How Good is Our Undergraduate Engineering Ethics Training? A Comparative Analysis of Engineering Ethics Textbooks

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ABSTRACT - Engineers play a critical role in bettering humanity via technological and scientific innovations. This ethical responsibility to the practice of engineering is the reason that engineering ethics is required of all accredited engineering programs at all levels of education, and engineering ethics is required of all facets of professional licensure in engineering. Educators at all levels leverage textbooks to teach engineering ethics. In this paper, we conduct a systematic, comparative review of twenty-six of the most widely used engineering ethics textbooks. This comparative analysis has enabled us to identify over forty thematic topics that are collectively covered across these twenty engineering ethics textbooks. Twelve of these thematic topics are covered in at least half of the textbooks. Gaps do exist in the topics and approaches used in this comparative textbook analysis and these gaps offer us an opportunity to evolve the field of engineering ethics. Initial findings from the engineering ethics textbook comparative analysis uncovered several prominent topics that the majority of textbooks included: public welfare and wellbeing, whistleblowing, safety and risk, and professionalism. Additional topics that were prolific included ethics in design and technological development, conflict of interest, and environmental ethics. The analysis also revealed important topics that only a few of the textbooks included such as competence, moral theories, the involvement of religious values, intellectual property and legal liability, employer/employee and mentor/mentee relationships, and employee rights. Under half of the textbooks included sections on ethics in research and education/academia. The findings of this study can (1) provide engineering educators insights about the current list of thematic topics that fall under engineering ethics, (2) identify gaps in engineering ethics knowledge, and (3) offer a discussion of the opportunities to improve engineering ethics education. To the best of our knowledge, this systematic and comparative engineering ethics textbook review is the first of its kind.

I. INTRODUCTION

Engineers play a vital role in bettering humanity through technological innovations, and their ethical responsibility to humanity must continue to serve as their moral compass. *How equipped do engineers feel to uphold this ethical responsibility?* **In this paper, we offer a glimpse into the current state of engineering ethics education and focus our attention on conducting a comparative analysis of prominent engineering ethics textbooks.** A comparative analysis of prominent engineering ethics textbooks offers an opportunity for engineering educators to see a holistic view of engineering ethics topics and to evaluate the adequacy of our current state of engineering ethics education.

The rate of technological advancement demands engineers to lead with purpose, strong ethical standards, agility, social responsibility, environmental responsibility, and moral leadership character. With technological advancements like artificial intelligence, the urgency and the responsibility of engineers continue to grow. To ensure that engineering solutions serve mankind, engineering education must train the next generation of engineers with an unyielding foundation in ethics and social responsibility. Undergraduate engineering students' exposure to ethics education establishes a vital basis for their professional activity in the future. Undergraduate engineering ethics courses prepare students for industry by teaching them moral thinking and ethical decision-making [1]. Students gain experience debating the kinds of difficult moral conundrums that they would encounter in the workplace as engineers by analyzing real-world case studies [2]. The development of students' sense of civic duty and the emphasis placed on engineers' contributions to the advancement of human welfare are other goals of the undergraduate ethics curriculum [3]. The early emphasis on social responsibility balances the majority of engineering courses' technical concentration. Furthermore, ethics classes can raise students' knowledge of environmental justice, sustainability, and safety concerns that they will need to consider at work [4]. Undergraduate instruction on the ethical aspects of engineering better prepares students to act honorably and consider the implications of their inventions and ideas [5]. The basis of an engineering education that incorporates ethical concepts offers the platform for ethically upright professional action.

At every level of engineering education, ethics is vital to provide students with the knowledge and abilities to make moral judgments that benefit society. Many engineering schools realize the importance of laying a strong foundation of ethics with engineering students to complement their technical knowledge [6]. In fact, all ABET-accredited engineering programs must demonstrate that their graduates are able to "recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts."

