AC 2012-4208: ETHICS EDUCATION AND RESOURCES: A SUMMARY OF ISSUES FACING THE FIELD AND RESOURCES TO ADDRESS THEM

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Taft H. Broome, Jr., is a professor of civil engineering at Howard University. He holds a Sc.D. degree in civil engineering and a M.S. degree in engineering ethics. He publishes regularly in engineering dynamics, engineering ethics, and philosophy of engineering literature, and has served in positions of national leadership in 12 scholarly societies, including the AAAS, Sigma Xi, AAUP, and the ASEE. He is a Fellow of the AAAS, the 2011 recipient of the ASEE Olmsted Award, a Fellow of the Rensselaer Alumni Association, a member of the editorial board of Science & Engineering Ethics, and a Founding Editorial Board Member of Engineering Studies.

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Legand L. Burge, Jr. is Dean of the College of Engineering and professor of electrical engineering at Tuskegee University. He received his B.S., M.S., and Ph.D. in electrical engineering from Oklahoma State University in 1972, 1973, and 1979, respectively. He has served on the faculty of George Washington University, Tuskegee, Regis College, Johns Hopkins, Bowie State University, and the U.S. Air Force Academy, and now as Dean since 1999 at Tuskegee University. In this position, he is responsible for efficient and effective operations of the college. Burge brings leadership to more than 700 students, 66 faculty, and 21 staff members, and effective and efficient management of a modest research and development program for the college. The college continues to be a top 10 producer of engineering graduates who possess the technical talent to compete in industry, government, and academia. Prior to joining Tuskegee, Burge was Dean at the Defense Systems Management College (DSMC), Vice Commander of Air Force Reserve Officer Training Corps (AFROTC), member of the Defense Secretary and Air staffs, Pentagon, Division Chief, National Security Agency (NSA), and Operations Officer for Secretary of the Air Force Special Projects. The Air Force held his services for 27 years, and retired Burge as Colonel (O-6) in 1999. He has served on the advisory board for the National Science Foundation (NSF) Engineering Directorate, the Advisory Committee on Government Performance Assessment, Northwestern University McCormick School of Engineering, Advancing Minorities' Interests In Engineering (AMIE), Historically Black Colleges and Universities (HBCU) Council of Deans of Engineering, and the National Society of Professional Engineers (NSPE). He served on the National Academy of Engineering (NAE) Study on the Engineering Studies at Tribal Colleges. He is the author of numerous articles and has served as a member of the American Society of Engineering Education Engineering (ASEE) Deans' Council (EDC) Public Policy Committee. Burge was elected to the ASEE Engineering Deans Council Executive Board. As part of the EDC, Burge chaired the EDC Committee on Diversity; served as a member of the ASEE Engineering Deans Institute (EDI) Colloquium Committee; and served as a member of the EDC K-12 Engineering Task Force. He continues to be an active transformational leader using his experience in national defense, academia, and the information technology industry to affect a dynamic program.

Dr. Rachelle Hollander, National Academy of Engineering

Rachelle Hollander directs the National Academy of Engineering's Center for Engineering Ethics and Society (CEES). CEES manages the NAE Online Ethics Center (http://www.onlineethics.org/). For many years, Hollander directed the science and engineering ethics activities at the National Science Foundation. In 2006, Hollander received the Olmsted Award "for innovative contributions to the liberal arts within engineering education" from the American Society of Engineering Education's Liberal Education Division. Hollander is a Fellow of the AAAS and currently a member of the Governing Board of the Association for Practical and Professional Ethics. She has been instrumental in the development of the fields of research

ethics and professional responsibility, engineering ethics, and ethics and risk management and is currently principal investigator on two NSF-funded projects.

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Michael C. Loui is a professor of electrical and computer engineering and University Distinguished Teacher-Scholar at the University of Illinois, Urbana-Champaign. His interests include computational complexity theory, professional ethics, and the scholarship of teaching and learning. He serves as Executive Editor of College Teaching, and as a member of the editorial board of Accountability in Research. He is a Carnegie Scholar and an IEEE Fellow. Loui 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 to 1991. He earned the Ph.D. at MIT in 1980.

