A Review of Ethics Cases: Gaps in the Engineering Curriculum

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ABSTRACT

A literature search concerning ethics in engineering from 1970 through August of 2018 yielded 171 case studies. One hundred fifty-four cases were gathered from National Society of Professional Engineer's (NSPE) Board of Ethical Review (BER). An additional 17, non-BER cases were extracted from several databases. Only cases that presented a clear violation of the NSPE Code of Ethics were analyzed. The cases were arranged based on date and engineering discipline. Each case was then sorted based on the specific code violations present. These code violations were then analyzed to see if they fell within one of the three main branches of ethical theory: utilitarianism, deontology, and virtue ethics. Additionally, 108 articles and conference papers on engineering ethics education in institutions of higher learning were reviewed and yielded 41 publications that can be sorted based on the same three branches of ethical theory.

The findings show that while engineering ethics education emphasizes utilitarianism and deontology significantly more than other ethical theories, the code violations fall almost entirely under rule-based deontology. The results also demonstrate noticeable shift over time in the focus of the case studies, as a possible result in changes in the Code of Ethics. As indicated by the reviewed articles, there now appears to be more of a focus on more generalized, macroethical "best practices," and less on specific microethical dilemmas.

The Code of Ethics in engineering is often seen as an introductory element for ethics education. However, the Code can be seen as a narrow expression of ethics; one that is mostly in the vein of personal or microethics and follows a more deontological theory framework. Additionally, continual revisions in a Code of Ethics over time provides no clear, consensus-based guidelines for ethics education. Perhaps better inter-professional collaboration with other disciplines is needed to identify the critical ethical variables that can be espoused continually in engineering education.

INTRODUCTION

Over the years, many have called for and supported the explicit inclusion of ethics in engineering education[1]. To this end, various engineering societies have codes of conduct to describe standards for professional behavior[2-6]. Most ethics education occurs through case studies. These case studies (developed scenarios or example situations) explicitly connect the various elements of a code to the proposed ethical dilemma presented in the scenario/situation. Codes typically address what can be called microethics as they largely relate to individual actions associated with individual projects. Another area of ethics, one that is commonly missing in various codes, is macroethics which considers the "collective, social responsibility of the engineering profession and societal decisions about technology".[7] Issues such as security and peace, social justice and social responsibility are often viewed as macroethical challenges.

In addition, unless ethics education is provided by instructors in the social sciences, most instances of ethics instruction to engineering students minimizes the discussion of various ethical theories that could be used in the categorization of ethical situations. Though numerous theories exist, most ethical concerns can be categorized under the broad umbrellas of utilitarianism, deontology, and virtue. In short, utilitarianism represents a collection of theories where the belief is that a moral act is that which maximizes "utility", usually defined as pleasure or well-being. Deontology represents an understanding that the right action is one which fulfills a 'duty', where the definition of what is the duty can be variable depending on the desire of the person. Virtue ethics is concerned with how to *be* an ethical person rather than with how to perform ethical *actions*. [While these general definitions of broad ethical concepts exist and are readily found in the ethics literature, they are limited and not commonly applied with regards to engineering education. The reader should recognize that this brief paragraph could not substitute for a deeper exploration of these theories.]

RESEARCH QUESTIONS

The question for ethics instruction is how to bring both a variety of ethical theories and macroethical considerations into existing ethics education. Two major research questions were explored in this work.

1. How do ethics case studies breakdown with respect to engineering discipline, ethical dilemma and the various ethical theories?
2. To what degree do ethics case studies currently used in engineering education favor microethics over macroethics challenges and/or emphases?

METHODS

For this study, 154 cases studies were examined from those developed by the National Society of Professional Engineer's (NSPE) Board of Ethical Review (BER)[8]. These BER case studies were developed to address specific areas of the NSPE Code of Ethics and are intended for teaching ethical behaviors to practicing professionals; though they can also be used in ethics education of engineering students. To date, NSPE's BER have developed over 500 case studies. In this research, the case studies examined were first developed by the BER between 1970 and 1998 (though, an additional study of cases beyond 1998 is underway). Appendix A provides a listing of the case studies used in analysis.

Additionally, 17 other case studies from non-BER sources were collected and examined. These cases, developed between 1977 and 2018, were collected from online databases using the following search terms: "engineering ethics", "case studies", "cases", "engineering disasters", "engineering ethical dilemmas", and "engineering failures". The search was limited to cases in the United States, as differing ethical codes are used globally. Only cases that presented a clear violation of the NSPE's Code of Ethics were reviewed[8]. A bibliography of these non-BER case is also provided in the Appendix.