There are many models of ethics education across four-year engineering degree programs. Undergraduate engineering curricula include engineering ethics through specialized courses and program-wide integration. While some engineering programs embed one stand-alone ethics course within a curriculum, other programs embed ethics modules across a few courses within a curriculum. Very few engineering programs weave engineering ethics across a four-year undergraduate curriculum in a concerted and developmental way [7]. Engineering ethics taught in stand-alone courses is usually offered within the first two years of study [4]. According to Davis [6], several engineering programs also embed ethical modules into technical writing and communication seminars, senior capstone projects, and introduction to engineering courses. To demonstrate ethics' applicability across broader learning domains, we also see engineering ethics being covered in subjects like design, sustainability, and safety.

In terms of engineering ethics content coverage, engineering students are exposed to ethical frameworks, engineering codes of ethics, ethical theories, and critical case study analysis. Principles and case studies are provided by widely used textbooks such as Fleddermann's Engineering Ethics [8] and Harris' Engineering Ethics [9]. Through the analysis of real-world case studies including ethical challenges, required ethics courses seek to increase understanding of the social and moral obligations that engineers have [10]. The significance of considering wider effects and unintended consequences while creating new technology and goods is another point of emphasis in ethics training [11]. Programs enable students to consider the ramifications of their work critically rather than merely the technical aspects of their job by incorporating ethics into engineering courses [12]. This fosters a feeling of moral obligation to apply their engineering knowledge to promote the welfare of people and the public instead of just serving corporate interests. Engineering students need to be prepared to manage ethically challenging situations now more than ever because of the immense promise of developing technologies like artificial intelligence [13]. Engineering graduates who have received a thorough ethics education are better prepared to use moral reasoning and make moral judgments in their professional capacities.

Pedagogical approaches used in teaching engineering ethics have shifted over the years to prioritize active learning through activities such as case-based learning, role-playing, group debates, and projects. Beyond rote memorization of codes, these experiential strategies seek to enhance moral thinking abilities [14]. Students are prepared for ethical challenges through assignments such as examining previous ethical failures and suggesting remedies. To integrate ethical concepts with practical situations, community service learning is being incorporated into many programs as well [3]. Active learning strategies in engineering ethics courses keep students motivated and engaged to gain moral competencies. Experiential learning is facilitated by case studies, ethical conundrums, talks, student presentations, and role-playing activities [14]. Assignments include researching historical tragedies, creating moral guidelines, and suggesting solutions to "failed" problems. There is also the use of project-based and problem-based learning strategies to teach engineering ethics. Evaluations show that instruction in engineering ethics has improved students' knowledge of and ability to make ethical decisions [15]. However, some research shows that diverse viewpoints and specific micro-ethics skills are not being well communicated [16]. To best prepare students for ethical engineering practice, educators are constantly enhancing goals, interaction techniques, and evaluation procedures. The dedication to providing engineering students with ethical competencies equivalent to their technical talents is demonstrated by the expansion of undergraduate ethics education.

II. METHODS

In conducting a comparative analysis of engineering ethics textbooks, the initial step involved the careful selection of relevant engineering ethics textbooks. This process was executed using a multifaceted approach, primarily through the utilization of Google Scholar, which offered ease in identifying the citation frequency of ethics textbooks. The textbooks that were chosen reflected general engineering ethics, aiming to identify works that exhibited distinct approaches in terms of flow, structure, and content. Textbooks were avoided that focused on discipline-specific engineering ethics such as biomedical engineering or computer engineering. The emphasis was on selecting generalized engineering ethics textbooks, each demonstrating unique perspectives while not overly concentrating on professional ethics. The criteria also considered the inclusion of case studies and the quality of conclusions within the chosen textbooks. By conducting such surveys of engineering ethics-related works, twenty-six engineering ethics textbooks were found to be commonly cited in engineering ethics literature. The textbooks were chosen from a reasonable time range in which the contents are relevant and still widely utilized. The final list of textbooks was published in the past twenty-six years with twenty-one of them having published years from 2010-2023. Two coders were involved in this process. Nevertheless, the same steps in selecting textbooks were adopted for both coders. Once each coder had compiled a set of books, the lists were combined for the finalized set of twenty-six textbooks, which are cited in the reference list. The final list of engineering ethics textbooks used in this comparative analysis are shown below.

