. doi:10.1007/s11948-012-9410-7.

OSTP [Office of Science and Technology Policy]. 2000. Federal Policy on Research Misconduct. Available online at www.ostp.gov/cs/federal_policy_on_research_misconduct.

Schein EH. 1991. What Is Culture? In *Reframing Organizational Culture*, ed. Frost PJ, Moore LF, Louis MR, Lundberg CC, Martin J. pp. 243–253. Newbury Park, CA: Sage Publications.

Sexton JB, Helmreich RL, Neilands TB, Rowan J, Vella K, Boyden J, Roberts PR, Thomas EJ. 2006. The safety attitudes questionnaire: Psychometric properties, benchmarking data, and emerging research. *BMC Health Serv Res* 6:44.

Steneck N, Mayer T. 2010. Singapore Statement on Research Integrity. Drafted at the Second World Conference on Research Integrity, July 21–24, Singapore. Available online at www.singaporestatement.org/.

Thrush CR, Vander Putten J, Rapp CG, Pearson LC, Berry KS, O'Sullivan PS. 2007. Content validation of the Organizational Climate for Research Integrity (SORC) Survey. *Journal of Empirical Research on Human Research Ethics* 2:35–52.

Vander Putten J, Thrush CR. 2006. Organizational culture for research integrity in academic health centers." In *Office of Research Integrity 2006 Conference on Research Integrity*. Tampa, FL.

Wasserstein AG, Brennan PJ, Rubenstein AH. 2007. Institutional leadership and faculty response: Fostering professionalism at the University of Pennsylvania School of Medicine. *Acad Med* 82:1049–1056.

Discussion

The discussion began with questions about redundant efforts (both in the structure and process) in organizational cultures that can address ethics issues or compensate for a lack of ethics education. An example of redundant efforts would be high quality regulatory oversight at institutions, such as IRBs, combined with easily available resources on RCR, such as resources listed on a lab webpage, and also good advisor-advisee relationships that allow for questions and discussions about ethical conduct. The idea of redundancy being built into a system is familiar in engineering and has also been used in medicine recently to prevent errors. Heather Canary observed that Martinson's assessment tool seemed to be able to measure the amount of redundant efforts or redundancy in organizational culture because of how it was set up to examine content domains that reflect the organizational redundancies in the process and/or structure. Martinson agreed and noted that that there is also some redundancy built in to what the SORC assessment tool measures.

Discussion also focused on inhibitors of cultural research integrity, such as institutional or professional pressures like requirement for high publication in prestigious journals. Martinson mentioned an article by Joshua M. Nicholson and John P.A. Ioannidis titled "Research Grants: Conform and Be Funded" (Dec. 6, 2012, *Nature* 492:34–36), which he said reveals some systemic problems in science that could result in misconduct. He suggested that publication pressures like those described in the article can lead to cynicism and desperation, factors which can inhibit research integrity.

Sara Wilson asked if institutional climate changes would be more effective than traditional RCR education in reducing incidents of misconduct or if the two methods were complementary. Martinson responded that the assessment research has not been done yet to answer the question, but that he thought it was not an "either/or" question, rather the two are integrally related.

Rachelle Hollander noted that the interpretation of Martinson's data seemed to suggest that the departments in institutions are the most influential variable for changing behavior and for achieving effective ethics education. She then asked what approaches would target departments and whether departments should be targeted to create institutional change. Martinson responded that institutional leaders—deans, chairs, and heads of labs—are crucial and that, when they have assessment data showing how they compare with other institutions, they are in the position to make changes in very specific areas of the institutional culture. C.K. Gunsalus reinforced this point, saying that having validated data about a specific institution is a very important step in enabling or at least encouraging organizations and leaders to make changes. She also noted that there is a robust literature on organizational climates and changes in them that could assist in efforts to change the ethics culture at academic institutions.

5

Final Discussion

The goal of the concluding session of the workshop was for participants to identify practical guidance on ethics education for faculty and administrators. To facilitate discussion the participants were asked about the goals and objectives of ethics education, institutional efforts, and assessment. They were also asked to identify examples of successful practices and efforts.

Goals and Objectives of Education

The wrap-up discussion began by addressing a key question of the workshop: What should be the goals and objectives for ethics education? Michael Kalichman observed that the papers presented at the workshop had outlined the current goals and objectives of RCR education, and that they varied widely. He suggested that it would be almost impossible to achieve all of the goals and objectives discussed.