RESULTS

<u>Research Question 1.</u>
Each case was sorted based on date and engineering discipline, including: civil, environmental, mechanical and other. Table 1 outlines this breakdown. Many of the cases spread across several disciplines.

Table 1: Breakdown of Engineering Disciplines for BER and non-BER Cases

Engineering Discipline	BER Cases		non-BER Cases		Overall	
	No. Cases	%	No. Cases	%	No. Cases	%
Civil	49	32%	8	47%	57	33%
Environmental	28	18%	1	6%	29	17%
Mechanical	9	6%	7	41%	16	9%
Other	13	8%	4	24%	17	10%
Not specified	74	48	0	0%	74	43%

It should also be noted that as part of the BER review process, all individual and company names are concealed and replaced with multiple-use names such as "Engineer X" and "Company A". As a result, the relevant engineering discipline could not be determined for nearly half of the BER cases examined and were subsequently marked as unspecified. This lack of specificity in engineering discipline could also be intentional as various element of an 'ethics' code are applicable to multiple disciplines.

One could hypothesize that because of this non-specificity in discipline, no significant correlations were found between the ethical dilemma and engineering disciplines. This element of our study requires further study.

The cases were sorted into thirteen categories based on the nature of ethical dilemma. The categories were then matched to major ethical concepts noted in the NPSE's Code of Ethics[8]. The categories and the relevant codes sections are shown in Table 2. The number of instances that a code was noted in either the 154 BER or 17 non-BER case studies is also included in the table.

Table 2: Categories for Ethical Dilemmas and Relevant NPSE Code Listings

Ethical Dilemma	Relevant NPSE Code	BER Cases (n=154) Total number, (%)	Non-BER (n=17) Total number, (%)
Misleading Information	II.3 , II.5.a, III.1 , III.3.a	35, (23)	0, (0)
Withholding Information	III.1.b, III.3	8, (5)	4, (24)
Disclosing Private Information	II.1.c , III.4	8, (5)	0, (0)
Public Safety Risk	II.1	16, (10)	15, (88)
Improper Solicitation	II.4.a-e, II.5.b, III.5, III.6.a	37, (24)	0, (0)
Poor Communication	III.1.b, II.2	9, (6)	11, (65)
Lack of action/Not speaking up	II.1.f	10, (6)	1, (6)
Incompetence	II.2	8, (5)	5, (29)
Negligence	III.8	8, (5)	16, (94)
Conflict of Interest	II.4.a, III.5	35, (23)	1, (6)
Improper Advertising	*	28, (18)	0, (0)
Unfair competition	III.7	24, (16)	1, (6)
Other	III.9, etc.	15, (10	1, (6)

* see 1971 version of code, Section III

For the BER cases and overall, the most frequently occurring ethical concepts were improper solicitations, misleading information, and improper advertising. For the non-BER cases, negligence, public safety, and poor communication occurred most frequently. That being said, due to the small sample size, little can be inferred from the non-BER cases alone.

Influence of Time.

Most notable for BER cases, those involving improper solicitations remained evenly distributed over time. Cases involving misleading information have increased in recent years, with 24 of the 35 (71%) occurring after 1985. On the other hand, a clear decrease in the cases involving advertising can be seen over time, with 22 of the 28 cases (79%) occurring before 1980. This phenomenon is likely tied to several changes in the Code of Ethics in the 1970's involving advertising[9]. The cases containing unfair competition also encountered a significant decrease over time, 79% of which ensued prior to 1985. In contrast, cases relating to disclosing private information and negligence, of which there were eight for each category, weren't pertinent until the mid-80s.

Based on the noted ethical dilemmas and how they are discussed in the Code of Ethics, it is clear that the Code highly reflects deontological theory; i.e., it consists of a series of doctrines that engineers must follow, with intrinsic morality tied to each behavior. In other words, the Code of Ethics can be seen as a reflection of an engineer's duty to society.

A difference from this dominate theoretical approach can be seen to emerge in the review of 108 articles and conference papers on macroethical education in engineering. Articles were reviewed and sorted based on the three main "families" of ethical theory: utilitarianism, deontology, and virtue ethics. This review showed that explicit reference to these three families of theory occurred in 41 of the 108 articles reviewed – 14 predominately noted utilitarianism, 17 predominately noted deontology, and 11 predominately noted virtue. Appendix C provides a list of these publications.