Ethics Education & Resources: A summary of issues facing the field and resources to address them

Introduction

The United States Congress has mandated that ethics education in STEM be a priority. In addressing this priority, there are many challenges. Undergraduate engineering programs have begun to address this by meeting ABET accreditation expectations. Graduate students, post-docs and current faculty have not necessarily had the same experience. Broadening our understanding of the audience of learners and the potential settings for learning about ethics is a first step in reaching this priority. Teaching ethics to engineers goes beyond responsible conduct of research, although resources can be shared and can be used to broaden the conversations educators have with undergraduate and graduate students. Next steps include the ongoing development of resources that support this learning throughout academic and professional engineering careers and the fostering of conversations that include the diverse perspectives and experiences of engineers, whether students, faculty or professionals in the field. This paper provides information about available resources as well as framing the discussion of key issues facing ethics education today.

There is clearly a need for resources to support engineering educators who teach ethics. While many institutions and individual faculty have developed courses and programs, it is not yet pervasive in our community. Research has shown that incorporating education components like professional skills, writing, and ethics across the engineering curriculum makes the most sense for learning in context. However, very few engineering faculty feel competent in teaching these important career skills, especially when there is little enough time to teach the expected technical content. Gathering the disparate tools and resources and building communities of practice will help address this.

The key questions that are addressed here (and in the panel) include:
What are barriers to incorporating ethics education into engineering programs?
What tools are available to address these barriers?
How can we support a community of practitioners learning and teaching ethics?

Barriers include education, experience, time, opportunity, institutional support and resources as well as many others. Tools include online resources as well as existing communities, supported through local, regional, national and international meetings. However, on a daily basis individual members face issues of "critical mass" and isolation on campuses. Creating affinity spaces for information sharing as well as providing a virtual meeting space can support this in more ways than simply providing content to faculty and students.

The paper includes information about two online resources supported by the National Science Foundation. The first is Ethics CORE and the second is the Online Ethics Center. These will be described below. The members of the panel discussion presented at the 2012 conference were Taft Broome, Legand Burge, Rachelle Hollander, and Michael Loui. They bring a variety of teaching, research and resource development perspectives to the conversation as well as a variety of institutional perspectives. The paper also includes brief biographies of the panelists and their

statements about their perspectives and experiences that were brought to the table. It is expected that the key elements of the conversation that extend beyond these statements will be preserved at the online forums.

Ethics CORE

The Ethics CORE (Collaborative Online Resource Environment) project is an Internet portal supporting ethics education in science, social science, engineering and math. It is being developed by National Center for Professional and Research Ethics at the University of Illinois-Urbana Champaign. The online environment consists of tools like searching, developing, and contributing resources, collaborative workspaces, discussion areas, wikis and blogs as well as essays on teaching and pedagogy, videos, online courses and links to other online resources. As a living site, all members of the engineering education community are encouraged to participate, whether by contributing resources or feedback, by actively participating in collaborative groups, or by using resources to enhance their teaching. The portal can be found at http://nationalethicscenter.org/.

NAE's Online Ethics Center for Engineering and Research

The Online Ethics Center, http://onlineethics.org, is a product of the National Academy of Engineering. It includes resources for responsible research, case studies, professional codes and guidelines, annotated bibliographies and a community of practitioners. Forums allow space for site users to learn more about the resource or to discuss particular case studies. In collaboration with Arizona State University, the center has expanded to include issues related to energy. The center also has a section on climate change.

Other Resources

Other online sources for engineering ethics education are also available, primarily in the form of case studies that can be used in classes. Some examples are:

- National Institute for Engineering Ethics, Cases from the National Society of Professional Engineers Board of Ethical Review: http://www.niee.org/cases/
- Texas A&M Engineering Ethics: http://ethics.tamu.edu/
- The Ethics Education Library at the Center for the Study of Ethics in the Professions at IIT: http://ethics.iit.edu/eelibrary/
- Penn State's College of Engineering Ethics website: http://www.engr.psu.edu/ethics/casestudies.asp
- Vanderbilt's Center for Ethics: http://www.vanderbilt.edu/CenterforEthics/cases.html#engineering

The Exploring Ethical Decision Making in Engineering (E^3) project is a multi-institution team exploring issues related to ethical development in engineering students. Results of their work can be used to guide institutional and teaching practice to support ethical development. More information and publications can be found at http://www.engin.umich.edu/research/e3/index.html.