1. Beyond the Code: A Philosophical Guide to Engineering Ethics (2021) by Heidi Furey, et. al
2. Contemporary Ethical Issues in Engineering (2015) by Satya Sundar Sethy
3. Engineering Ethics 4th Edition (2011) by Charles B. Fledderman
4. Engineering Ethics and Design for Product Safety (2020) by Kenneth d'Entremont
5. Engineering Ethics: Concepts and Cases 6th Edition (2018) by Charles E. Harris, et. al
6. Engineering Ethics for a Globalized World (2015) by Colleen Murphy, et. al
7. Engineering Ethics: An Industrial Perspective 1st Edition (2006) by Gail Baura
8. Engineering Ethics: Contemporary and Enduring Debates (2020) by Deborah G. Johnson
9. Engineering Ethics: Real World Case Studies (2017) by Steven K. Starrett, et. al
10. Ethical Engineering: A Practical Guide with Case Studies (2023) by Eugene Schlossberger
11. Ethics and Responsibilities of Engineers (2021) by Frederick Bloetscher
12. Ethics for Engineers (2019) by Martin Peterson
13. Ethics in Engineering Practice and Research (2011) by Caroline Whitbeck
14. Ethics Within Engineering: An Introduction (2016) by Wade L. Robison
15. Ethics, Politics, and Whistleblowing in Engineering (2018) by Nicholas Sakellariou and Rania Milleron
16. Ethics, Technology, and Engineering: An Introduction (2011) by Ibo van de Poel and Lamber Royakkers

17. Global Engineering Ethics (2017) by Heinz Luegenbiehl and Rockwell Clancy
18. Loose Leaf for Ethics in Engineering 5th Edition (2021) by Mike Martin
19. The Ethical Engineer: Contemporary Concepts and Cases (2018) by Robert McGinn
20. Engineering Ethics: Challenges and Opportunities (2014) by W. Richard Bowen
21. Engineering Ethics (2005) by Michael Davis
22. The Decision Makers: Ethics for Engineers (1999) by James Armstrong, et. al
23. Engineering Ethics (2004) by M. Govindarajan
24. Engineering Ethics: Balancing Cost, Schedule, and Risk-lessons Learned from the Space Shuttle (1997) by Rosa Lynn B. Pinkus
25. Ethics and Engineering: An Introduction (2021) by Behnam Taebi
26. Ethics in Engineering (2004) by Mike W. Martin and Roland Schinzinger

The table of contents of each textbook was then reviewed closely by two coders to identify engineering ethics topical themes. The coders worked independently to identify the topical themes and then, converged to create one common set of topical themes – 41 of them. Once the topical themes were identified, each coder independently evaluated each textbook's table of contents against the 41 topical themes and came together to compare and align the topical coverage of each textbook. The result is a topical mapping matrix. The topical themes were initially identified by reviewing the following three textbooks - Ethics in Engineering Practice and Research [27], Engineering Ethics: Concepts and Case [9], and Engineering Ethics [8]– and then continued by adding each additional textbook. Thus, more topics were iteratively added after each textbook examination. The final list of forty-one ethical topics identified, shown in Table 1, reflects a comprehensive list of engineering ethics topics. When a keyword was mentioned or clearly alluded to, the topic was marked on the table with an "X" to indicate it was included in that textbook. It is noteworthy that there were differences in the format of the textbooks' table of contents, specifically with the headings. The table of contents ranged from first to fourth-level headings. However, if a topic was found among any heading level, it was marked with an "X" regardless.

Table 1. Table of Topical Themes Identified Across the 26 Engineering Ethics Textbooks.

