

# ONLINE RESOURCES FOR ETHICS EDUCATION IN ENGINEERING AND SCIENCE

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**Abstract** *This paper reports on the Online Ethics Center for Engineering and Science (OEC) <http://onlineethics.org>. The OEC is the foremost Web site for ethics in engineering and science in the USA. It receives primary funding from the U.S. National Science Foundation. Founded at the Massachusetts Institute of Technology (MIT) in 1995, it has been at Case Western Reserve University (CWRU) since 1997. It is the result of a unique collaborative effort among engineering ethics educators. Its mission is to provide easily accessible literature, case studies, references, and discussions of ethics in engineering and science. The Center focuses on problems that arise in the work life of engineers and scientists. The OEC serves practicing engineers and scientists, educators and students of engineering and science, and individuals interested in professional and research ethics.*

**Index Terms** *active learning, engineering ethics, ethics education, research ethics, the responsible conduct of research.*

## AN OVERVIEW OF THE OEC

### The Mission and History of the OEC

**The mission of the Online Ethics Center for Engineering and Science** is to provide readily accessible literature, case studies, references, and discussion groups on ethics in engineering and science. The Center focuses on problems that arise in the work life of engineers and scientists. It serves practicing engineers and scientists, educators and students of engineering and science, and individuals interested in professional and research ethics. Since when engineers and scientists outside of academic setting use the information and services of the Center, they usually do so in accord with their own interests and concerns, the subject of this essay will be selecting materials for the formal and informal education of students, faculty and other research investigators.

The *Online Ethics Center* started in 1995 under a grant (#SBR-9511862) from the National Science Foundation and is currently operating under a renewal grant (#SBR-9976500). In 1997, it moved with me from the Massachusetts Institute of Technology (MIT) to Case Western Reserve University (CWRU). Students at both universities have contributed much to the OEC and to

individual Web pages. The OEC is the primary science and engineering ethics Web site in the U.S. It now has about 3,000 files and 2,000 Web pages. We continually update our links. Our policy is to annotate all our links, so users do not waste their effort going down blind alleys. (If you have materials in science and engineering ethics that you would like other people to know about, please send us the URL for the material with an appropriate annotation for our link.)

### Resources in the OEC

When you go to <http://onlineethics.org> for the first time, you will be on the main page of the graphics version. The graphics version has graphical menus that link to the sections and resources of the OEC and will be helpful for most users viewing the Web pages. If you select "text version" at the top or bottom of that (or any other) page, a cookie will be sent to your computer. That cookie will cause the text version of the page you were on to be created on your computer. From that point on, you will see the text version of pages, until you choose "graphics version" on a text version page (or until you flush your cookies). The text version of a page may be more useful for those printing out that page. The text version is also useful for those who want or need to view all words in the OEC in larger font than is used in the graphical menus.

On the graphics version of the Main page, <http://onlineethics.org>, the principal content areas are listed across the top of the page. Each is a pull-down menu, so moving your pointer to a subtopic under a content area and clicking will take you to the Web page for that subtopic. The a subsidiary menu listing a variety of special aids or materials for special audiences is shown on the left side of each graphics page.

Among the items in the subsidiary menus are:

- a bibliography at <http://onlineethics.org/bib>
- a glossary, <http://onlineethics.org/glossary.html>
- a list of organizations and their acronyms, <http://onlineethics.org/abbr.html>, with links to the Web sites of the organization.
- A list of other science and engineering ethics Web sites, <http://onlineethics.org/othersites.html>. We also link to other Web sites that are relevant to particular topics, as appropriate throughout the Online Ethics Center.

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- Some of our most popular pages are offered in Spanish, <http://onlineethics.org/spanish/index.html>, as well as English.

The OEC has an **Ethics Help-Line** service at <http://onlineethics.org/helpline/index.html>. The National Institute for Engineering Ethics co-sponsors this service. It provides experienced peer counseling to those facing ethically significant problems in science and engineering. We have an experienced team of counselors. Some of those on the team had run the Institute of Electrical and Electronics Engineers' Ethics Hotline. Most of the questions to the Help-Line are about research practice or engineering practice.

