

## **Building a Community of Ethics Educators in Graduate Engineering Programs: Developing an Ethics Workshop Following a User-Oriented Approach**

### **Dr. Xiaofeng Tang, Pennsylvania State University, University Park**

Xiaofeng Tang is a postdoctoral fellow in engineering ethics at Penn State University. He received his Ph.D. in Science and Technology Studies from Rensselaer Polytechnic Institute.

### **Eduardo Mendieta, Pennsylvania State University, University Park**

Eduardo Mendieta is professor of philosophy and acting director of the Rock Ethics Institute at Penn State University

### **Dr. Thomas A. Litzinger, Pennsylvania State University, University Park**

Thomas A. Litzinger is Director of the Leonhard Center for the Enhancement of Engineering Education and a Professor of Mechanical Engineering at Penn State. His work in engineering education involves curricular reform, teaching and learning innovations, assessment, and faculty development. Dr. Litzinger has more than 50 publications related to engineering education including lead authorship of an invited article in the 100th Anniversary issue of JEE and for an invited chapter on translation of research to practice for the first edition of the Cambridge Handbook of Engineering Education Research. He serves as an Associate Editor for *Advances in Engineering Education* and on the Advisory Board for the *Journal of Engineering Education*. He was selected as a Fellow of ASEE in 2008 and of ASME in 2012. He holds a B.S. in Nuclear Engineering from Penn State, an M.Eng. in Mechanical Engineering from RPI, and a Ph.D. in Mechanical and Aerospace Engineering from Princeton.

# **Building a Community of Ethics Educators in Graduate Engineering Programs: Developing an Ethics Workshop Following a User-Oriented Approach**

## **Abstract**

Ethics education in undergraduate engineering programs tends to focus on ethical issues that arise in the professional context. By contrast, ethics education for graduate students in engineering often addresses different kinds of ethical challenges, ones that relate to norms and expectations in the research community as well as the broad social impact of engineering research. In recent years, leading organizations such as the National Science Foundation (NSF), the National Institutes of Health (NIH) and the National Academy of Engineering (NAE) have made significant efforts to promote ethics training for graduate researchers. In spite of these concerted efforts, few sustainable models for incorporating ethics in graduate engineering programs have been described in the literature. As designers of ethics education programs, we argue that considerable progress can be achieved through engaging and empowering our users—the engineering faculty members who teach graduate courses and advise graduate students in research groups.

This paper presents a user-oriented approach to building a community of ethics educators in graduate engineering education. We begin the paper by reporting our “user study” of engineering faculty’s current approaches, challenges, and needs for teaching ethics to graduate students at a large, public research university. Findings of the user study guided our design of a workshop on “Ethical Literacy and Ethical Data Management” that helped engineering faculty members develop conceptual understanding and instructional skills for teaching ethical inquiry that are related to particular areas of engineering research.

Design of the workshop sought to meet three objectives: 1) helping participating faculty members develop basic understanding of ethical theories and concepts; 2) introducing ethical issues related with engineering research, especially with the handling of research data; 3) sharing and demonstrating instructional methods for leading discussion-based ethical analysis.

Feedback from the workshop participants and their subsequent presentations of ethics teaching plans indicate that our user-oriented approach successfully engaged a cohort of ethics educators in graduate engineering programs. We conclude this paper by reflecting on the lessons we learned from the workshop design and reporting our plans for refining the workshop in the future.

**Keywords:** Graduate Ethics Education, Faculty Development, Engineering Ethics

## **1. Introduction**

The current ABET Engineering Accreditation Criterion 3, Student Outcomes, includes “an understanding of professional and ethical responsibility”[1]. Thanks to this requirement, engineering schools in the U.S. have integrated ethics into their undergraduate curricula, and a number of them have achieved impressive success [2].