Research Question 2.

In addition, many of these articles explicitly discuss macroethical issues including professional, environmental and social responsibility as well as compassion. While this part of the study is still under review, an indication of a 'gap' in ethics education may now be forming as to the inclusion of macroethical challenges and the range of theories that can be found for the instruction of engineering students – a pedagogical approach that may differ substantially from the predominance of microethics and deontological theories in the instruction of professional engineers.

DISCUSSION

The Code of Ethics has encountered numerous changes since its first occurrence in 1935[8]. Although many of these changes are minor clarifications, some have greatly redefined the acceptable practice of professional engineers. In 1971, a portion of code heavily restricting advertising was rewritten to make it more lenient, with additional measures taken in 1993. In 1986, a clause was added allowing indemnification for professional services.

In more recent years, several additions have been made that bring an increasingly macroethical viewpoint to the code. Most notably, sections have been added instructing engineers to pursue lifelong learning (2003) and increase sustainability in design (2006)[9]. Without a more in-depth

review of modern BER cases, however, it is unclear if these code alterations have yet to take full effect in practice.

CONCLUSION

This study shows that NSPE's BER case studies provide a well-guided connection to NSPE's Code of Ethics, especially given that the ethical dilemmas described in the cases can be directly connected to specific ethical concepts noted in the Code. Similarly, non-BER case studies may be viewed through the same ethical lens. However, when evaluated further, it become evident that the BER case studies may be influenced by the events of the time and are strongly connected to microethical dilemmas and deontological theories of ethical conduct. These two constraints create narrow pathways to explore ethics, leaving room for the exploration of alternate ethical dilemmas that may be better explained by other ethical theories and through a macroethical lens. In summary, codes of ethics as constituted now, provide no broad, consensus-based guidelines in teaching ethics. Perhaps better, inter-professional collaboration with other disciplines is needed to identify the critical ethical variables; i.e., alternate theories and level of ethical sophistication, required in engineering education, both for students and practicing professionals.

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Appendix A – Index of BER Cases from 1970-1998

Case No.	Subject
70-1	Promotional Distribution of Planning Report
70-2	Operation of Related Business for Nonprofessional Services
70-3	Unauthorized Use of Drawings of Other Firm
70-5	Dispute Between Engineers in Public Service
71-1	Credit for Engineering Work - Cover Sheet and Advertisement for Bids
71-2	Brokerage of Engineering Services
71-4	Expert Testimony Report and Redesign by Another Engineer
71-8	Advertising-Recruiting
72-1	Advertising - Bold Face in Telephone Directory
72-2	Conflict of Interest - Use of "Free Engineering" from Manufacturer
72-4	Supplanting Another Engineer - Employee Participation - Registration - Adverse Comments on Applicant
72-5	Restrictive Employment Agreement
72-7	Competitive Bidding - Study Contracts
73-1	Advertising - Professional Cards
73-5	Advertising - Directory
73-6	Political Contributions
73-7	Supplanting Another Engineer - Indefinite Contract
73-8	Solicitation of Business by Mail
74-3	Participation in Strike by Publicly Employed Engineers
74-4	Conflict of Interest - Part-time Consultant
74-5	Exhibit at Association Meetings
74-7	Letterheads - Promotional Statements
74-8	Brochures - Format and Content
74-10	Political Announcement on Firm Stationery
74-11	Expert Witness - Patent Ownership
75-4	Advertising - Testing and Engineering Laboratory
75-5	Personal Misconduct
75-6	Brochure - Text and Built-In Reply Card
75-8	Selection of Engineers - Finders' Fees - Contingent Contract
75-11	Plagiarism
75-14	Political Candidacy - Criticism of Other Engineers
75-15	Attempt to Restrain Employment of Engineer-Employees
75-16	Group Advertisement by Engineering Firms
76-2	Conflict of Interest - Engineer Ownership of Construction Firm
76-3	Conflict of Interest - Consultant to County Testimony Adverse to County Client
76-4	Public Welfare - Knowledge of Information Damaging to Client's Interest
76-7	Promotional Letter - Emphasis on Non-Insurance of Other Firms