Julia Kent pointed out that the principles that guide the development of both RCR and research ethics education are also important, and she articulated six principles for ethics education efforts more generally: (1) education should be both broad and discipline specific, (2) it should be appropriate to the student's stage of study and appropriately sequenced, (3) it should be outcome oriented in the area of learning assessment, (4) it should be "reverse engineered" so that the outcomes meet the goals, (5) the outcomes should be made explicit to students, and (6) the education should be flexible to accommodate different career paths.

Institutional Responsibility

Robert Nerem agreed with Kent's call for guiding principles, and emphasized their importance to an organization's culture. Kent responded with three key elements to successful institutional interventions to improve the ethical culture: (1) institutional leadership at the very top, (2) collaborative ethics education, and (3) evidence-based ethics education.

Kalichman proposed that one "guiding principle" should be for ethics education to have an impact on the institution as a whole, emphasizing that the focus should be not just on the individual but rather on the community.

Joe Herkert observed a tension he often perceives between faculty in the humanities and in the sciences over who should have the authority to teach ethics in science and engineering, so he argued a successful program needs an institutional climate that supports collaborative ethics education.

Kent proposed that institutions think about how faculty might be rewarded for good mentoring and ethics education, because the current institutional culture and tenure process do not reward those efforts. Stephanie Bird seconded this call and added that it was important to have faculty and postdocs model the correct behavior. Carl Lineberger suggested that one goal should be to define very clearly the hierarchy of responsibilities in an institution relating to RCR, and that those in a position of authority had a responsibility to imbue students and colleagues with the concepts of RCR.

Standards and Comparisons

Building on the subject of institutional culture and Kent's and Kalichman's descriptions of how their research compares institutions, the discussion turned to the possibility of educational standards or a framework that would span institutions. Michael Davis introduced this idea when he said that universities these days are in the business of creating research and researchers, and that if both could earn an integrity stamp they would be more marketable. He suggested that the assessment methods described by Kent and Kalichman might be used to establish the elements of a technical standard in which institutional climate and processes could be assessed and, if they met the requirement, awarded a certificate. Kent demurred, saying she was wary of any attempts to use the CGS assessment tools as certifications or stamps of quality. But she did note that the ultimate goal of the CGS project was to lay out a framework for evaluating the climate and identifying best practices at an institution, while also giving individual institutions benchmarks for comparison with other institutions. The CGS provides online tools and information on benchmarking (www.cgsnet.org/benchmarking).

Brian Martinson partially agreed with Davis's idea about certificates because they could get institutions to compete with each other over their culture on ethics and their ethics education efforts. However, he noted that research and assessment are still focused inward with the goal of giving institutional leaders the information they need to lead change, and not yet on having institutions compare themselves. Deborah Johnson concurred that it was a good idea to bring to light how institutions compare but said she would not support a certification process because of problems associated with it, such as gaming the system.

Life Long Learning and Decision-making Skills

Returning to the goals and objectives of ethics education, Kalichman argued that good ethical decision-making skills should not be *the* goal of ethics training but rather a side effect of the better goal of increasing people's willingness and ability to have conversations about ethical challenges of conducting research. Sara Wilson argued that it is not possible to teach students everything they need to know to be responsible engineers, they should instead be taught to be lifelong learners of ethics and social responsibility, and they should learn to continue to engage themselves in ethical questioning and discussion. She called for the creation of institutional environments that foster such discussion. Bird added that students should be encouraged, persuaded, and taught to think in the larger context about the implications and circumstances of cases they study in the classroom.

Herkert noted that understanding how to go about solving ethical problems is a very important skill that engineering students will need in their careers. Kalichman acknowledged that undergraduates need more guidance on decision making, but stood by his earlier statement. He clarified that he was not suggesting that case studies not be discussed or that teachers not explicitly describe how one analyzes cases; rather, he objected to an approach to ethics education that tells students they are not skilled at dealing with ethical challenges and must be taught to be ethical..He argued that this approach was a bad place to start with students, but that it could be turned around by reframing ethics education by telling students that we want to talk about some ethical challenges they are likely to face and that this is part of being a good scientist.

Framing Ethics Education

Ronald Kline echoed Kalichman's point about framing the education so that the ethics component is part of being a good scientist or engineer. He also argued that it is not possible to separate the individual from the climate because individuals create the climate. He added that ethics needs to be taught in a way that incorporates good practice, which includes social responsibility in addition to the traditional RCR training.

Johnson also agreed with Kalichman, adding that if ethics is framed as separate from science and engineering we risk losing the bigger battle, which is to have people understand that ethical practices are an integral part of research and engineering. She also suggested "good science" might be a better term than "research ethics" or "research integrity." Davis countered that "good science" might not be an effective term because research that advances the field might be good but it could have negative societal implications, such as research on chemical poisons. Kline liked the idea of using "good science" instead of RCR because the word "conduct" excludes social responsibility, although in response to Davis's concern about the term "good science" he suggested "responsible science" and "responsible engineering." Martinson pointed out that "research integrity" is already in use and that it leaves space for social responsibility to be included, so "integrity in research" or "integrity of research" might be viable terms. Bird and C.K. Gunsalus preferred "responsible science" and "responsible engineering" because these terms have good connotations and promote the idea of lifelong learning in ethics.