However, it is unclear whether ethics education in undergraduate engineering adequately prepares students for ethical challenges they might encounter as graduate students. After all, engineering ethics education at the undergraduate level often focuses on ethical issues that arise in the professional context. By comparison, graduate students in engineering face ethical challenges of different sorts, such as norms in the research community and the broad social impact of engineering research. In recent years, leading organizations such as the National Science Foundation (NSF), the National Institutes of Health (NIH) and the National Academy of Engineering (NAE) have made significant efforts to promote ethics training for graduate researchers [3]. In spite of these concerted efforts, few sustainable models for incorporating ethics in graduate engineering programs have been described in the literature. In this paper, we explore a key factor in establishing effective and sustainable graduate ethics education in engineering: the engagement of faculty members who teach graduate courses and advise graduate students in research groups. In particular, we describe a user-oriented approach for faculty development in ethics education, one that places faculty's needs at the center of designing a workshop that helped engineering faculty members develop conceptual understanding and instructional strategies to introduce ethical inquiry to graduate students. We engaged engineering faculty at multiple stages throughout the workshop development. Prior to the workshop design, we conducted a user study. Findings of the study laid the groundwork for a conversation with engineering graduate program coordinators in which we asked for their input on the topics of a faculty workshop. One of the primary objectives of this project was to develop a "community of practice" among engineering faculty members who would actively and consistently engage in discussions and practices of ethics teaching at the graduate level [4].

## **2. A User-Oriented Approach to Engineering Ethics Education**

Previous research has recognized the critical role engineering faculty members play in educating students about engineering ethics [5][6]. Such recognition, however, contrasts with a general trend in engineering education: faculty members are usually slow and reluctant in adopting research-based pedagogical practice, a trend that challenges numerous designers of educational innovations [7] [8] [9]. In particular, scholars have reported that educational innovations that follow a "replication model," in which faculty members passively accept and adopt pedagogical innovations designed by educational researchers, have very limited effect in generating faculty engagement [10]. Instead, researchers suggest, research-based pedagogical innovations are more successful when they are foregrounded in user (faculty) needs, and when the development process involves active participation by the end users (faculty) [7] [11] [12] [13]. As a starting point of a "user-oriented" approach to education design, "the research team developing a new practice must understand the needs of potential users before beginning their research" [7].

The ethics related educational innovation reported in this paper took place at the Pennsylvania State University (Penn State)—a large, public, research university. A decade-long partnership between the Rock Ethics Institute and the Leonhard Center for the Enhancement of Engineering Education at Penn State has led to multiple workshops

that helped engineering faculty members to incorporate ethics into undergraduate engineering teaching [14]. In 2009, Penn State implemented a new scholarship and research integrity (SARI) program that required all graduate students in the university to complete the online Collaborative Institutional Training Initiative (CITI) course as well as five hours of face-to-face, discussion-based training in topics that fall into the broadly conceived area of research ethics. The university also requires that at least three of the five hours of discussion-based ethics training ought to be conducted in the students' own disciplines. In 2014, five years after implementing the SARI program, the Leonhard Center and the Rock Ethic Institute launched a project to enhance engineering departments' existing practices for meeting the SARI requirements and educating graduate students in ethics.

The lead author of this paper interviewed graduate program coordinators from nine engineering departments to explore the following topics:<sup>1</sup>

- 1) The department's current approach to educating graduate students in ethics;
- 2) The types of ethical issues graduate students in the program should be able to address;
- 3) Major challenges and perceived needs for enhancing graduate ethics education in the program.

Interviews were conducted in the Spring semester of 2015. The interviews lasted between 30 and 45 minutes. With IRB approval, the interviews were recorded and transcribed. Results of the user-study led to three main findings. First, the departmental SARI training for graduate students in engineering took one of the three formats: 1) a one-credit course on graduate professional development that includes ethics components; 2) dedicated ethics discussion events, such as a specific session following the graduate orientation, or an evening gathering during which students watch and discuss movies related to engineering ethics; 3) seminar talks focusing on ethics topics. Second, from the standpoint of graduate educators, graduate students across all engineering disciplines most commonly encounter three types of ethical challenges: authorship practice, data management, and intellectual property issues. Third, main challenges for graduate ethics education in engineering included low incentive for faculty engagement, lack of dedicated departmental resources, and faculty's lack of formal training in ethics instruction. It is worth noting that all three challenges involved faculty's motivation, availability, and capacity for teaching ethics.