	Topic	Description
1	Ethics and Engineering Ethics	The fundamental ideas around what makes ethics and, more particularly, framing ethics
2	Public Welfare & Public Wellbeing	The engineer's role in advancing public welfare, public wellbeing, and social responsibility
3	Normative Ethics	An investigation of normative ethics in engineering, encompassing the assessment of moral standards that direct behavior in the field
4	Aspirational Ethics	The presentation and implementation of aspirational ethics in an engineering context
5	Virtue Ethics	Ethics in engineering that places an emphasis on virtue-based personal qualities and character
6	Values and Value Systems	A fundamental inspection of values and their role in guiding the conclusions made in engineering
7	Moral and Ethical Decision-Making	The examination of moral decision-making procedures, together with the methods and strategies recommended by each book.
8	Religion in Engineering Ethics	An investigation on the influence of religious principles on moral judgment in the engineering field.
9	Moral and Ethical Theories	An analysis of the many moral and ethical ideas discussed in each volume, showcasing the range of theoretical viewpoints in the field of engineering ethics.
10	Responsibilities of Engineers	The distinction between the ethical issues related to engineers' professional activities and the personal obligations that they have.
11	Whistleblowing	An analysis of the idea of whistleblowing, covering the circumstances that justify it as well as its ethical ramifications.
12	Honesty & Integrity	An explanation of honesty and integrity in engineering, as well as how to recognize the instances of shortcomings in these areas.
13	Safety and Risk	The consideration of ethical aspects of safety, risk assessment, and the computations involved in engineering decision-making
14	Public Policy	An examination of the interactions between public policy and engineering ethics
15	Product and Legal Liability, Law	The connection between legal frameworks and ethics and its appearance in engineering ethics, along with the legal duties that engineers face and how those responsibilities overlap with ethical ones.
16	Intellectual Property	An analysis of moral concerns about intellectual property in regards to using engineering innovations responsibly
17	Environmental Ethics and Laws	Engineering procedures that consider the moral obligations associated with environmental sustainability and environmental law compliance.
18	Mentor/ee Employer/ee Relationships	The investigation of moral aspects of mentoring, the interaction between employers and employees, and the obligations related to professional advice.
19	Ethics in Education and Academia	An examination of moral issues in academic contexts and educational settings with a focus on educators' moral obligations.

20	Ethics in Research	The assessment of ethical research procedures, considering responsible conduct within engineering research
21	Ethics of Loyalty to an Organization	Analysis of the moral implications and limitations of employee loyalty to companies and the level of protection provided to dissidents
22	Ethics in Profession / Codes of Ethics	An examination of professional codes of ethics and its implementation in the engineering field with a focus on professionalism
23	Ethics in Design and Tech Development	Investigating the moral issues that arise during the conception and creation of technological advancements
24	Competence	An analysis of moral obligations associated with professional proficiency, encompassing professional growth and skill improvement
25	Moral and Ethical Problem-Solving	Analysis of the foundations for ethical problem-solving in the engineering setting
26	Ethics in the Global Context and Setting	Considering ethical viewpoints from around the world, acknowledging differing cultural contexts and worldwide effects of engineering choices
27	Case Studies	A thorough examination of the case studies included in each book to identify practical applications of morality and judgment
28	Conflict of Interests and Resolution	Examination of the moral dilemmas raised by conflicts of interest in engineering practice and possible solutions
29	Workplace and Employee Rights	Analysis of moral issues pertaining to employee rights, workplace dynamics, and employers' obligations to promote moral workplace cultures
30	Morality & Morals	The set of values that inform both professional norms and personal morality while making ethical judgments in engineering.
31	Utilitarianism	Aiming to maximize enjoyment for everybody, ethical philosophy; in engineering, choices are made with the majority's best interests in mind.
32	Emotional Intelligence (EQ)	Emotional intelligence is essential for moral leadership and handling emotionally charged circumstances, playing a significant role in engineering ethics.
33	Social Justice	Ensuring that the benefits of engineering decisions are distributed fairly, address equality and inclusion, and consider the wider social implications for a more just and equitable society.
34	Duty Ethics	An ethical philosophy that highlights the intrinsic obligations and duties people have; in the context of engineering, this means upholding professional duties and obligations.
35	Eng. as Social Experimentation	In the perspective of seeing engineering projects as social experiments, this entails moral questions about unforeseen repercussions and the societal effects of engineering choices.
36	Privacy and Confidentiality	Safeguarding sensitive data and guaranteeing the protection of people's privacy are key aspects of engineering techniques that uphold confidentiality.