Johnson urged the group to seriously consider Kalichman's argument that teachers focus not on ethical decision making but on improving the willingness of students to engage in ethical conversation. She endorsed this approach because it focuses on making a space for ethics as an appropriate topic for active study and exploration, and thus is in harmony with the idea that ethics is part of science and engineering.

Two additional suggestions were made regarding the improvement of ethics education. Johnson, contending that liberal arts education was an important part of ethics education strategies, called for an update of the liberal arts curriculum to address current issues in science and engineering ethics. Nerem added that science and engineering textbooks might also be updated to include a historical perspective on the two fields and to bring to light ethical dilemmas associated with particular engineering projects or research.

Goals and Objectives of Assessment

The discussion moved to consideration of the goals and objectives of assessment of ethics education. Michael Loui noted that a good ethics education assessment, with both qualitative and quantitative data, is crucial in determining whether educational and cultural interventions were successful. He noted that there is not much research on the effectiveness of classroom interventions because it cannot be done ethically as a controlled experiment and thus is fraught with uncertainties in the assessment process.

Heather Canary reiterated this point and described some examples of qualitative methods. One method involves asking students what they felt were some of the most effective—and ineffective—methods for addressing ethics and social responsibility. Based on her research, Canary said that students liked having multiple ways that they could engage in issues, so she suggested that teachers use mixed pedagogical methods. Loui added that open-ended qualitative questions could reveal unintended outcomes of the education; for example, what did students remember from the class, what were the takeaway lessons, and what were the high points?

Examples of Successful Educational Efforts

The discussion concluded with examples of successful educational efforts and methods for impacting institutional culture. Gunsalus described interdisciplinary efforts with faculty in the sciences at the University of Illinois at Urbana-Champaign (UIUC) to demonstrate that responsible work takes significant effort and practice. The UIUC guidance for faculty on teaching research ethics focuses on problem identification, resources for resolving problems, and differentiation between ethics and compliance. She made clear that the UIUC faculty guidance does not entail focusing on a range of topics that must be covered but on modeling good behavior and ensuring that informal practices match the students' formal education. And she recognized that there probably is not a one-size-fits-all model for ethics education.

Kline described a program at Cornell University that is integrating business, legal, and engineering ethics through the use of a case called *Incident at Morales* (www.niee.org/ProductsServices- IncidentatMorales.htm). He explained that the idea for the integrated class with business and law came about because engineering students pointed out that they were not the only ones that had to consider ethical decisions in the world of engineering firms and businesses. Gunsalus agreed that *Incident at Morales* was a good case and noted that it is used in business ethics classes at UIUC.

Herkert reported that the class described in his paper was able to effectively engage students in micro- and macroethics issues in the same class, though not always at the same time, and that it was a good example of successful ethics education. He also mentioned a required course developed at Lafayette College about 20 years ago called Values in Science and Technology (VEST) and a requirement for all students at North Carolina State University to study Science and Technology Studies (STS), which engineering students there often fulfilled by taking a course in engineering and science ethics.

Johnson noted that the University of Virginia has had success in creating a whole curriculum that incorporates ethics and social responsibility. The senior project of engineering students there is a portfolio that includes engineering research and an STS research paper on a social or ethical issue related to their engineering research. Furthermore, the humanities and social science education requirements for engineers are structured so that they are focused around engineering research. Rachelle Hollander noted that one positive characteristic of many successful programs is that they are interactive and engage students to focus their attention on the material.

Kelly Laas suggested that one way to effectively promote social responsibility might be through service learning–type projects that get students out of the classroom. She mentioned the option of building bridges between on-campus social groups like Engineers Without Borders to get students to think about social responsibility and also help create a lifelong practice of reflecting on engineering and science and their impacts on society. Elizabeth Cady, NAE program officer, reinforced this point by citing a recent NAE report, *Real World Experiences in Engineering Education*, that describes programs, including those involving service learning, that bring up ethical issues for students and lead them to think about their social responsibility.

Davis described some successful methods for influencing institutional culture through the efforts of individual faculty rather than led by institutional leaders; he referred to these efforts as "guerrilla ethics strategies." One possibility was to hold an "ethics bowl" on campus, focused on ethical issues in science or engineering. And he recounted a second example, one he had seen in practice many years ago, in which a teacher asked undergraduate students to come up with questions about research ethics and interview faculty members. This, Davis reported, had the effect of causing the faculty to begin discussing ethical issues at lunch in the faculty room.