During a "report back session" with graduate program coordinators in the College of Engineering, the authors shared the main findings of the user-study and proposed three initiatives to address these challenges. First, the authors suggested the graduate program coordinators and their department heads consider appointing a faculty member as dedicated SARI coordinator and offering this person one course release in exchange for three years of service. Second, the Rock Ethics Institute and the Leonhard Center offered to create a series of online learning modules in order to help faculty and students examine cross-cutting ethical issues in engineering research. Third, the authors proposed to create a series of workshops that would help engineering faculty members develop basic understanding of ethical theories and instructional strategies for teaching ethics to

---

<sup>1</sup> In two cases, the interviewees were faculty members who had experience teaching ethics to graduate students.

graduate students. In addition, we proposed to build each workshop around one of the three major ethical challenges—authorship practice, data management, and intellectual property—that are confronted by graduate students across engineering disciplines. We also asked the engineering graduate program coordinators to provide input on the topic for the first year’s workshop, and the majority of graduate coordinators “voted” for ethical data management.

### 3. Developing a Faculty Workshop in Ethical Literacy and Ethical Data Practice

With input from the engineering graduate program coordinators, we designed and ran our first ethics workshop in the summer of 2016. The workshop helped twelve engineering faculty members engage the ethical literacy framework and develop instructional strategies to introduce ethical data practice to graduate students. The format of the workshop was modeled after the Rock Ethics Institute and the Leonhard Center’s previous workshops at Penn State University, which were adapted from workshops philosopher Davis had organized at the Illinois Institute of Technology [15]. The design of our workshop sought to meet three objectives: 1) helping participating engineering faculty members develop basic understanding of ethical theories and concepts; 2) introducing ethical issues related with engineering research, especially with the handling of research data; and 3) sharing and demonstrating instructional methods for leading discussion-based ethical analysis. According to these objectives, the two-day workshop consisted of three main sections: a morning presentation and discussion on basic ethical concepts and the ethical literacy framework; an afternoon session on resources for teaching ethical data practice; and an introduction of instructional design strategies that focused on creating ethics learning outcomes for graduate engineering students (A sample agenda for the two-day workshop is presented in Table 1). To illustrate leading discussion-based ethical inquiry, the workshop leaders also engaged the participants in extensive discussion and analysis of two ethical cases related to the handling of data in research and development.

**Table 1 Sample Agenda for the Ethics Workshop**

<b>DAY ONE</b>	
8:30 to 9:00	Breakfast
9:00 to 9:30	Introductions and overview of workshop
9:30 to 10:00	Collective conversation: Ethical issues in engineering research and data generation, management and use
10:00 to 12:00	Ethical literacy framework <ul style="list-style-type: none"> <li>• Discussion of major ethical theories</li> <li>• Introducing a step-based process for analyzing ethical issues</li> </ul>
12:00 to 1:00	Lunch
1:00 to 3:30	Teaching and learning resources for ethical data management <ul style="list-style-type: none"> <li>• Introducing the “ecology of data”</li> <li>• Existing and emerging resources for teaching ethical data practice</li> <li>• Case analysis</li> </ul>
<b>DAY TWO</b>	
8:30 to 9:00	Breakfast
9:00 to 9:30	Questions/discussion from Day 1.
9:30 to 12:30	Case discussion (role play).
12:30 to 1:30	Lunch
1:30 to 2:30	Learning outcomes for SARI training and data management