37	Autonomy	To describe respecting people's individuality and independence; in engineering, this means letting people make educated decisions and taking stakeholders' interests into account.
38	Unfair Competition	Involves unethical actions that impair fair competition in engineering projects, such as bid rigging or misleading tactics, in competitive settings.
39	AI & Computers	Investigating the moral ramifications of creating and applying artificial intelligence in engineering; issues to be taken into account are accountability, transparency, and possible social effects.
40	Engineering & Other Disciplines	Multidisciplinary issues in engineering ethics: this refers to identifying and resolving moral dilemmas that arise when engineering intersects with other disciplines such as business, politics, and economics.
41	Applied Ethics	The practical application of moral concepts to actual circumstances, assisting engineers in making moral decisions by resolving moral conundrums and encouraging responsible behavior.

III. RESULTS

In this section, we share the results of our engineering ethics textbook comparative analysis. Table 2 shows the topical themes (41 of them per Table 1) mapped to the twenty-six engineering ethics textbooks. Table 2 thus shows which ethical topics were covered in the selected textbooks' table of contents. The table is sorted from the most frequently covered ethics topic to the least frequently covered topic. As mentioned before, the "X" signifies that the topic was mentioned in the textbook belonging to that column. If there is a blank space, then the topic was not included in the textbook's table of contents.

Table 2 shows that only one ethical topic – *Introduction: Ethics and Engineering Ethics* - was included across all of the twenty-six engineering textbooks that were part of the comparative analysis. The top five common ethical topics identified were *Intro to Engineering Ethics*, *Ethics in Design and Tech Development*, *Engineering Case Studies*, *Environmental Ethics*, and *Engineering Code of Ethics*. In direct contrast, the ethical topic of *Emotions and Emotional Intelligence (EQ)* appears only in 2 of the 26 (7%) engineering ethics textbooks that were part of this analysis. The least five common ethical topics identified are *Emotional Intelligence*, *Engineering and Social Investigation*, *Aspirational Ethics*, *Public Policy*, and *Social Justice*.

There were just 12 ethical topics (29% of the 41 identified) that were covered in the majority (≥13) of the engineering ethics textbooks. These were the common and most prominent ethical topics covered across the 26 engineering textbooks that were part of this analysis:

Ethics & Engineering Ethics	*Ethics in the Profession / Codes of Ethics*
Public Welfare and Wellbeing	*Ethics in Design & Tech. Development*
Whistleblowing	*Ethics in the Global Context and Setting*
Safety and Risk	*Engineering Ethics Case Studies*
Product and Legal Liability	*Conflicts of Interests and Values*
Environmental Ethics and Laws	*Morality and Morals*

There were 29 ethical topics (71% of the 41 identified) that were least frequently covered across the 26 engineering ethics textbooks. These were the ethical topics that were least covered (≤13) across the 26 engineering textbooks that were part of this analysis:

Normative Ethics	*Ethics in Research*
Aspirational Ethics	*Ethics of Loyalty to an Organization*
Virtue Ethics	*Competence*
Applied Ethics	*Moral and Ethical Problem-Solving*
Duty Ethics	*Workplace and Employee Rights*
Values and Value Systems	*Utilitarianism*
Moral and Ethical Decision-Making	*Emotional Intelligence (EQ)*
Moral and Ethical Theories	*Social Justice*
Responsibilities of Engineers	*Engineering as Social Experimentation*
Honesty and Integrity	*Privacy and Confidentiality*
Public Policy	*Autonomy*
Intellectual Property	*Unfair Competition*
Mentor/ee Employer/ee Relationships	*Artificial Intelligence (AI) and Computers*
Ethics in Education and Academia	*Engineering and Other Disciplines*

It is thus evident that there are both sparse and prominent topics covered in the twenty-six engineering ethics textbooks that were part of our comparative analysis. The average number of ethical topics covered by the books was 15 ethical topics. The most comprehensive textbook, in terms of the number of topics covered, was *Ethics in Engineering* by Mike W. Martin and Roland Schinzinger [40]. This textbook covered 33 out of the 41 topics identified in Table 1. The least comprehensive textbook, in terms of ethical topics covered, was *Ethics, Politics, and Whistleblowing in Engineering* by Nicholas Sakellariou and Rania Milleron [29] as it included five out of the forty-one ethical topics identified in Table 1. Eleven of the twenty-six textbooks included 15 or more ethical topics.