Bird concluded that based on many of the examples discussed it seemed like a good idea for institutions to integrate ethics in all sorts of ways. This meant going beyond traditional courses on research ethics or RCR to include guerrilla ethics strategies. She suggested that having at least one lecture a year, in a department seminar, on ethical issues or social responsibility would be another good strategy. She added that these strategies are important because they help to establish a climate for discussing ethics issues among both students and faculty.

Appendix A

Biographies

Joint Advisory Group

John Ahearne, executive director emeritus of Sigma Xi, was director of the Ethics Program of Sigma Xi, The Scientific Research Society, where he was director from 1997 to 1999 and executive director from 1989 to 1997. Dr. Ahearne was elected to NAE membership in 1996 "for leadership in energy policy and the safety and regulation of nuclear power." He is also a fellow of the American Academy of Arts and Sciences, the American Physical Society, the Society for Risk Analysis, and the American Association for the Advancement of Science (AAAS).

Stephanie J. Bird is coeditor of *Science and Engineering Ethics*, a journal that explores ethical issues of concern to scientists and engineers. Formerly she was special assistant to the provost of the Massachusetts Institute of Technology (MIT), where she was responsible for the development of educational programs addressing ethical issues in research and the professional responsibilities of scientists and engineers. Her current work emphasizes the ethical, legal, and social policy implications of scientific research, especially in neuroscience, as well as teaching the responsible conduct of research and research ethics in science and engineering.

Felice Levine is executive director of the American Educational Research Association, where her work focuses on research and science policy issues, research ethics, data access and sharing, the scientific and academic workforce, and higher education. She was previously associate editor of the *Journal of Empirical Research on Human Research Ethics*. She is a fellow of the AAAS, the American Educational Research Association, and the Association for Psychological Science, an elected member of the International Statistical Institute, and past president of the Law and Society Association.

W. Carl Lineberger is the E.U. Condon Distinguished Professor of Chemistry and Biochemistry and a fellow of JILA in Boulder. His work is primarily experimental, using a wide variety of laser-based techniques to study structure and reactivity of gas phase ions. He has been awarded the H.P. Broida Prize in Atomic and Molecular Spectroscopy and the Earle K. Plyler Prize by the American Physical Society, the Meggers Prize by the Optical Society of America, and the Michelson Prize by the Coblentz Society. He has received the Irving Langmuir Prize in chemical physics and the Peter Debye Prize in physical chemistry from the American Chemical Society. He is a member of the National Academy of Sciences (1983), the American Academy of Arts and Sciences (1995), a fellow of AAAS and the American Physical Society, and a member of Sigma Xi and the American Chemical Society.

Michael C. Loui is professor of electrical and computer engineering and University Distinguished Teacher-Scholar at the University of Illinois at Urbana-Champaign. He conducts research in computational complexity theory, professional ethics, and the scholarship of teaching and learning. He has served as executive editor of *College Teaching* since 2006, and as editor of the *Journal of Engineering Education* since 2012. He was selected as a Carnegie Scholar and elected fellow of the IEEE. He was associate dean of the Graduate College at Illinois from 1996 to 2000. He directed the theory of computing program at the National Science Foundation from 1990–1991.

Robert M. Nerem is the Parker H. Petit Distinguished Chair for Engineering in Medicine, Institute Professor, and Founding Director of the Parker H. Petit Institute for Bioengineering and Bioscience (IBB) at Georgia Tech. From 1995 to 2009 he served as director of the Parker H. Petit Institute for Bioengineering and Bioscience (IBB), a research institute whose mission is to integrate engineering, information technology, and the life sciences in the conduct of biomedical research. He served on a part-time basis from 2003 to 2006 as the senior advisor for bioengineering in the National Institute of Health's (NIH) newest institute, the National Institute for Biomedical Imaging and Bioengineering. In recognition of his work, he was elected to the National Academy of Engineering in 1988 and to the Institute of Medicine in 1992. He is a fellow of the American Academy of Arts and Sciences, and past president of the International Federation for Medical and Biological Engineering and the International Union for Physical and Engineering Sciences in Medicine. He was the founding president of the American Institute of Medical and Biological Engineering, served on the Science Board of the Food and Drug Administration from 2000 to 2003, and received the NAE Founders Award in 2008.