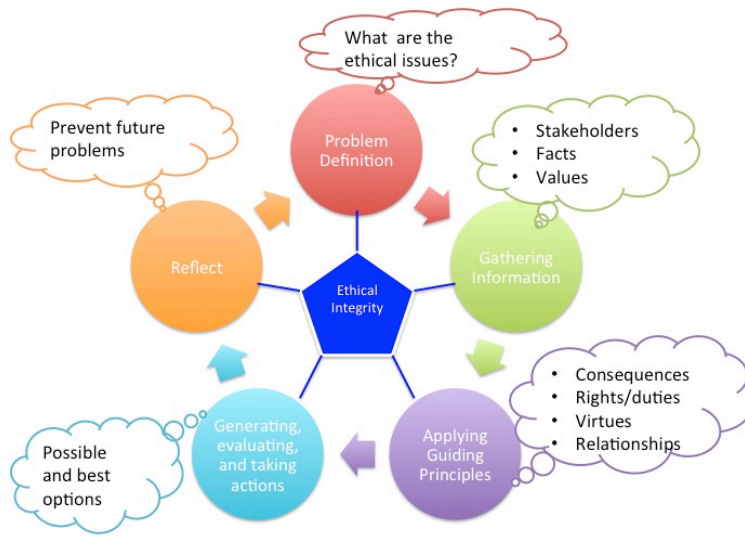
	<ul style="list-style-type: none"> <li>• Discuss overall goals for SARI training in the College of Engineering and program specific goals for ethics education</li> <li>• Develop statements of possible learning outcomes</li> </ul>
2:30 to 3:30	Small groups work on preliminary instructional designs based on common interests (e.g., SARI training, graduate courses, other ethics education programs)

### ***The Ethical Literacy Framework***

To familiarize engineering faculty members with basic concepts and terminology in ethical theories, one of the authors gave a presentation on the development of ethical literacy. We explained to the engineering faculty participants that this presentation was meant to lay the groundwork for them to think about ethics instruction, and we did not recommend—let alone require—them to directly present the “theory-heavy” contents to engineering students. Inspired by Tuana’s systematic interpretation of moral literacy, the ethical literacy framework emphasizes ethical sensitivity, ethical decision making, and ethical imagination [16]. Our presentation focused on helping the participants develop basic understanding of ethical sensitivity and ethical decision making. Ethical sensitivity refers to an individual or a group’s abilities to discern ethical issues in a given situation, assess the intensity of ethical issues, and identify relevant ethical values [16] [17]. We stressed that ethical inquiry in engineering often starts with identifying the ethical issues (“ethics spotting”). Ethical decision making includes understanding different ethical frameworks and applying them to a perceived ethical situation. In order to make the presentation as effective as possible, given the short time available, we avoided traditional philosophical labels such as deontology, that were likely to be unfamiliar, and quickly moved to examples to illustrate major ethical frameworks, such as character-based frameworks, ends-based frameworks, rule-based frameworks, and rights-based frameworks. In addition, we introduced a 12-step approach for enhancing ethical literacy and analyzing ethical challenges. The step-based approach to analyzing ethical cases has been developed and adapted by several ethicists [15]. We adopted the 12-step approach from the Rock Ethics Institute [18]. This approach involves iteratively going through the next 12 steps:

- “1.State the nature of the ethical issue you’ve initially spotted.
- 2.List the relevant facts.
- 3.Identify stakeholders.
- 4.Clarify the underlying values.
- 5.Consider consequences.
- 6.Identify relevant rights/duties.
- 7.Reflect on which virtues apply.
- 8.Consider relevant relationships.
- 9.Develop a list of potential responses.
- 10.Use moral imagination to consider each option based on the above considerations.
- 11.Choose the best option.
- 12.Consider what could be done in the future to prevent the problem” [18].

To indicate to the engineering audience that the process for ethical decision making resembles the process of solving open-ended design challenges in engineering—a process many an engineer is well familiar with—the authors rearranged the 12 steps into a 5-stage process using the language of engineering design (see Figure 1).



1

**Figure 1 A Design-based Process for Ethical Reasoning**

### ***Teaching Ethical Data Practice***

The afternoon session of the first day’s workshop introduced resources and strategies for engaging engineering graduate students to explore ethical issues that are associated with the handling of research data. We started this session by presenting six fictitious “statements about data management” that represent ethically questionable views about data from new graduate students, junior faculty members, PIs, and practicing engineers. For example, a fictitious PI states that “I have thoroughly informed my graduate students, lab technicians, and statisticians about the proper ways of handling data; therefore, I should not be held accountable if issues about the credibility of research data arise in our co-authored publications.” These statements served as “prompts” to generate open-ended discussions about data ethics in classrooms.