76-8	Free Engineering - Preliminary Sketch and Cost Estimate of Facility
76-11	Contingent Contract - Fee Dependent on Lower Construction Cost
76-12	Political Contributions - Solicitation by Retained Consultant
77-1	Use of Sales Organization on Basis of Stipulated Payments and Percentage of Contract Amount
77-2	Dual Use of Business Card
77-4	Contingent Contract-Engineer Retained on Speculative Basis
77-6	Continued Practice Under No Competition Agreement
77-7	Obligation to Write Letter of Recommendation for Other Engineers
77-9	Selection of Former Member of Selection Team for Promotion
77-10	Value Engineering-Contingency Fee
77-11	Supplanting-Promotion of Work by Former Employees
78-3	Conflict of Interest - Binary Service to Same Client
78-6	Naming of Staff Engineer in Firm as Inducement for Contract
79-1	Conflict of Interest-Payment From Related Party
79-6	Advertising - Statement of Project Success
79-8	Gift to Public Official
79-9	Identification of Firm Ownership - Specification of Products of Owner
79-10	Taking Over Clients of Former Employer
80-2	Brochure of Subsidiary Firm
80-4	Participation of Engineer with Competing Firms for Same Contract
80-5	Conflict of Interest-Recommendation of Former Firm
80-6	Conflict of Interest-Use of Former Public Employee
81-1	Contingent Contract
81-4	Gifts to Engineers
81-5	Advertising
82-1	Promotional Letters
82-2	Confidentiality of Engineering Report
82-3	Recruitment Finder's Fee
82-6	Conflict of Interest - Expert Witness for Contractor
82-7	Participation in Professional and Technical Societies Ethical Duty of Employer and Employee
83-1	Conflict of Interest - Duty of Loyalty of Terminated Employed Engineer To Employer - Misleading Brochure
83-2	Contingent Fees
83-3	Using Technical Proposal of Another Without Consent
83-5	Payment of Fee to Landscape Architect Above True Value of Work in Order to Receive Leads
84-2	Advertising Services Of Engineering Staff
84-5	Engineer's Recommendation For Full-Time, On-Site Project Representative
84-6	Participation in Protest Action as Part of a Political Campaign

93-2	Registration Implying Registration In Another State
93-3	Appropriate Notification and Review of Another Engineer's Work
93-6	Conflict of Interest - Providing Views on Feasibility of Project
93-7	Agreement Not To Disclose Data, Findings, Conclusions
93-8	Use of Broad Indemnification Clause for Pollution Services
94-1	Conflict of Interest - Engineer Retained by State
94-2	Professional Service Contract Negotiations
94-3	Conflict of Interest - Engineering Consultant Serving as Equipment Manufacturing Sales Representative
94-4	Testimony Re: Safety Standards
94-5	Conflict of Interest - Providing Both City Engineer and Inspection Services
94-6	Signing & Sealing Another Engineer's Plan
94-7	Disclosure of Client Information to Insurance Company
94-8	Competence to Perform Foundation Design
94-9	Conflict of Interest - Accident Reconstruction Services
94-10	Conflict of Interest - Registration - Not Licensed in State
94-11	Conflict of Interest - Disclosure & Participation as Government Official on Work Related to Former Firm
95-3	Promotional Efforts - Providing Referral Fees to a Contractor
95-5	Failure to include Information in Engineering Report
95-7	Authorship of Article - Misleading Reference
95-9	Conflict of Interests - Services to a Village
95-10	Engineering Titles - Use of Engineering Title by Non-engineers
95-11	Receipt of Rebate Check From a Vendor
96-1	Misrepresentation of a Business Relationship
96-3	Refusing to Sign/Seal Construction Documents
96-7	Conflict of Interest - Returning Retainer Prior to Accepting Another Assignment
96-9	Reference to "Member" of Professional Society
96-10	Comments by One Engineer Concerning Another
96-11	Advertising - Promotional Reference to Work and Clients of Previous Employers
97-3	Conflict of Interest - Obligations of Engineer on a Defaulted Project
97-4	Conflict of Interest - Reviewing Own Work - Failure to Disclose Property Ownership/Relationship With Developer
97-5	Signing a Confidentiality Agreement - Duty to Disclose Danger to the Public Health
97-6	Use of Title "Engineer" - Refusing to Sign/Seal Documents
97-9	Restrictive Employment Agreement - Crossing Out References
97-10	Payment of Referral Fee For Being Selected By Engineer
97-12	Copyright - Duty to Report Violation of Copyright Licensing Agreement
98-3	Use of CD-ROM for Highway Design
98-5	Public Health and Safety -- Code Enforcement
98-6	Use of Slogans in Political Campaigns, Etc.