Some of our pages contain materials that are unique to the Online Ethics Center, other pages we maintain contain materials that are also available elsewhere. For example, we maintain a copies of some codes of ethics and guidelines containing ethical standards for research practice and for treatment of human subjects, <http://onlineethics.org/codes>. The OEC also has links to other major sites that have materials on responsible conduct of research, including human subjects protection and animal research subjects, <http://onlineethics.org/reseth/index.html#sites>

Several items in the OEC's subsidiary index are useful in **finding specific types of information**. These are given in the bulleted list below. (The subsidiary index appears in the upper left of each page in the "graphics version" of an OEC Web page or in the pulldown menu at the bottom right of each page of the "text version".of an OEC Web page.)

- Topic Index <http://onlineethics.org/keywords/keywds.html>
- Bibliography <http://onlineethics.org/bib/index.html>
- Search Capability This is being upgraded. Look in the upper right of any graphics page for the link.

### Guides to Contents of the OEC

The discussion of the selection of materials is organized in terms of the purposes and the intended audience:

**1. Ethics in Engineering Practice for Engineering Students, Trainees, and Professionals** (In the U.S. at least, part of the interest in this education is to fulfill item (f) of the ABET-CSAB Engineering Criteria 2000 <http://www.abet.org/eac/engineer.htm> "ABET" is the Accreditation Board for Engineering and Technology and "CSAB" is the Computer Science Accreditation Board. Item "f" requires demonstration of "an understanding of professional and ethical responsibility". Some OEC material is also relevant to fulfilling criteria d, g, h, and j on teamwork, communication, understanding of societal context of engineering solutions, and knowledge of contemporary issues respectively.

- A brief guide in response to an ABET Readiness Committee for handbook to help prepare the engineering faculty to address ethical issues in their teaching is at <http://onlineethics.org/edu/cwabet.html>
- A Plan for Undergraduate Education in Practical Ethics with sample assignments for engineering students using teaching materials from the Online Ethics Center is at <http://onlineethics.org/edu/cwethed.html>.
- Course-tested online assignments from *Science and Engineering Ethics*, CWRU, are at <http://onlineethics.org/edu/see/assignments.html>. The assignments at the beginning of the course may be used with students at any level, but those in the second half of the course should be used only with juniors, seniors, and graduate students.
- Syllabi and Other Resources for Designing Courses in Professional Ethics or Research Ethics for Engineers, Scientists and Computer Engineers and Scientists, are at <http://onlineethics.org/edu/index.html#anch7>

**2. Materials on the Responsible Conduct of Research (RCR)** for research trainees in science and engineering (and fulfillment of PHS requirement for education in RCR for all faculty, trainees and research staff who work on PHS-supported projects or with PHS funds at institutions receiving PHS funds)

- Reference Materials, Protocols, and Standards for the Responsible Conduct of Research are at <http://onlineethics.org/reseth/index.html#ref>. (This section is being greatly expanded in 2001-2002.)
- Modules on the responsible conduct of research for discussion by faculty, students and staff of laboratories and departments may be found at <http://onlineethics.org/reseth/mod/index.html>
- Cases written by graduate students and post-doctoral trainees that reflect their experiences and problems are at <http://onlineethics.org/reseth/appe/appetoc.html>

**3. An Index Learning Resources for Pre-college students** shows which of our materials for education at the university level are also suitable for pre-college students. It guides users to a soon-to-be expanded section of new materials specifically designed for secondary and high school audiences and educators. This index may be found at <http://onlineethics.org/edu/precol/index.html>.

## CONTENT AREAS OF THE OEC

### Ethics in Engineering Practice

The OEC has a variety of case materials on ethics in engineering practice and a growing collection of essays on topics in engineering ethics and on active learning methods

for learning professional ethics in computer science, engineering, and research.