Following the “warm up” discussion, one of the authors introduced two concepts: “the ecology of data” and “the lifecycle of research data.” These concepts were meant to extend discussion about ethical data practice beyond “management,” which implies control, hierarchy, and clearly defined rules and obligations. Instead, we recommended the concept of “ecology,” which describes the human and non-human actors, values, institutions, as well as technical infrastructures that interact with data in distinct ways and collectively shape the ethical implications of data practice. Our presentation of the “ecology of data” was inspired by the use of “information ecology” in information management [19] [20]. Meanwhile, we stressed the lifecycle of research data to counteract the misunderstanding of data handling as a linear process [21]. We proposed a lifecycle of research data consisting of four interrelated stages: 1) data planning; 2) data generation; 3) data processing and analysis; and 4) data usage, sharing, and preservation. The presentation discussed a few distinct ethical challenges confronting researchers in each of the four stages, such as protecting research subjects in data generation, and intellectual property issues in data sharing. In addition to the four stages that usually characterize the “internal” flow of data in the research group, we added an additional category, the ethics of big data research.

### ***Case Discussion***

Discussion during the workshop culminated in the analysis of two ethical case studies, which are based on recent, real-world incidents in the academic community and the tech industry. The first case focuses on issues of responsible conduct of research, or “micro-ethical issues” in research [22] [23] [24]. We created the case based on a recent controversy in stem cell research, where a research group in Japan’s Riken Center for Developmental Biology published two articles in *Nature* that reported a simple and efficient method of making stem cells out of ordinary body cells. Soon after the publication, however, readers found the articles contain inappropriately manipulated images and texts copied from previous papers. A greater scandal followed when no lab was able to replicate the experiments reported in the *Nature* articles and their authors were accused of fabricating data [25]. During the workshop, discussion of this case was structured following the 5-step process illustrated in Figure 1. Based on the available information, most participants identified data fabrication as one of the central ethical problems in this case. As the analysis proceeded, our participants in turn examined the obligations of the PI, the lab directors, and the editorial group of the journal. The analysis also drew from a number of ethical frameworks; for example, a rule-based analysis highlighted honesty as a duty for researchers, whereas an ends-based analysis called attention to the waste of resources in replicating inauthentic research results. It was interesting to observe that some faculty participants became very invested in the case analysis. A participant who originally came from Japan shared the latest coverage of this incident in Japanese news media. It was reported that Haruko Obokata, a female researcher who allegedly fabricated the results, was actually victimized by a jealous male colleague who sabotaged the experiment. Another participant, who works in the field of stem cell research and whose lab had also attempted to replicate the published research, shared the stem cell research community’s assessment of this case. During the discussion of the case a female participant commented that the case described a female researcher as the “wrongdoer.” She also observed that most of the moral philosophers cited in the morning session, when we introduced major ethical frameworks, were male. Her comments made an impression on all of us who were facilitating the workshop. We were unaware that our discussions of the frameworks and the case might result in an impression of gender-bias. We had intended to illustrate that individual research misconducts often reflect institutional and systemic ethical problems. As a team of all-male workshop leaders, we also learned a rich lesson from this participant’s comment.

We had selected the second case to illustrate the broad impact of big data research and development, or what is called macro-ethical issues in data technology [22] [23] [24]. In early 2016, federal officers of national security met with leaders of major IT companies to discuss ways of fighting terrorism on social networks. The proposals discussed at the meeting included algorithms that would allow social networking users to “flag” radical posts, and the algorithms would then assign these posts a score of “radicalization” [26].

Instead of distributing a written case, we played a short audio clip from WNYC in which the host interviewed a national security expert about legal challenges facing the proposed “security algorithms” [27]. After listening to the six-minute interview, the