IV. DISCUSSION

Our comparative engineering ethics textbook analysis points to a wide variety of ethical topics being covered across engineering ethics textbooks. Because engineering ethics textbooks are widely used to teach engineering ethics, the findings herein offer meaningful insights to rethink how we teach engineering ethics in undergraduate education. These prominently used engineering ethics textbooks provide the knowledge and the ethical issues that will inevitably arise in the lives of engineers. It is of no surprise that all the textbooks offer an introduction to ethics and an introduction to the importance of engineering ethics. Many of the textbooks (N=21) embed case studies to illustrate ethical decision-making (or lack thereof) in real-world engineering scenarios. Social responsibility is also prevalent throughout most of the textbooks. Engineering ethics across a diversity of contexts (e.g. profession, education and academia, technological development and design) seems to be prominent in many of the textbooks as context is so critical to the ethical norms that an engineer may experience. Ethics in research contexts was least covered from other contexts (N=9). Ethical topics related to environmental justice and sustainability were visible across many textbooks (N=21) and reflective of the growing importance of sustainable development and protecting our natural resources amid drastic climate change over the past decades. In contrast, AI and computer ethics were only visible across only ten textbooks (N=10), and we predict coverage of this topic will increase over the coming years and within future editions of many of these textbooks. Moreover, globalized ethics education is becoming increasingly relevant and the frequency of this topic among the textbooks reflects the need for training to account for globalization. As engineers continue to find themselves working across diverse global contexts, we will continue to see cultural ethics and global ethics being part of future engineering ethics textbooks.

In terms of coverage of ethical lenses and ethical foundations, we observe major gaps across the twenty-six textbooks. While *morals and morality* is a topic covered across many textbooks (N=16), there is not much attention placed on presenting a diversity of ethical lenses (e.g. aspirational ethics, virtue ethics, normative ethics, duty ethics, etc.) to guide moral decision-making in engineering. Even the more prominent ethical lenses like utilitarianism are not systematically covered across the engineering textbooks. Because engineering is a collaborative profession with engineers playing many diverse roles across organizations and with differing authority levels, it is vitally important that we equip engineers with a more diverse set of ethical lenses.