At <http://onlineethics.org/cases/nspe/index.html> are open-ended discussion cases based on cases considered by the Board of Ethical Review (BER) of the National Society of Professional Engineers (NSPE). These brief cases present situations that raise ethical questions common in engineering practice and research. The cases were rewritten to make them more suitable for group and class discussion. The NSPE BER reviews cases with the narrower purpose of making an ethical judgment on the actions of (only) the engineers in the cases, based solely on the NSPE Code of Ethics. Each of the discussion cases has a link to the original NSPE case. Cases are grouped into five categories. Some cases appear in more than one category.

We provide links to interesting materials on other's Web sites, such as, **two cases of bridge collapse** maintained by Carleton University that illustrate the role of risk and failure in engineering work at [http://cee.carleton.ca/Exhibits/Quebec\\_Bridge/intro.html](http://cee.carleton.ca/Exhibits/Quebec_Bridge/intro.html) and [http://cee.carleton.ca/Exhibits/Tacoma\\_Narrows/index.html](http://cee.carleton.ca/Exhibits/Tacoma_Narrows/index.html). We sometimes provide an index and summary of such cases, such as, to the **Eleven Detailed Cases from Texas A&M University** at <http://onlineethics.org/cases/texindex.html>.

"Two Cases of Engineering Errors That Led to Accidents in Japan" by Hiroshi Iino, Kanazawa Institute of Technology. The two accidents in nuclear energy development that are described here were disclosed, analyzed and attracted much public interest in Japan. They supply engineering students with many useful lessons. <http://onlineethics.org/cases/iino.html>

The "Structural Engineer's Standard of Care" by Joshua B. Kardon is at <http://onlineethics.org/cases/kardon.html>. This paper briefly describes a few engineering failures with which the author has become familiar in his practice as a consultant and expert in construction defects lawsuits, and in published accounts.

"Some Recent Engineering Ethics Cases" by Stephen H. Unger, Columbia University at <http://onlineethics.org/cases/unger.html> reports cases that came to the attention of the IEEE Ethics Committee. Most came in via the ethics hotline, while the initial contacts for others was via communications addressed to authors of ethics columns that appeared in the IEEE Institute. Names and other information that might identify individuals or organizations have been suppressed or fictionalized.

*Teaching Engineering Ethics: A Case Study Approach*, edited by Micheal Pritchard, at <http://onlineethics.org/cases/pritchard/pritchard.html>, gives thirty-two cases which address a wide range of ethical issues that can arise in engineering practice.

The Three Mile Island Nuclear Accident at <http://onlineethics.org/cases/tmi/index.html> recounts one of the most serious accidents in the U.S. nuclear history. The

account here offered includes a timeline of events accompanied by pictures, and some technical information.

The Composite-Material Bicycle Case at <http://onlineethics.org/corp/bike.html> is a case study and analysis by Robert McGinn based on a consulting engineer's experience in coping with ethical conflicts at work, specifically: 1) a conflict between the duty not to undermine another consulting engineer who has hired him in an attempt to secure a contract to develop a composite material bicycle, and the obligation to uphold public safety; and 2) a conflict between directives to heed the problematic work orders of his client's manager, and specific obligations to follow good practices derived from the engineer's general obligation to serve the legitimate interests of the client to the best of her or his ability.

### Computer Science and Internet

The Detailed Case of David LaMacchia the MIT student who allegedly used university hardware to distribute commercial software over the Internet may be found at <http://onlineethics.org/cases/lamacchia/index.html>.

The Killer Robot Case by Richard G. Epstein is at <http://onlineethics.org/cases/robot/robot.html>. In this hypothetical scenario, a programmer is blamed for the death of an operator of a robot that he designed. The scenario features tongue-in-cheek humor and unexpected twists in plot.

A growing section on Internet Privacy is at <http://onlineethics.org/privacy/index.html>. With the growth of computer technology in the past twenty years, a serious new issue faces the engineer and scientist, as well as anyone in a computer related field. That issue is Privacy over networks and the Internet.

### Ethics in Other Scientific Practice

Information about the landmark hazardous waste case at Love Canal, New York may be found at <http://onlineethics.org/cases/l.canal/main.html>. Included is a timeline that summarizes the major Love Canal events in an accessible format together with a brief historical narrative, and a special section which provides the most recent Love Canal news. We have also included summaries of eight of the major scientific studies that have attempted to assess the health impacts of Love Canal and a detailed map showing the canal's location and several links to other materials and sites.