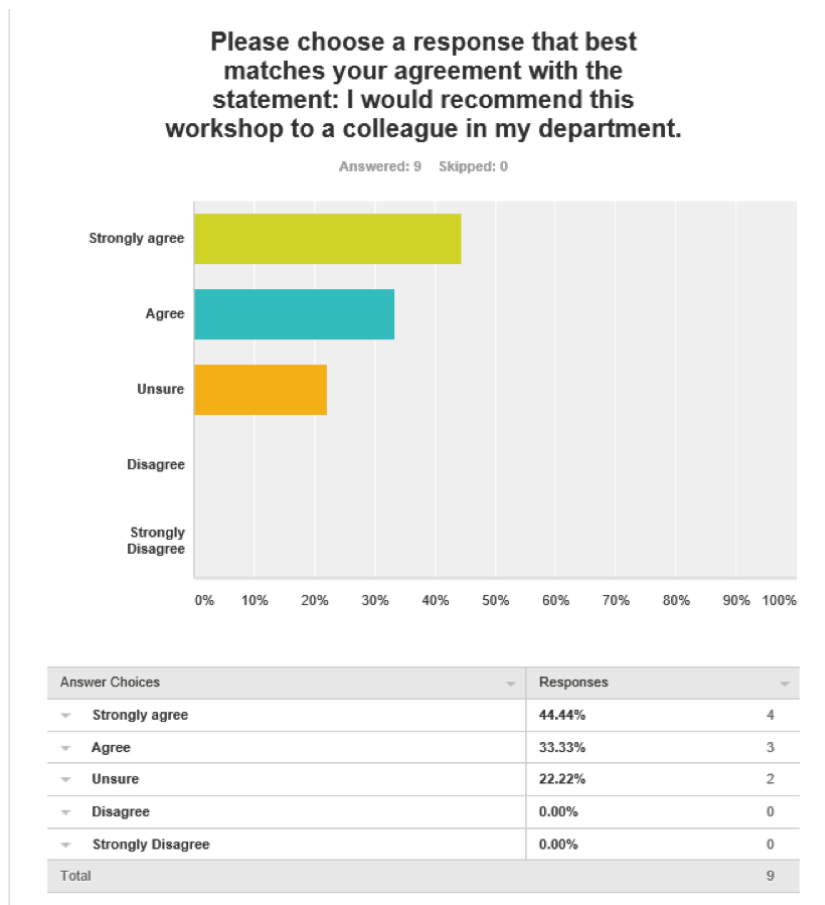


participants applied the 5-step method to analyze the proposal of security algorithms. The faculty participants identified a broad range of ethical problems, such as the unclear—and potentially overbroad—definition of terrorism in the proposal, the unfairness of targeting social networks among various means of spreading terrorism, challenges in accurately assigning a “radicalization score,” as well as impingement on social networking users’ privacy. The participants also identified the IT companies, social networking users, the government, terrorists, and ordinary citizens as stakeholders in this case. After defining the ethical problems and gathering information about relevant stakeholders, facts, and values, we asked the participants to “role play” one of three stakeholder groups: IT companies, citizens, and governmental agencies. We invited each group to develop a list of actions based on the values and principles embraced by its stakeholders. The exercise sparked a lively discussion and generated a number of creative solutions. The group representing IT companies prioritized a trusting relationship with their customers—social networking users. Accordingly, this group proposed to conduct a feasibility study to understand how the security algorithms will impact their customers. The citizens group suggested that the ultimate decisions should be made by individual citizens; i.e., every one of them will have to decide whether and how to use social networking had the security algorithms become a reality. The group that represented governmental agencies stressed transparency in the algorithm development; they also pointed out the importance to balance security and civil rights.

### ***Assessment and Follow-up***

To gather faculty participants’ perception of the workshop, we set up a post-workshop survey on SurveyMonkey. Nine participants (out of twelve) voluntarily completed the survey. The results (Figure 2) indicate that seven out of the nine respondents strongly agreed or agreed that they would recommend this workshop to colleagues in their own departments, and two respondents were unsure if they would do the same.

To ensure continued discussion and to maintain a community of ethics educators, we invited the faculty participants to get together one month after the workshop and to present their plans of incorporating ethics in their educational activities during the following academic year. Prior to face-to-face presentation, the participants uploaded their teaching plans to a shared online folder. In a day-long session, each participant introduced their teaching plan and received feedback from their peers and the workshop leaders. At the end of the following academic year, the faculty participants will gather again to share their experiences implementing their ethics teaching plans.