Table 2. Ethical Topical Coverage by Engineering Ethics Textbook

TEXTBOOK TOPIC	TOPIC COUNT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Ethics and Engineering Ethics	26	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ethics in Design and Tech Development	21	X	X		X	X	X		X		X	X		X	X	X	X	X		X	X	X	X	X	X	X	X
Case Studies	21	X	X	X	X	X	X	X		X	X	X		X	X	X		X		X		X	X	X	X	X	X
Environmental Ethics and Laws	20		X	X		X	X			X	X		X	X		X	X	X	X				X	X		X	X
Ethics in Profession / Codes of Ethics	18	X	X	X		X		X		X	X	X	X			X		X	X	X	X	X	X				X
Safety and Risk	16		X	X	X	X				X	X	X		X		X	X		X		X		X	X	X	X	X
Product and Legal Liability, Law	16	X	X	X	X	X				X	X	X	X	X		X	X			X		X		X	X		X
Morality & Morals	16	X	X	X		X	X			X	X		X	X	X	X		X				X		X		X	X
Public Welfare & Public Wellbeing	15	X			X	X	X	X		X	X					X	X		X	X	X	X		X			X
Conflict of Interests and Resolution	14	X		X		X		X		X		X	X			X	X		X				X	X		X	X
Whistleblowing	13		X		X		X	X		X		X			X		X		X		X	X	X				X
Ethics in the Global Context and Setting	13		X		X	X					X	X		X	X	X		X		X		X	X		X	X	
Responsibilities of Engineers	11		X		X						X		X	X	X	X	X	X	X							X	
Ethics in Education and Academia	11	X	X		X	X	X				X		X		X			X		X	X					X	
Virtue Ethics	10				X		X			X		X			X			X	X	X	X						X
Workplace and Employee Rights	10		X							X	X	X		X	X		X		X								X
AI & Computers	10		X	X		X		X		X	X		X	X			X		X			X			X		
Engineering & Other Disciplines	10		X							X	X			X		X		X	X	X	X			X			X
Values and Value Systems	9		X		X					X			X			X	X					X	X		X		
Moral and Ethical Theories	9	X	X	X		X						X			X							X	X	X			X
Honesty & Integrity	9	X				X		X		X		X			X		X					X	X				X
Ethics in Research	9		X	X		X	X					X			X		X		X						X	X	X
Privacy and Confidentiality	9	X	X			X			X	X	X	X											X				X
Moral and Ethical Decision-Making	8								X	X	X	X	X		X					X	X	X	X				X
Competence	8	X					X		X	X	X			X													X
Utilitarianism	8				X	X				X		X			X								X			X	X
Autonomy	8	X			X					X			X		X					X		X					X
Unfair Competition	8		X		X				X	X										X	X	X					X
Mentor/ee Employer/ee Relationships	7	X			X		X	X		X		X															X
Normative Ethics	6	X	X												X	X								X	X		
Ethics of Loyalty to an Organization	6	X			X	X							X							X							X
Duty Ethics	5					X				X	X												X				X
Applied Ethics	5	X			X	X							X		X												
Religion in Engineering Ethics	4		X							X													X				X
Intellectual Property	4				X					X			X										X				
Moral and Ethical Problem-Solving	4		X	X																			X				X
Social Justice	4	X				X		X		X												X					
Aspirational Ethics	3	X				X				X																	
Public Policy	3					X																				X	X
Engineering as Social Experimentation	3		X			X													X					X			X
Emotional Intelligence (EQ)	2		X			X																					
Total Topics Covered		20	21	14	8	31	9	13	7	11	28	12	16	19	5	10	16	18	10	13	8	20	14	29	9	12	33

Further, while *code of ethics* is a prominent topic across many textbooks (N=18), we must be guiding the next generation better in regard to ethical standards pertinent to *employer/employee and mentor/ mentee relationships* (N=7). Similarly, ethical topics related to the *law and liability* are prominently covered across the textbooks (N=16), but the topic of *intellectual property law* appears four times only (N=4) even though it likely impacts most (if not all) engineers at some point in their professional journey.

Other ethical topics are surprisingly covered less than we would expect because of how important such topics are to engineering practice. Examples include *bidding and bribery* (N=10 textbooks), which engineers face in all competitive practices. Ethics pertinent to the cross-disciplinary work of engineers with *interactions with other disciplines like economics and politics* are significant; nevertheless, mentioned in only ten textbooks (N=10). It is also unfortunate that other essential ethical topics - *religion*, *competence*, *social justice*, *autonomy*, *privacy and confidentiality*, and *public policy* – are so poorly covered in engineering ethics textbooks.

V. CONCLUSION

Thinking about engineering, no other profession can impact the broad and urgent global issues that face our society, including pollution, climate change, sustainability, environmentally friendly technologies, production to support a growing population, clean energy systems, healthcare, security, etc. [41]. Through engineering, new enterprises and industries are enabled and lead to economic growth [42]. Engineering is a field dedicated to improving, directly or indirectly, the lives of all humankind. Playing such an immense part in how society functions, the decisions and actions of the engineering community affect us all. In examining the contents of widely used engineering ethics textbooks, the gaps and strong points of ethics instruction in engineering are made apparent. The state of engineering ethics education serves as a predictor of the behaviors to be found among future engineering practitioners. Ensuring that socially responsible and ethical decision-making stays at the forefront of engineering, engineering ethics education must evolve to address the challenges of the era. In other words, the contents should reflect the timeless elements of engineering ethics yet also be relevant to current issues like the development of artificial intelligence. One significant issue is the rapid advancement of technology, impacting engineers, is the challenge to foresee ethical ramifications [4]. It is difficult to properly forecast the hazards and implications of emerging technologies like genetic engineering and artificial intelligence. Even in the face of uncertainty, engineers must try to proactively evaluate alternative outcomes. A related issue is the growing complexity of sociotechnical systems, which leads to vulnerabilities due to networked technology [2]. Full lifecycle accountability is challenging as a result. Managing conflicting demands and incentives that might compromise ethical behavior inside organizations is another enduring difficulty [43]. Demands for shareholder profits, performance targets, cost-cutting strategies, and inflexible hierarchies can lead to unethical behavior concerning sustainability, safety, and transparency.