Participant Bios

Heather E. Canary is an assistant professor in the Department of Communication at the University of Utah. Her work appears in several books, including *The International Encyclopedia of Communication and Communication* and *Organizational Knowledge: Contemporary Issues for Theory and Practice*. She has published articles in *The American Journal of Public Health*, *Communication Theory*, *Health Communication*, *The Journal of Applied Communication Research*, *The Journal of Business Ethics*, and *Management Communication Quarterly*, among other scholarly journals. Dr. Canary has been co-principal investigator for two interdisciplinary projects of graduate ethics education funded by the National Science Foundation and she was a Lincoln Ethics Teaching Fellow at Arizona State University. Her teaching infuses ethical considerations in courses ranging from communication theory to organizational communication. Her primary research focus is human communication across lay and professional groups, particularly processes of knowledge construction and decision making in contexts of public policies, health, and disability. She completed her PhD at Arizona State University in 2007.

Michael Davis is a senior fellow at the Center for the Study of Ethics in the Professions and professor of philosophy at the Illinois Institute of Technology in Chicago. Before coming to IIT in 1986, he taught at Case Western Reserve University, Illinois State, and the University of Illinois at Chicago. In 1985–86, he held a National Endowment for the Humanities fellowship. He has published more than 190 articles (and chapters) and authored seven books: *To Make the Punishment Fit the Crime* (Westview, 1992); *Justice in the Shadow of Death* (Rowman &

Littlefield, 1996); *Thinking Like an Engineer* (Oxford, 1998); *Ethics and the University* (Routledge, 1999); *Profession, Code, and Ethics* (Ashgate, 2002); *Actual Social Contract and Political Obligation* (Mellen, 2002); and *Code Writing: How Software Engineering Became a Profession* (Center for the Study of Ethics in the Professions, 2007). He also edited or coedited *Ethics and the Legal Professions* (Prometheus, 1986; 2nd edition, 2009); *AIDS: Crisis in Professional Ethics* (Temple, 1994); *Conflict of Interest in the Professions* (Oxford, 2001); and *Engineering Ethics* (Ashgate, 2005). Since 1991, he has held—among other grants—four from the National Science Foundation to integrate ethics into technical courses.

C.K. Gunsalus is director of the National Center for Professional and Research Ethics (NCPRE), professor emerita of business, and a research professor at the UIUC Coordinated Sciences Laboratory. She has been on the faculty of the UIUC colleges of Business, Law, and Medicine and served as special counsel in the Office of University Counsel. In the College of Business, she teaches leadership and ethics in the MBA program and is the director of the required professional responsibility course for all undergraduates in the college. She was a member of the faculty of the Medical Humanities/Social Sciences program in the College of Medicine, where she taught communication, conflict resolution skills, and ethics. A licensed attorney, Ms. Gunsalus graduated magna cum laude from the University of Illinois College of Law and has an AB with distinction in history from UIUC. She served on the Committee on Research Integrity of the Association of American Medical Colleges (AAMC) and the National Research Council's Government-University-Industry Research Roundtable Ad Hoc Group on Conflict of Interest. She was a member of the US Commission on Research Integrity and served four years as chair of the AAAS Committee on Scientific Freedom and Responsibility. In 2004, she was elected a AAAS fellow in recognition of her "sustained contributions to the national debate over improving the practical handling of ethical, legal, professional and administrative issues as they affect scientific research." She has served on the Illinois Supreme Court's Commission on Professionalism since 2005. She has a written book on survival skills for academic leaders, *The College Administrator's Survival Guide* (Harvard University Press, 2006), and one about preventing and responding to workplace challenges, *The Young Professional's Survival Guide: From Cab Fares to Moral Snares* (Harvard University Press, 2012).

Joseph R. Herkert, DSc, is Lincoln Associate Professor of Ethics and Technology in the School of Letters and Sciences and the Consortium for Science, Policy and Outcomes at Arizona State University. He has been teaching engineering ethics and science, technology, and society courses for 25 years. He is coeditor of *The Growing Gap Between Emerging Technologies and Legal-Ethical Oversight: The Pacing Problem* (Springer, 2011), editor of *Social, Ethical and Policy Implications of Engineering: Selected Readings* (Wiley/IEEE Press, 2000), and has published numerous articles on engineering ethics and societal implications of technology in engineering, law, social science, and applied ethics journals. Current projects include ethical and legal issues related to emerging technologies, integrating micro- and macroethics in graduate science and engineering education, and societal implications of the smart grid. Herkert was editor of *IEEE Technology and Society Magazine*, published by the Society on Social Implications of Technology (SSIT) of the Institute of Electrical and Electronics Engineers (IEEE). He has served as SSIT president (1995–1996) and is currently a member of the SSIT board of governors. In 2007 he was the first recipient of the SSIT Distinguished Service Award. Herkert is a senior member of IEEE and recently completed a three-year term on the IEEE Ethics and Member