**Figure 2 Post-workshop Survey Results**

#### **4. Discussion and Conclusion**

This paper reports our effort to create a community of ethics educators for graduate students in engineering. Following a user-oriented approach, we grounded our educational design firmly on engineering faculty’s perceived challenges and needs for educating graduate students about ethics. Based on inputs from faculty and graduate program coordinators, we designed a workshop that helped participants understand the ethical literacy framework and develop instructional strategies to introduce ethical data practice from an “ecological” perspective. The workshop also demonstrated a method for ethical reasoning by engaging the participants in extensive discussion of two cases about controversial handling of data in academic research and industrial development. A post-workshop survey indicates that the majority of the participants find the workshop valuable. As of this writing, the faculty participants are implementing their ethics teaching plans, developed as part of the deliverables of the workshop.

Reflecting on this project, we have learned three main lessons. First, faculty’s pedagogical needs provide a potent guide for designing educational interventions in ethics that engage the faculty users. Following the recommendations of literature, we intentionally avoided a “replication model” and instead focused on the needs of our end users—the engineering faculty members—throughout this project [10]. This strategy

proved powerful in getting access to faculty interviews, inviting them to review and brainstorm about the interview results, and eventually attracting faculty to participate in the workshop.

Second, given the overall “buy-in” of faculty members who participated in the workshop, we also observed varied intellectual interests among the participants. While some participants actively asked questions and engaged in discussions during the presentation about basic ethical theories and concepts, others were more engaged during the case discussions. The “role-play” during the second case analysis successfully engaged all of the participants. We also found it helpful to provide a structured process for analyzing ethical cases while giving the participants sufficient flexibility to direct the discussion.

Third, the workshop also provided rich opportunities for us to learn as educational designers. In particular, participants’ comments drew our attention to the cultural and gender representation of actors in ethical cases. We learned that considerate and balanced representation of culture and gender is both an educational issue, as it impacts the engagement of workshop participants, and an ethical issue, for such representation might implicitly communicate unchallenged assumptions.

Moving forward, we are pursuing the following steps as a way of extending this project. First, during the post-workshop presentation of teaching plans, a number of faculty participants expressed a need for flexible and effective tools to assess the impact of ethics instruction. We will explore appropriate assessment tools and share them at future workshops. Second, currently we are developing an online module on ethical data practice. Built around “the ecology of data,” the module will support faculty members to lead “flipped classroom” style discussion about ethical issues related to the handling of research data.

### **Acknowledgements**

This work is supported by gifts from Chick and Joan Rolling and by the endowments of the Rock Ethics Institute and the Leonhard Center for the Enhancement of Engineering Education at the Pennsylvania State University. The authors would like to thank Jonathan Beever, program chair for the ASEE Engineering Ethics Division, and anonymous reviewers for constructive feedback on prior drafts of this paper.

### **References**

- [1] ABET Engineering Accreditation Commission. 2015. “Criteria for Accrediting Engineering Programs: Effective for Reviews During the 2016-2017 Accreditation Cycle.” ABET.
- [2] Center for Engineering, Ethics, and Society, National Academy of Engineering. 2016. *Infusing Ethics into the Development of Engineers: Exemplary Education Activities and Programs*. The National Academies Press.