Our materials on ethical issues commonly arising for scientists and engineers working in a large corporate setting may be found at <http://onlineethics.org/corp/index.html>. The mini-case quiz and the advice reveals the ethical standards of some concerned corporations and the methods they use to educate their employees about these standards.

We provide a link to cases created and maintained by the Ethics Advisory Committee of the Endocrine Society <http://www.endo-society.org/index.cfm>, to their 1999 cases,

at <http://www.endo-society.org/about/ethiccase.cfm>, and to their 2000 cases at <http://www.endo-society.org/about/2000cases.cfm>. Each case is accompanied by a discussion and references.

Detailed Cases of Exemplary Behavior in our Moral Leaders Section contain stories of both scientists and engineers. These are detailed descriptions of cases in which engineers or scientists showed exemplary behavior in fulfilling their professional responsibilities or acting for the public good. Our presentations focus on the problems that each engineer or scientist faced.

- Roger Boisjoly's Attempts to Avert the Challenger Disaster (at <http://onlineethics.org/moral/boisjoly/RB-intro.html>)
- William LeMessurier's Emergency Repair of the Structural Supports of the Citicorp Tower in New York (at <http://onlineethics.org/moral/LeMessurier/lem.html>).
- Rachel Carson's Campaign for Control of Pesticides Use (at <http://onlineethics.org/moral/carson/main.html>)
- Fred Cuny Improvement of Disaster Relief (at <http://onlineethics.org/moral/cuny/intro.html>)
- The story of Inez Austin's efforts to raise safety concerns at the Hanford Nuclear Facility in Richland Washington (at <http://onlineethics.org/moral/austin/mainpage.html>)

### Responsible Research Conduct

The OEC also has links to other major sites that have materials on responsible conduct of research, including human subjects protection and the use of animals in research, <http://onlineethics.org/reseth/index.html#sites>. For example, at <http://onlineethics.org/reseth/townmtg.html> we have information on the National Town Meeting that was held as part of the public comment activities for the new Uniform Federal Policy on Research Misconduct. We show what parts of the draft policy came up for (favorable or unfavorable) comment at that meeting, <http://onlineethics.org/reseth/misc.html>.

We have copies or link to most of what is available on the responsible conduct of research that is on the Web, but I will now consider in some detail the materials we have that you will not find elsewhere. We have research ethics cases and commentaries developed by the Association for Practical and Professional Ethics (APPE). These are cases were developed by graduate students who were participating in workshops run by APPE. There are now five volumes, each of which is organized by topic. You will find these posted at <http://onlineethics.org/reseth/appe/appetoc.html>.

Finally, I will consider in some detail the project that a team of us are conducting at CWRU to provide learning experiences for faculty and students/trainees in departments. This work may be of interest, both because it and the materials created for it are on the cutting edge of ethics education that in the U.S. is called "the responsible

conduct of research", and because our method was *developed first for engineering and computer science departments*, and is being further developed for them as well as for other science and medical departments. Most other educational efforts in the responsible conduct of research have tended to be developed first for biology and medicine.

Many of us who are involved in this project have also taught the responsible conduct of research in formal courses, in informal sitting, in seminars and speaker series. Often, as good as those are—and some of them are still being offered at CWRU—they address only students. The key is to find ways of helping the faculty, both to learn what they do not know and to help transmit what they do know to their students. Most faculty members know the basics. In fact, they often have a very sophisticated understanding of how to behave, but they do not know how to talk about it; they do not know how to transmit their understanding to their students. Students often do not know how to approach their advisors with questions about research conduct.