Panelist Biographies

Taft H. Broome, Jr. is a Professor of Civil Engineering at Howard University. He holds the Sc.D. in civil engineering and the M.S. in engineering ethics. He publishes regularly in the engineering dynamics, engineering ethics, and philosophy of engineering literatures, and has served in positions of national leadership in twelve scholarly societies, including the AAAS, Sigma Xi, AAUP, and the National Academy of Engineering. He is a Fellow of the AAAS, a Fellow of the Rensselaer Alumni Association, 2011 recipient of the ASEE Sterling Olmsted Award, a member of the editorial board of *Science & Engineering Ethics*, and a Founding Editorial Board Member of *Engineering Studies*.

Legand L. Burge, Jr. is Dean of the College of Engineering and Professor of Electrical Engineering at Tuskegee University. He has served on the faculty of George Washington University, Tuskegee, Regis College, Johns Hopkins, Bowie State University and the United States Air Force Academy and since 1999 at Tuskegee University. His former positions include Dean at the Defense Systems Management College (DSMC), vice commander of Air Force Reserve Officer Training Corps (AFROTC), member of the Air Staff, Pentagon, and division chief, National Security Agency (NSA). The Air Force held his services for 27 years, and retired Dr. Burge as a colonel in 1999. He has served on the advisory board for the National Science Foundation (NSF) Engineering Directorate, Northwestern University McCormick School of Engineering, Advancing Minorities' Interests In Engineering (AMIE) and the National Society of Professional Engineers (NSPE). He served on the National Academy of Engineering (NAE) Study on the Engineering Studies at Tribal Colleges. He is the author of numerous articles and has served as a member of the American Society of Engineering Education Engineering (ASEE) Deans' Council (EDC) Public Policy Committee. In 2005 Dean Burge was elected to a first 2-year term on the ASEE Engineering Deans Council Executive Board, and re-elected in 2007. He chairs the EDC Committee on Diversity, is a member of the 2007 ASEE Engineering Deans Institute (EDI) Colloquium Planning Committee, and a member of the current EDC K-12 Engineering Task Force.

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Michael C. Loui is Professor of Electrical and Computer Engineering and University Distinguished Teacher-Scholar at the University of Illinois at Urbana-Champaign. His interests include computational complexity theory, professional ethics, and the scholarship of teaching and learning. He serves as Executive Editor of *College Teaching*, and as a member of the editorial board of *Accountability in Research*. He is also a member of the Advisory Group for

the Online Ethics Center at the National Academy of Engineering, and the Executive Board of the National Institute for Engineering Ethics. He is a Carnegie Scholar and an IEEE Fellow.

Rebecca Bates is serving as the moderator of the panel. She is a 2011-12 AAAS Science and Technology Policy Fellow at the Division of Engineering Education & Centers in the National Science Foundation. She incorporates ethics education in her teaching at Minnesota State University, Mankato where she is on leave from her faculty position with the computer science and Iron Range Engineering programs.

Panelist Statements

Rachelle Hollander lays out the scope of ethics and engineering and the important issue of communication and necessary skills for communicating ethical issues. Michael Loui describes barriers to teaching and ways to address them. Legand Burge presents the example of teaching ethics to engineers at Tuskegee University. Taft Broome discusses "storied teaching" where historical foundations of society are used to mediate perspectives on ethical issues.

Rachelle Hollander

Communicating and Research Ethics: Educators in research ethics have perhaps only recently begun thinking explicitly about communication as an important aspect of this field and recognizing the need to address communication in research ethics, to enable scientists and engineers to initiate and promote ethical programs, behaviors and choices. This presentation will identify some topics that might have priority and ways to acknowledge and develop these skills in engineering education.