- [3] Benya, F. F., Fletcher C. H., and Hollander R. D., eds. 2012. *Practical Guidance on Science and Engineering Ethics Education for Instructors and Administrators: Papers and Summary from a Workshop*. The National Academies Press.
- [4] Wenger, E. 1998. *Communities of Practice: Learning, Meaning, and Identity*. Cambridge University Press.
- [5] Colby, A., and Sullivan, W. M. 2008. "Ethics Teaching in Undergraduate Engineering Education." *Journal of Engineering Education* 97 (3): 327–38.
- [6] Hollander, R., and Arenberg, C. R., eds. 2009. *Ethics Education and Scientific and Engineering Research: What's Been Learned? What Should Be Done? Summary of a Workshop*. The National Academies Press.
- [7] Litzinger, T. A., and Lattuca, L. R. 2014. "Translating Research to Widespread Practice in Engineering Education." In A. Johri, and B. M. Olds eds. *Cambridge Handbook of Engineering Education Research*. Cambridge University Press.
- [8] Borrego, M., Froyd, J. E., & Hall, T. S. 2010. Diffusion of Engineering Education Innovations: A Survey of Awareness and Adoption Rates in US Engineering Departments. *Journal of Engineering Education*, 99 (3), 185-207.
- [9] Sheppard, S. D., Macatangay, K., Colby, A., & Sullivan, W. M. 2008. *Educating Engineers: Designing for the Future of the Field*. Jossey-Bass.
- [10] Bodilly, S. J., Glennan, T. K., Kerr, K. A., and Galegher, J. R. 2004. "Introduction: Framing the Problem." In T. K. Glennan, S. J. Bodilly, J. R., Galegher, and K. A. Kerr eds. *Expanding the Reach of Education Reforms: Perspectives from Leaders in the Scale-Up of Educational Interventions*. Rand Education.
- [11] Cohen, D. K., and Ball, D. L. 2007. "Educational Innovation and the Problem of Scale." In B. Schneider and S. McDonald, eds. *Scale-up in Education: Ideas in Principle*. Rowan & Littlefield Publishers, Inc.
- [12] Glennan, T. K., Bodilly, S. J., Galegher, J. R., and Kerr, K. A. 2004. "Summary: Toward a More Systematic Approach to Expanding the Reach of Educational Interventions." In T. K. Glennan, S. J. Bodilly, J. R., Galegher, and K. A. Kerr eds. *Expanding the Reach of Education Reforms: Perspectives from Leaders in the Scale-Up of Educational Interventions*. Rand Education.
- [13] Dearing, J. W. 2009. "Applying Diffusion of Innovation Theory to Intervention Development." *Research on Social Work Practice* 19 (5): 503-518.
- [14] Litzinger, T., Christman, J., Lau, A., Tuana, N., and Wise, J. 2003. "Learning and Teaching Ethics in Engineering: Preparing Engineering Faculty to Teach Ethics." In Proceedings of American Society for Engineering Education Annual Conference.
- [15] Davis, M. 1993. Ethics Across the Curriculum: Teaching Professional Responsibility in Technical Courses. *Teaching Philosophy* 16(3): 205-235.
- [16] Tuana, N. 2007. Conceptualizing Moral Literacy. *Journal of Educational Administration* 45(4): 364-378.
- [17] Mendieta, E. 2016. "Engineering Ethics for Graduate Education." <http://www.onlineethics.org/File.aspx?id=36425&v=3adcf41>.
- [18] Rock Ethics Institute. 2017. "12-Step Approach: From Moral Literacy to Ethics Spotting." <http://stem-researchethics.org/ru001/node/102>.
- [19] Davenport, T. H. 1997. *Information Ecology: Mastering the Information and Knowledge Environment*. Oxford University Press.
- [20] Treloar, A. 2012. "Conceptualising Collaboration and Competition in the Changing Ecology of Research Data." Online Presentation. <http://www.slideshare.net/atreloar/research-data-ecology>.

- [21] Chisholm, M. 2015. "7 Phases of A Data Life Cycle." <http://www.information-management.com/news/data-management/Data-Life-Cycle-Defined-10027232-1.html>.
- [22] Herkert, J. R. 2001. "Future Directions in Engineering Ethics Research: Microethics , Macroethics and the Role of Professional Societies." *Science and Engineering Ethics* 7 (3): 403–14.
- [23] Ladd, J. 1985. "The Quest for a Code of Professional Ethics: An Intellectual and Moral Confusion." In *Ethical Issues in the Use of Computers*. Wadsworth Publ. Co.
- [24] Tuana, N. 2013. "Embedding Philosophers in the Practices of Science: Bringing Humanities to the Sciences." *Synthese* 190 (11): 1955–73.
- [25] Rasco, J. and Power, C. 2015. "What Pushes Scientists to Lie? The Disturbing but Familiar Story of Haruko Obokata." *The Guardian*. <https://www.theguardian.com/science/2015/feb/18/haruko-obokata-stap-cells-controversy-scientists-lie>.
- [26] Hill, K. 2016. "The Government Wants Silicon Valley to Build Terrorist-spotting Algorithms. But Is It Possible?" *Fusion*. <http://fusion.net/story/255180/terrorist-spotting-algorithm/>.
- [27] "Detecting Terrorism Online Raises Legal Questions." WNYC. <http://www.wnyc.org/story/terrorism-algorithm-legal/>.