Part of our purpose is to create the circumstances in which discussions between students or trainees and their supervising faculty members will take place. We are not just transferring information. The learning situation we offer is very different from that of individuals memorizing regulations and taking a test on them, the approach that, in the U.S. at least, is often used to acquiring and demonstrating knowledge of the ethical requirements for research with human subjects. We are focus on education that develops awareness, discretion, and judgment of departments, laboratories and other research communities as well as the individuals in them. The goal is not merely to ensure that everyone is following the rules but to strengthen the investigators' ability to address the host of subtle issues of research practice. Strengthening the investigators' ability requires improvement of the group recognition of, and support for, norms appropriate to particular research contexts, and for the development of the ability to satisfy many potentially competing demands simultaneously.

I started this mode of education 10 years ago in the computer science "area" of the electrical engineering and computer science department at the Massachusetts Institute of Technology with Albert Meyer, the then "area chairman" (comparable to the head of graduate studies for computer science). The microsystems area of EECS later took it up and made it their own. The basic goal is to develop education for all members of a department that will be taken over and become a part of the life of the department. Members of the team run a few a sessions and demonstrate how to replace lectures and case presentations with problem solving of problems common to the groups research practice. We model how keep the session focused on problem-solving, rather than in disputing over what value trumps what, or taking sides in the conflicts described in the scenarios.

The problem-oriented presentation of material is central; that is, we ask people to solve practical problems together. We use an active learning approach; that is, we generally start by giving people some scenarios that present problem situations. We realize that most people will do the reading until only after they become engaged in solving the problems. On-line readings for each topic are on the Web, along with a selected bibliography on the topic.

A method we most commonly use is to compile a collection of scenarios--open-ended descriptions of problem situations in the topic area, such as authorship, reviewing articles and grants, or the supervisor-trainee relationship and send them out by e-mail. The scenarios do not have to be discipline specific, but the majority of them have to present problems that would be plausible in that discipline. An ever growing collection of these is in the OEC. We invite participants to submit other scenarios for discussion. Identifiers are removed and they are included among the scenarios handed out at the session. (Some students who submit scenarios prefer not to have their names associated with the scenarios.) As valuable as it is to have the new scenarios, it is valuable just to *ask* people if they would like to add scenarios, so they understand that the session is about addressing the problems they actually face.

People attend for many reasons: some because they are curious about the situations, some because they are looking for better answers to those problems, some want to share their hard-earned experience, some wish to see their department come to some common understanding, and some even attend because they don't want the department to common to consensus without their input. Ideally the department adds to our store of scenarios and eventually takes over running the discussions.

The scenarios and invitation usually go out under the department signature of the department head with the names of the members of a panel who will start the discussion of the scenarios. Respected figures in the department are asked to serve on the panel. If we are considering a topic like the supervisor-trainee topic or authorship, we make sure we have at least experienced students or other trainees on the panel, too.

Let us look at a few scenarios. Here, at <http://onlineethics.org/reseth/mod/interest.html>, is one on the subject of the reviewing and editing. The scenario says that you are asked to review an article that contains a proof and become intrigued by the topic. After a few weeks, you come up with a shorter and better proof. You feel clear about your recommendations about the publishability of this result. What, if anything, do you do with your better proof?

Our Web page statement of this scenario also has links to interpretive comment from two people in different disciplines that both produce theorems. The first is in computer theory the second in statistics. The two disciplines each bring different expectations to the scenario. The difference in expectations is due in part to a difference in the two disciplines over the relative significance of having any

proof of some theorem as compared with having an elegant proof of a theorem. This difference illustrates the point that we are seeking to strengthen the skills of groups for solving ethical problems, not come up with a new set of rules that apply to all investigators.

Here-- <http://onlineethics.org/reseth/mod/whofirst.html> -are two scenarios from the responsible authorship module (at <http://onlineethics.org/reseth/mod/auth.html>) that raise questions about authorship and the order of authors when one student or trainee starts a project. The first of these was created by Gerald Saidel, professor in the biomedical engineering department at CWRU.