98-7	Expert Witness Services
98-8	Competence to Certify Arms Storage Rooms
98-9	Duty to Report Unsafe Conditions -- Client Request for Secrecy

Appendix B – Bibliography of 17 non-BER Case Studies

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Appendix C – Titles and Authors of 41 Publications that Illustrate At Least One of Three Families of Ethical Theories

Utilitarianism – 14 publications

Article title	Author(s)
Teaching Ethics to Undergraduate Engineering Students: Understanding Professional Responsibility Through Examples	I. Soudek
Team Ethics Assignment: Based on Engineering Student Co-op Experience	L. Grossenbacher
Ethics Sessions in a Summer Undergraduate Research Program	M. Loui
Determining the Rules: Applying Ethics in a Tissue Engineering Course	J. G. Bledsoe
Developing ethics competencies among science students at the University of Copenhagen	T. Børsen
The Development of a One Credit Ethics course for Engineering Technology	J. Brown, R. Pfile
Integrating Ethics into the Freshman Year Engineering Experience	G. Catalano
Senior Capstone Design and Ethics: A Bridge to the Professional World	G. Catalano
Integrating a Compassion Practicum into a Biomedical Engineering Ethics Course	G. Catalano
An Effective Strategy for Integrating Ethics Across the Curriculum in Engineering: An ABET 2000 Challenge	J. Cruz, W. Frey
Engagement with Ethics in a Large Engineering Program: A Status Report	S. Culver, V. Lohani, I. Puri
Implementation of Competences of Social and Environmental Responsibility in IT Engineering Degrees	R. Miñano, C. Fernandez, A. Anguera
Strategies for Teaching Professional Ethics to IT Engineering Degree Students and Evaluating the Result	R. Miñano, A. Uruburu, A. Moreno-Romero, D. Pérez-López

Deontology – 17 publications

Article title	Author(s)
Engineering Ethics at Drexel University	M. Manion, M. Kam
Teaching Ethics to Undergraduate Engineering Students: Understanding Professional Responsibility Through Examples	I. Soudek
Team Ethics Assignment: Based on Engineering Student Co-op Experience	L. Grossenbacher
Ethics Sessions in a Summer Undergraduate Research Program	M. Loui
Determining the Rules: Applying Ethics in a Tissue Engineering Course	J.G. Bledsoe
Developing ethics competencies among science students at the University of Copenhagen	T. Børsen
The Development of a One Credit Ethics course for Engineering Technology	J. Brown, R. Pfile
Teaching engineering ethics with sustainability as context	E. Byrne
Integrating Ethics into the Freshman Year Engineering Experience	G. Catalano
Senior Capstone Design and Ethics: A Bridge to the Professional World	G. Catalano
Integrating a Compassion Practicum into a Biomedical Engineering Ethics Course	G. Catalano
An Effective Strategy for Integrating Ethics Across the Curriculum in Engineering: An ABET 2000 Challenge	J. Cruz, W. Frey
Engagement with Ethics in a Large Engineering Program: A Status Report	S. Culver, V. Lohani, I. Puri
Ethics Instruction in Engineering Education: A (Mini) Meta-Analysis	D. Haws
Ethics and the Design Process	R. Meade

Virtue – 11 publications

Article title	Author(s)
Problem-based Learning in a Professional Ethics Course for Undergraduate Engineering Students	R. Kirkman
PRIME Ethics: Purdue's Reflective & Interactive Modules for Engineering Ethics	A. Brightman, J. Beever, J. Hess, A. Iliadis, L. Kisselburgh, M. Krane, M. Loui, C. Zoltowski
Ethics Sessions in a Summer Undergraduate Research Program	M. Loui
Developing ethics competencies among science students at the University of Copenhagen	T. Børsen
The Development of a One Credit Ethics course for Engineering Technology	J. Brown, R. Pfile
Integrating Ethics into the Freshman Year Engineering Experience	G. Catalano
Integrating a Compassion Practicum into a Biomedical Engineering Ethics Course	G. Catalano
Cultivating engineering ethics and critical thinking: a systematic and cross-cultural education approach using problem-based learning	P.F. Chang, D.C. Wang
An Effective Strategy for Integrating Ethics Across the Curriculum in Engineering: An ABET 2000 Challenge	J. Cruz, W. Frey
Teaching Ethics to Engineers: A Socratic Experience	G. Génova, M. Rosario González
Ethics Instruction in Engineering Education: A (Mini) Meta-Analysis	D. Haws