Conduct Committee. He is a distinguished life member of the executive board of the National Institute for Engineering Ethics, an associate editor of the journal *Engineering Studies*, a board member of the Engineering Ethics Division of the American Society for Engineering Education (ASEE), and past chair of the Liberal Education/Engineering and Society (LEES) Division of ASEE. In 2005 Herkert received the Sterling Olmsted Award, the highest honor bestowed by LEES, for "making significant contributions in the teaching and administering of liberal education in engineering education." Herkert received his BS in electrical engineering from Southern Methodist University and his doctorate in engineering and policy from Washington University in St. Louis. He is a former registered professional engineer with more than five years experience as a consultant in the electric power industry.

Michael Kalichman leads NIH- and NSF-funded research on the goals, content, and methods for teaching research ethics. He has been invited to teach train-the-trainer, research ethics workshops throughout the United States and in Central America, Europe, Africa, and Asia. He is founding director of the UC San Diego Research Ethics Program (http://ethics.ucsd.edu) and the San Diego Research Ethics Consortium (http://sdrec.ucsd.edu), and cofounding director of the Center for Ethics in Science and Technology (http://ethicscenter.net). In 1999, with support from the Office of Research Integrity (ORI), he created one of the first online resources for the teaching of research ethics (http://research-ethics.net).

Julia D. Kent (PhD) is director of global communications and best practices at the Council of Graduate Schools (CGS). Since arriving at CGS in 2008, she has conducted research on a broad range of topics in graduate education, including scholarly and research integrity, learning assessment, interdisciplinary graduate education, career outcomes for graduate students, professional doctorates, and international collaborations. She is co-principal investigator of a CGS initiative funded by the National Science Foundation, Modeling Effective Research Ethics Education in Graduate International Collaborations. CGS and partner universities will develop model approaches to assessing the learning of graduate students who participate in collaborations such as joint and dual degree programs and research collaborations and exchanges in STEM fields. Prior to this project she was program manager for the Project for Scholarly Integrity, funded by the US Department of Health and Human Services and ORI. This research and educational initiative has resulted in models for embedding the responsible conduct of research (RCR) into graduate education and has been disseminated widely in US graduate education through CGS broad network of member institutions. She is coauthor (with Daniel Denecke and Jeff Allum) of the resulting report, *Research and Scholarly Integrity in Graduate Education: A Comprehensive Approach* (2012). She also oversees CGS's Strategic Leaders Global Summit, an annual global forum that has included graduate educational leaders from 29 countries since 2007. She is managing editor of CGS's Global Perspectives series, the summit proceedings volumes, which includes *Global Perspectives on Research Ethics and Scholarly Integrity* (2009). She completed her graduate degrees at Université de Paris VII–Jussieu and at Johns Hopkins University. Before her arrival at CGS, she served on the faculty of the American University of Beirut (AUB).

Ronald Kline is Bovay Professor in History and Ethics of Engineering at Cornell University, and director of the Bovay Program under that name in the Engineering College. He holds a joint appointment between the Science and Technology Studies Department in the College of Arts and

Sciences and the School of Electrical and Computer Engineering in the College of Engineering at Cornell. Previously, he was director of the Center for the History of Electrical Engineering at the Institute of Electrical and Electronics Engineers (IEEE) in New York City (1984–1987). He has served as president of the IEEE Society on Social Implications of Technology, editor of *IEEE Technology and Society Magazine*, and an advisory editor for *Isis*, *Technology and Culture*, and *IEEE Spectrum*. He is currently president of the Society for the History of Technology and an advisory editor for *Social Studies of Science* and *Engineering Studies*. He is the author of articles on the history of technology and engineering ethics, the books *Steinmetz: Engineer and Socialist* (1992) and *Consumers in the Country: Technology and Social Change in Rural America* (2000), and is completing a book on the history of cybernetics, information theory, and information discourse in the Cold War.

Brian C. Martinson, PhD, is a senior research investigator and director for science programs at HealthPartners Institute for Education and Research (HPIER) in Minneapolis. As a principal investigator, over the past 10 years he has led several federally funded research projects studying research integrity as it relates to aspects of organizational climates in academic research settings. The most recent of these projects, completed in mid-2012 with results published in the *Journal of Science and Engineering Ethics*, was focused on the development and validation of the Survey of Organizational Research Climate (SORC), an instrument for universities to use in assessing their own research integrity climates. In 2009–2010, he was a consultant to a three-university consortium participating in the CGS Project on Scholarly Integrity. During that time he also served on an invited expert panel on research integrity, convened by the Council of Canadian Academies at the request of Industry Canada, leading to the report *Honesty, Accountability and Trust: Fostering Research Integrity in Canada*. Martinson is a member of the US National Research Council panel charged with revising the 1992 publication *Responsible Science: Ensuring the Integrity of the Research Process*.