What is engineering? According to Michael Davis, "Engineering should be defined historically, as an occupation, and ethically, as a profession. An engineer is … a member both of an occupation that is engineering by 'birth,' 'adoption,' or 'marriage' and of the profession committed to engineering's code of ethics."[1]

What is engineering ethics?

- Neither an occupation nor a profession.
- A field of inquiry (and practice?) with a distinctive history involving institutional commitments and demands, and conceptual and intellectual content.
- Evolved with the specializations characteristic of our modern era[2] and democratic demands.
- Differentiations: Micro and macro-ethics, or a focus on individual professional behavior (micro) or issues of science, engineering, and technology in society (macro).
- Differentiations (continued): From common morality to institutionally divided moral responsibility. [3]
- Views relevant to engineering ethics:
  - Professional, Research, Anticipatory Ethics[4]
  - Procedural, Extrinsic, Intrinsic Ethics[5]
- Professional (=Procedural) ethics tends to take the micro perspective.

- Anticipatory (Extrinsic + Intrinsic) ethics uses the macro perspective, emphasizes social responsibility.
- Research ethics (needs to) combine both.

What are the necessary skills that must be developed for desirable behavior?

- Framing the problem including ethical dimensions and issues; recognizing it is an iterative process
- Soliciting advice and opinions in problem development phase and throughout process as needed; developing communications strategies
- Identifying relevant stakeholders and socio-technical systems; collecting relevant data about them
- Understanding and evaluating relevant stakeholder perspectives
- Identifying value conflicts
- Constructing viable alternative courses of action or solutions and identifying constraints
- Assessing alternatives in terms of consequences, public defensibility, institutional barriers, etc.
- Engaging in reasoned dialogue or negotiations
- Revising options, plans, or actions

(Adapted from 2009 NAE Workshop Report.[6])

How to model appropriate conduct/behavior?

- The kinds of *active learning* that work well for teaching many subjects also work for teaching research ethics and developing communications skills; teaching tools are available at: www.onlineethics.org/Resources/TeachingTools.aspx
- Nothing substitutes for *engagement with scientists, engineers, and stakeholders* in examining associated issues in the lab or field or classroom.
- *Case development and assessment* often spark student interest. There are many kinds of cases to choose from.
- The OEC has a large collection of relevant cases in which communications issues are relevant.
- A new resource called Ethics CORE Digital Library: National Center for Professional and Research Ethics is coming on-line: http://nationalethicscenter.org

Michael Loui

Why do engineering faculty resist engineering ethics? And what can we do about it? To meet accreditation requirements, undergraduate engineering programs in the United States must include some instruction in engineering ethics. Although Davis[7] and Harris et al.[8] have explained why engineering faculty members should teach professional ethics, and how they can integrate ethics into engineering programs, mainstream engineering faculty members still resist engineering ethics. Sometimes engineering programs outsource the teaching of engineering ethics to departments of philosophy or of technology and society.

Why do engineering faculty members fail to embrace the teaching engineering ethics? I propose that they suffer from three mistaken beliefs.

Mistaken Belief #1: Expertise is necessary for teaching a subject. Most faculty members believe that college teaching consists of transferring information from experts to students; consequently, subjects should be taught by experts. In particular, as profession, engineering highly values technical expertise. Yet one of the dirty little secrets of the academy is that faculty members often teach outside their expertise.[9] For example, when they teach a survey course that introduces students to the breadth of a discipline, they may be experts in only one of the course topics. Although few engineering faculty members have any formal background in ethics, they can still teach engineering ethics successfully, as several exemplars have shown (e.g., Passino[10]).

Mistaken Belief #2: Ethics belongs to philosophy, not to engineering. Although applied mathematics is one of the standard branches of mathematics, all engineering disciplines have incorporated their mathematical foundations. For instance, linear system theory and control theory are taught in electrical engineering programs. Analogously, although ethics is one of the standard branches of philosophy, every professional program incorporates instruction in the special ethical responsibilities of its profession. Medical students learn the professional responsibilities of physicians; law students, the professional responsibilities of attorneys. Similarly, since engineering is a profession, engineering schools should teach the professional responsibilities of engineers. A fortiori, every profession is devoted to a public good: medicine to human health, law to justice in society. Consequently, ethics is central to every profession, including engineering.