There are pressures on practitioners to sacrifice ethics for the sake of convenience or profit. Furthermore, unexpected results may result from the inherent uncertainties in engineering design and issue solutions [11]. Because of the inherent limits of human knowledge and foresight, undesirable outcomes can still occur even with the greatest of intentions and procedures. It is morally required to be open and responsible when anything goes wrong. Divergent cultural and social standards across the locations where multinational corporations operate can additionally complicate the process of making ethical decisions [5]. Activities that are deemed immoral in one nation could be deemed OK in another. There are difficulties while navigating these gray zones. Last but not least, it is a continual ethical responsibility to stay current with fast-emerging technology and preserve competence [44]. However, broadening one's skill set to stay relevant might be difficult as well. Being inexperienced with novel techniques and instruments may cause problems with accountability. To summarize, ethical engineering practice faces obstacles from the present rate of change, system complexity, organizational constraints, inherent unpredictability, cultural variances, and growing skill needs. Nonetheless, direction is provided by a dedication to fundamental human ideals and transparency.

This paper, to the best of our knowledge, offers the first comparative study of twenty-six classic engineering ethics textbooks. Our comparative analysis offers insights into the content and coverage of engineering ethics topics as covered by prominent engineering ethics textbooks. The twenty-six engineering ethics textbooks that were part of this comparative analysis/investigation revealed a list of forty-one ethics topics covered across the textbooks and covering a broad spectrum of topics. Some of the ethical topics were covered across the majority of the engineering ethics textbooks, but the majority of topics were only partially covered. Emerging areas of engineering ethics, like AI, were not covered well.

The implications of this analysis are many. A well-rounded awareness of the ethical topics pertinent to engineering is essential and this paper offers that. Engineering educators can now target specific engineering ethics textbooks to ensure adequate coverage of ethical topics are covered and addressed. We hope to see engineering ethics more prominently covered across engineering curricula, and not just in one ethics course across four years of study; thus, this paper offers a comprehensive list of ethical topics and textbooks that address those important areas. There is considerable work that is still needed to prepare engineering graduates to be ethical engineers and ethical leaders in their professional environments. This study is intended to bring awareness to what engineering ethics education should continue and improve. The results offer insight into the critical topics that society's future engineers might not have mastered. It is hoped that engineering ethics educators are given the guidance to incorporate concepts in their classrooms like emotions— the least covered topic but something every engineer has and needs to learn how to manage.

VI. LIMITATIONS & FUTURE WORK

These papers and our findings targeted general engineering ethics textbooks rather than professional engineering ethics textbooks or discipline-specific engineering ethics textbooks (e.g. biomedical ethics). Future work should target a more thorough analysis beyond the table of contents of engineering ethics textbooks and include more textbooks.

The differences in formatting among the textbooks' table of contents acted as a limitation in this study. Some textbooks offered higher levels of headings than other textbooks. Some textbooks stopped at first-level headings and therefore, did not have subsections listed. Others went up to third and fourth-level headings, reporting even the most minor ethical topics mentioned within them. It is thus possible that some of the ethical topics were covered in the textbooks with lower heading levels, but the limited preview hindered us from identifying such topics. Future work can focus on a more in-depth analysis of book content and a more thorough analysis of the ethical topics included in that textbook. Further, while 41 ethical topics were identified in this study, providing a larger number of topics would contribute to a greater understanding of the strengths and shortcomings of engineering ethics education. Better definitions of such topics could also put forth results with increased accuracy.

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