Appendix B

Practical Guidance on Science and Engineering Ethics Education for Instructors and Administrators

Workshop Agenda

8:00–8:30 **Continental Breakfast**

8:30–9:00 **Welcome and Introductions:**

Proctor Reid, National Academy of Engineering

Rachelle Hollander, National Academy of Engineering Center for Engineering, Ethics, and Society

9:00–10:30 **Session I: Goals and Objectives for Instruction**

Chair: **C.K. (Tina) Gunsalus**
National Center for Professional and Research Ethics, University of Illinois Urbana-Champaign

Speakers: **Michael Kalichman**
Center for Ethics in Science and Technology, University of California San Diego
Responsible Conduct of Research Instruction

Ron Kline
Electrical and Computer Engineering, Cornell University
Social Responsibility and Research Instruction

Brainstorming, Discussion, and Questions (30 min): *How should a course be designed? How can students be taught to make better ethical decisions? That is: What should students learn? What methods and approaches work in teaching science and engineering ethics? What doesn't work? How should students be engaged in ethical decision making so that they continue to do so throughout their careers?*

10:30–10:40 **Break**

10:40–Noon Session II: Goals and Objectives for Instructional Assessment

Chair: **Beth Cady**
National Academy of Engineering

Speakers: **Michael Davis**
Center for the Study of Ethics in the Professions, Illinois Institute of Technology
Assessment in the Classroom

Joseph Herkert and Heather Canary
Arizona State University and University of Utah
Assessment in Programs and Centers

Brainstorming, Discussion, and Questions (30 min): *What criteria should be measured when doing assessment? What are the relative merits of qualitative and quantitative assessment? Are there cost-effective ways of combining these approaches? What constraints need to be considered in developing and implementing an assessment plan? How can constraints be dealt with effectively? Are there helpful resources that everyone should be aware of?*

Noon–1:00 Lunch

1:00–2:30 Session III: Institutional and Research Cultures

Chair: **Bob Nerem**
Institute of Bioengineering and Bioscience, Georgia Institute of Technology

Speakers: **Julia Kent**
Council of Graduate Schools
Institutional Efforts

Brian Martinson
HealthPartners Institute for Education and Research
Institutional and Research Culture

Brainstorming, Discussion, and Questions (30 min): *What are the characteristics of successful institutional efforts? Are there cost-effective ways of assessing these efforts? What constraints need to be considered in developing and implementing these efforts? How can constraints be dealt with effectively? Are there helpful resources that everyone should be aware of?*

2:30–4:30 Wrap-up Discussion: Guidance Checklists for Instructors and Administrators

Moderator: **John Ahearne**
Sigma Xi, The Scientific Research Society

Questions:

1. What are the goals and objectives for RCR education? How can instructors determine whether they are being met in the classroom, programs, or centers?

2. What are the goals and objectives for instruction in social responsibility regarding scientific and engineering practice and research? How can instructors determine whether they are being met in the classroom, programs, or centers?
3. Are there examples of successful practices for RCR education or education in/about social responsibility? What characteristics do they share? How have they been assessed?
4. Are there examples of successful efforts in administrative and institutional settings that support education on RCR and social responsibility? What characteristics do they share? How have they been assessed?
5. Are there examples of successful innovations in institutions and in research cultures that improve ethical practice in science and engineering? What characteristics do they share? How have they been assessed?
6. Are there examples of integrated assessments that have evaluated instructional and administrative efforts at an institution or institutions? Are there meta-analyses of ethics education programs or might such an effort be useful?

4:30 PM Workshop Adjourns

Appendix C

Workshop Participants

John Ahearne, *Chair*
Executive Director Emeritus
Sigma Xi, The Scientific Research Society

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Global Communication and Best Practices
Council of Graduate Schools

Ronald R. Kline
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Kelly Laas
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Illinois Institute of Technology

* Attended virtually

Linda Layne
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Rensselaer Polytechnic Institute

Felice Levine
Executive Director
American Educational Research Association

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E.U. Condon Distinguished Professor of Chemistry and Fellow of JILA
University of Colorado

Michael Loui
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Institute for Bioengineering and Bioscience
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Vivienne Chin
Senior Administrative Assistant
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Appendix D

Bibliography of Suggested Resources

The following list is a compilation of participants' suggestions of the three most relevant and useful resources in their topic area.

Anderson, Melissa Susan. *International Research Collaborations: Much to Be Gained, Many Ways to Get in Trouble*. Taylor & Francis, 2011.