Mistaken Belief #3: Only technical knowledge qualifies as engineering knowledge. Engineering faculty members are so accustomed to teaching technical subjects that they have difficulty accepting the notion of a nontechnical engineering subject, such as engineering ethics. Further, the culture of engineering valorizes the technical and disparages the nontechnical. Yet every profession includes both technical and nontechnical knowledge. Skilled physicians, for example, should not only understand the biochemical action of a drug, but should also know how to communicate the risks of the drug to patients.

The rare engineering faculty member who overcomes these three mistaken beliefs might be willing to teach engineering ethics. How can a new instructor of engineering ethics be effective? For newcomers, I can recommend several resources.

Instructors can choose from short textbooks[11,12] and full-length textbooks.[13,14] They can find supplemental resources, such as cases and scenarios, through two online ethics centers: the Online Ethics Center for Engineering and Research at the National Academy of Engineering (www.onlineethics.org), and Ethics CORE, a project of the National Center for Professional and Research Ethics at the University of Illinois at Urbana-Champaign (www.nationalethicscenter.org). The National Institute for Engineering Ethics (www.niee.org) offers videos that dramatize engineering ethics cases; see Loui et al.[15] and Loui et al.[16] for suggestions for using the two most recent NIEE videos.

Ethics CORE also supports several online communities. As of this writing, one of the online communities ("groups") is the Engineering Ethics Instructors group. Through online communities, instructors can share advice and help each other. In addition, the Engineering

Ethics Division of ASEE could organize a workshop for new engineering ethics instructors at each ASEE Annual Meeting.

Legand Burge

The work at Tuskegee University describes a course that has been offered to the engineering students during the past ten years. This course provides students with an understanding of: 1) the nature of engineering ethics, 2) the engineering activities in a societal context, and 3) the contemporary issues in the engineering profession. Moral complexities in the engineering profession have been highlighted through exposure to historical development, ethical reasoning, risk assessment, effects on environment, and global issues. Team projects are inserted for open-ended discussions and find solutions to the complexities of technology applications for society. Workplace responsibilities and professional codes of ethics are discussed. Several case studies are presented as well.

It has been apparent for some time that engineering education must provide insight for students related to the ethical issues in the engineering profession. Recently, the National Academy of Engineering published *The Engineer of 2020: Visions of Engineering in the New Century*[17] to predict the roles that engineers will play in the future. Also, the Accreditation Board for Engineering and Technology (ABET) gives criteria for engineering programs to follow. [18] Several of these criteria represent "professional skills" and are considered that they can be taught. In view of these, the engineering departments at Tuskegee University have jointly developed a 3-credit hour course entitled "Engineering, Ethics and Society" which is required for all undergraduate engineering students.

This course has three major components: 1) the nature of engineering ethics, 2) the engineering activities in a societal context, and 3) the contemporary issues in the engineering profession. This course satisfies the following four of eleven ABET criteria:

- Criterion f: an understanding of professional and ethical responsibility,
- Criterion g: an ability to communicate effectively,
- Criterion h: the broad education necessary to understand the impact of engineering solutions in a global and societal context, and
- Criterion j: a knowledge of contemporary issues

The uniqueness of this course stems from the fact that, it is taught by a large number of faculty representing many disciplines such as philosophy, bioethics, physics, as well as aerospace, chemical, electrical, and mechanical engineering. We believe that in this way students will be exposed to views of ethics from a variety of perspectives. Besides, many guest lecturers are invited to give lectures on ethical issues that they have experienced in the course of practicing their respective professions. An overarching objective of this course is to motivate students to life-long learning. Students participate in interactive town hall settings and produce major project reports.

Course Description: Our vision for this course is that it will give students an insight to key concepts of engineering ethics, sketch alternative views, and demonstrate examples of failures and successes in decision making processes. The course currently uses *Introduction to*

Engineering Ethics by Martin and Schinzinger[12] as the reference text for the class. It provides a cogent approach to the issues in engineering ethics using a philosophical framework. It gives the reader an understanding of the social importance of technology and how intellectual challenge should be handled.