One of the things that participants learn from one another in the module session where we discuss the scenarios is the variety of things that may be underlying the situation described in the scenario. That discussion helps both the faculty and trainees to learn:

- The factors that are morally and practically relevant
- The sorts of things one should inquire about in such a situation, and how one would use the information obtained
- The potential pitfalls to watch for when faced with a somewhat ambiguous situation

Sometimes participants will want immediately to issue a judgment on the situation or the individuals in it. It may take a bit of time for them to see that we are trying to understand the situation and the uncertainties in it, not jump to one conclusion or another. We try to help the group engage in wise deliberation, and demonstrate how reasonable and responsible people deal with ethically significant problems about the conduct of research. The goal is to increase the group's ability to discern what's going on and to make intelligent and responsible queries in a situation, and to learn from each other.

I emphasize that we are not seeking to teach an algorithm for coming to a judgment about the rights and wrongs in a particular case, although we often do refer to some clear ethical standards where they exist. Our purpose is rather to prepare a community to discuss these things with one another so that they can take wiser approaches and prevent many later problems. Serious conflicts or wrong doing in research is much easier to prevent than to resolve once they have occurred.

Here are some scenarios from the module on the relationships of supervisors (or "mentors") and their trainees, <http://onlineethics.org/reseth/mod/advis.html>. Another, <http://onlineethics.org/reseth/mod/consult.html>, is about a student who is finishing a dissertation. The professor who is the thesis supervisor has some outside consulting and asks if the student would like to earn some extra money by creating some computer code for the consulting project. The student does not feel free to refuse. This scenario can raise all sorts of issues. Some are quite subtle. For example, they special vulnerability of foreign students, because if they lose their research assistantship, they are less likely to be able to

borrow the money to stay in the program, as a U.S. student could.

In the scenario on consulting, we put an additional piece of information: some universities do not allow faculty to hire their own thesis students in their consulting to prevent situations such as this one. We do add some references to organizational responses and good practices that prevent some of the problems we describe.

Here is one on bias on the part of a supervisor, <http://onlineethics.org/reseth/mod/bias.html>. It is written from the position of a student whose parents comes from a country that has centuries-old enmity toward the country of origin of the student's thesis supervisor. The student notices that students who share the supervisor's ethnicity get invited more to meet the visiting scientists and other career opportunities. The student is getting a good technical education, however. What, if anything should the student do? How would the student even raise this kind of issue?

Another scenario concerns gender issues, <http://onlineethics.org/reseth/mod/bias.html>. Sometimes when your advisor when talking about research with you and others of his students (all the rest of whom are male), he walks into the men's room, continuing the conversation. The guys follow him in and you are left out and have to hope that one of the male students will fill you in later. In the scenario are other elements draw from life. All the scenarios are based on compilations of real incidents although not all of them happened together, nor did they always happen to one person. A new scenario can sometimes raise consciousness, which may be of some use by itself.

We provide some variations on our method. For example, we provide some additional questions for the "endless dissertation" scenario, <http://onlineethics.org/reseth/mod/advques.html>, to help raise some consciousness about the supervisor-trainee relationship issues. When we offer the authorship module, sometimes we vary the method from the panel-led discussion. One of the methods is to have student trainees interview one or more potential supervisors. Postdocs already have their supervisor, but it is useful with beginning graduate students. It became a required activity for the new students in computer science within the EECS department at MIT, when I offered the modules there. Albert Meyer, and I created sample questions for those interviews, <http://onlineethics.org/reseth/mod/sampques.html>. If the supervisors did not like these questions, they could take it up with us, rather than the students. Now that the questions are on the web, students at other institutions may be able to use them to start their own conversations with their thesis supervisor or departmental advisor. That may make it easier for students elsewhere to get answers to such questions.

Some faculty may refuse to answer the questions of course. Indeed, in collaborating on an ethics statement on responsible research conduct for an illustrious scientific group, I recall one collaborator saying that there was no way he would let his students ask him these questions on

apportioning credit. He said that if trainees were going to work with him, they would just have to trust him. I think we do need to make senior investigators more articulate. Sometimes a faculty member refuses to discuss things with students because he or she does not know how to speak about the issues. Some very smart investigators do not know how to begin to talk about research conduct. They do not like to do something badly. What they do not know how to do well, they avoid doing at all unless they are given an opportunity to learn. We want to give them that opportunity, wherever they are.

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