Antes, Alison L., Xiaoqian Wang, Michael D. Mumford, Ryan P. Brown, Shane Connelly, and Lynn D. Devenport. Evaluating the effects that existing instruction on responsible conduct of research has on ethical decision making. *Academic Medicine: Journal of the Association of American Medical Colleges* 85, no. 3 (March 2010): 519–526.

Antes, Alison L., Stephen T. Murphy, Ethan P. Waples, Michael D. Mumford, Ryan P. Brown, Shane Connelly, and Lynn D. Devenport. A meta-analysis of ethics instruction effectiveness in the sciences. *Ethics & Behavior* 19, no. 5 (2009): 379–402.

Borenstein, Jason, Matthew J. Drake, Robert Kirkman, and Julie L. Swann. The Engineering and Science Issues Test (ESIT): A discipline-specific approach to assessing moral judgment. *Science and Engineering Ethics* 16, no. 2 (June 1, 2010): 387–407.

Canary, Heather, Joseph Herkert, Karin Ellison, and Jameson M. Wetmore. Microethics and macroethics in graduate education for scientists and engineers: Developing and assessing instructional models. *Proceedings of the 2012 American Society for Engineering Education Annual Conference* (2012). Available online at www.cspo.org/projects/eese-daim/publications/ASEE-2012-Paper.pdf.

Committee on Assessing Integrity in Research Environments, National Research Council, Institute of Medicine. *Integrity in Scientific Research: Creating an Environment That Promotes Responsible Conduct*. Washington: National Academies Press, 2002.

Committee on Science, Engineering, and Public Policy, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. *On Being a Scientist: A Guide to Responsible Conduct in Research*, 3rd ed. Washington: National Academies Press, 2009.

Council of Graduate Schools. *Research and Scholarly Integrity in Graduate Education: A Comprehensive Approach*. 2012.

Crain, A. Lauren, Brian C. Martinson, and Carol R. Thrush. Relationships between the Survey of Organizational Research Climate (SORC) and self-reported research practices. *Science and Engineering Ethics* (2012): 1–16.

Kalichman, Michael. Evidence-based research ethics. *American Journal of Bioethics* 9, no. 6–7 (2009): 85–87.

Kalichman, Michael W. Responding to challenges in educating for the responsible conduct of research. *Academic Medicine: Journal of the Association of American Medical Colleges* 82, no. 9 (September 2007): 870–875.

Kalichman, Michael W., and Dena K. Plemmons. Reported goals for responsible conduct of research courses. *Academic Medicine: Journal of the Association of American Medical Colleges* 82, no. 9 (September 2007): 846–852.

Kline, Ronald. Research ethics, engineering ethics, and science and technology studies. In *Encyclopedia of Science, Technology, and Ethics*, edited by Carl Mitcham, 1: xxxv–xli. New York: MacMillan, 2005.

Kraus, Rachel. You must participate: Violating research ethical principles through role-play. *College Teaching* 56, no. 3 (2008): 131–136.

Loui, Michael C. Assessment of an engineering ethics video: Incident at Morales. *Journal of Engineering Education* 95 (January 1, 2006): 85–91.

Martinson, Brian C., Carol R. Thrush, and A. Lauren Crain. Development and validation of the Survey of Organizational Research Climate (SORC). *Science and Engineering Ethics* (2012): 1–22.

Mumford, Michael. Validation of ethical decision making measures: Evidence for a new set of measures. *Ethics & Behavior* 16, no. 4 (2006): 319–345.

Mumford, Michael, Shane Connelly, Ryan P. Brown, Stephen T. Murphy, Jason H. Hill, Alison L. Antes, Ethan P. Waples, and Lynn D. Devenport. A sensemaking approach to ethics training for scientists: Preliminary evidence of training effectiveness. *Ethics & Behavior* 18, no. 4 (2008): 315–339.

Sindelar, Mark, Larry Shuman, Mary Besterfield-Sacre, Ronald Miller, Carl Mitcham, Barbara Olds, Rosa Pinkus, and Harvey Wolfe. Assessing engineering students' abilities to resolve ethical dilemmas. *Proceedings of the 33rd Annual American Society for Engineering Education / Institute of Electrical and Electronics Engineers Frontiers in Education Conference, Westminster, Colorado* (November 5–8, 2003): S2A-25–S2A-31.

Sloan, Susan Sauer, and Tom Arrison. *Examining Core Elements of International Research Collaboration: Summary of a Workshop*. Washington: National Academies Press, 2011.

Whitbeck, Caroline. *Ethics in Engineering Practice and Research,* 2nd ed. Cambridge University Press, 2011.