In the beginning of the class, students are familiarized with the Engineering Code of Ethics of the National Society of Professional Engineering. Moral complexities in the engineering profession are highlighted through exposure to historical development, ethical reasoning, risk assessment, effects on environment, and global issues.

Background of Ethics: This lecture defines ethics by distinguishing it from aesthetics, religion, and science. At the same time, attention is given to the interaction between ethics and these three other branches of knowledge. The session includes an introductory-level account of the characteristics of professional and applied ethics, and of engineering ethics. Rudiments of philosophy of science such as the ethical basis of the scientific method are also reviewed.

International concerns come into considerations of these and similar issues:

- the universality of scientific language and methods
- the need for professionals to take conceptual approaches to questions of tastes, beliefs, and cultural practices
- an engineer's life-long commitment to serve the disadvantaged
- an engineer's perseverance in scholarly understanding of global problems and their feasible solutions

Methods and Resources:

The approaches vary. Classroom activities range from open discussion to Socratic questioning to lecture. Citations include but are not limited to:

- references to the history of ideas and to the thought of particular philosophers, especially Kierkegaard, Bergson, Whitehead, Dewey, Langer, and Deleuze,
- case studies; rudiments of how to dissect cases, and
- engineers' code of ethics: discussion of particular sections' meaning and significance

The Syphilis Study: Lessons for Engineers, Technologists, and Innovators: Tuskegee University provides a unique intersection for today's solutions given the historical context of the United States Public Health Service Study on Syphilis conducted at Tuskegee, in Macon County, Alabama from 1932 to 1972. The negative legacy of this study has been cited as hindrance to the full participation of African American and others in medical care and scientific research. It is the aim of the Tuskegee University National Center to reverse the burden of this negative legacy. The Tuskegee University National Center for Bioethics in Research and Health Care works with the local, regional, national and international communities in areas addressing ethical and human values issues in science, technology and health as they impact people of color.

Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers

require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct. When a solution can be found it is important to contribute the innovation in technology to society.

Taft H. Broome, Jr.

Storied teaching of ethics in STEM: A program for teaching ethics in STEM to students, undergraduates and graduates alike, and to their professors, has emerged from a twenty-year project partly funded by the NSF (SES-0530068), the Ethics CORE (subcontract on NSF SES-1045412), and by MIT through their support of a graduate course in Engineering Ethics (available through MIT OpenCourseWare, ESD 932, Spring 2006). The project culminated in the theory called *The Generalist Expert* centering on the idea of an academic work, i.e. a human composition exhibiting story elements. The storied teaching program transmits that idea to learners using the University of Berlin's model of teaching *qua* research. Today, focus is put on the proper point of view from which to categorize an issue as an ethical issue, and from which to grasp its sides, meditate upon them, advance them and discuss them. While improper points of view do not promise failures to achieve high grades or high public office or success in business, their price is a commitment to pathways of life that avoid passages through the heroic mythologies of the academy, public leadership and the workplace. The proper moral and legal points of view are proper points of view from which to contemplate and perform action upon ethical issues. The storied teaching program considers cases, e.g. the HeLa case told of in Rebecca Skloot's 2011 best-seller *The Immortal Life of Henrietta Lacks*.

In the presentation, historical connections motivate contemplation of the relationship between ethics, morality, enacted law and judicial law, moving from classical Greece and Aristotle through the Roman Republic and Cicero to the Roman Empire and Marc Antony and to the Holy Roman Empire and Pope Julius II. Suggested resources related to this work are listed in the reference section.[21-47]

Summary

The issues addressed in this paper and in the panel discussion are important for improving how the profession of engineering addresses ethical questions that arise in our field. We are called to provide our students with skills that will let them navigate not only the technical problems they will encounter but also the societal and ethical problems and nuances that often accompany the grand challenges as well as the everyday challenges engineers face. Participating in the online spaces and face-to-face conversations when possible will help form the resources into areas that are truly useful for practitioners.

Acknowledgments

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