Science, Business, and Public good: Competing Priorities in Engineers' Professional Organizations [Research Paper]

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Abstract:

The primary objective of this paper is to examine how "public good" is characterized in the ethical codes and websites of engineers' professional associations. While engineers are expected to hold the public paramount over client and employer needs, historic accounts of engineers' professional formation suggest that scientific authority and the economic bottom line have been powerful drivers of engineers' work since the turn of the 20th century [1, 2]. How do these three occupational authorities—science, business, and public service—shape the contemporary messaging systems of engineers' professional organizations and to what extent do these messages differ across industrial and national contexts? My critical analysis of eight engineering organization websites suggests an amplification of scientific and managerial discourses woven into the public service promises of organized professional engineers in both Canada and the United States, with slight disciplinary differences. Civil engineers prioritized safety, and sustainability, mining engineers prioritized industrial development and technical stewardship, and biomedical engineers prioritized health and wellness. While all eight professional organizations wove social good into their messaging systems, they did so in ways that characterised public impact as a product of industrial innovation. This passive acceptance of capitalist forces as an inherent aspect of Canadian and American engineers' collective professional identity formation provides one possible explanation for persistent gap between the rhetoric of public service and the reality of economic paramountcy.

Background:

Professionalism, even according to functionalist theorists, includes public service as a key element of professional status [3-6], making "public good" a core engineering responsibility [5, 7-11]. As many engineering ethicists have argued, however, the notion of "public good" remains vague and unenforceable, often formalized through generic, minimally consequential public paramountcy clauses in engineers' codes of conduct [2, 4, 5, 12-22]. What does it mean to hold the public paramount? At a minimum, it means that engineers are expected to prioritize the needs of the public over the needs of their employers or clients, but historic accounts of engineers' professional formation suggest that technical and economic success have driven engineers' work for more than a century [1, 2]. Given the power and durability of scientific and market forces in the United States and Canada, engineers' associations may implicitly frame "public good" in technicist and capitalist ways, foregrounding scientific innovation and economic growth as key professional "good*s*." Alternately, or maybe simultaneously, they may turn to ethical theories generated by philosophers and sociologists who have been defining public good for centuries. What does it mean to hold the public paramount and how can we realize this goal with a vague and largely unenforceable clause? As a researcher who believes professional practice cannot be accidentally ethical in capitalist economies, I would like to take a closer look at the websites of engineering associations in two capitalist democracies—the United States and Canada—to see how they define "public good."

One of the ways "public good" has been realized has been through a compound formulation of social justice merging diversity, equity, and inclusion (DEI, or EDI in Canada). DEI has become institutionally mainstreamed in higher education and engineers' workplaces over the past two decades. Over this period, it has also been integrated into the ethical codes of two US-based professional associations—the Institute of Electrical and Electronics Engineers (IEEE) [17] and the American Society for Civil Engineers (ASCE) [23]. North of the border, equity has been included in an accreditation-based graduate attribute[1] through the Canadian Engineering

[1] CEAB graduate attributes are functionally similar to ABET learning outcomes.

Accreditation Board (CEAB—GA10 ethics and equity) [24-28]. These centralized accountability measures may have been set up to bring about justice in the profession, but inequities persist in undergraduate classrooms [29-48] and engineering workplaces [16, 38, 44, 49-53], leaving the historically authoritative forces of business and science intact in the profession [1]. The key objective of this paper is to examine discursive traces of ethics, equity, and public good on the one hand, and business and science on the other, in the public facing messaging systems of engineers' professional organizations. How do six professional engineering associations pin down the nebulous concept of "social good" for their members? And to what extent do these socially constructed messages include traces of dominant economic and scientific norms? After briefly reviewing the literature on the history of professionalization in engineering and contemporary empirical studies on engineering ethics, I share my data sources, analytic processes, and findings. I then use these findings to discuss implications for engineering ethics education.

Literature Review:

This paper builds on two bodies of literature: historic accounts of engineers' professional formation and empirical studies of engineering ethics in professional practice. Historically, engineers' work was shaped in relation to nested authority structures—the state, military, higher education, professional associations, commerce, and the increasingly globalized marketplace [1, 2, 5, 54-58], with peak growth periods catalyzed by the first [5] and second [1, 2] industrial revolutions. Historic accounts of engineers' professional formation demonstrate the dynamic and ongoing struggle to attain or maintain professional status. Alexander's brief history of engineering divides the emergence of engineering disciplines into three eras—pre-modern, modern, and contemporary [2], with civil and military engineering coming of age in the pre-modern era, mechanical, chemical, material, and electrical engineering forming in the modern era of professionalization, and inter-disciplinary specializations like biomedical engineering emerging in the contemporary era of globalized capital. Of the many historical tensions shaping engineers' professional formation, Layton suggests that the contrasting forces of business and science have been especially durable and powerful [1]. Transcending Layton's and Alexander's specific attention to engineers, Larson's historic analysis of professionalization traces the political and economic processes through which medicine, engineering, and other occupations organized themselves to attain market power in the early to mid1800s [5]. Reinforcing Layton's analysis, Larson documents the ways in which engineers' close dependence on corporate power limited their ability to claim scientific authority and professional autonomy. Finally, Tang, Nieusma [57] and Vesilind [58] trace the deeply politicized formation of ethical codes in the Institute for Electrical and Electronics Engineers and American Society of Civil Engineers, documenting the public relations project of inserting professional ethics into pre-existing codes of conduct. These five historic accounts are relevant to my discursive analysis of engineering ethics in professional practice because they prime us to see macroethical traces in the public messaging systems of engineers' associations [59]. While engineers may think of themselves as autonomous professionals who call upon their personal integrity to solve technical problems, the collective narratives of their organizations may carry traces of state, economic, and scientific authority passed down for decades, or even centuries through their disciplinary training.

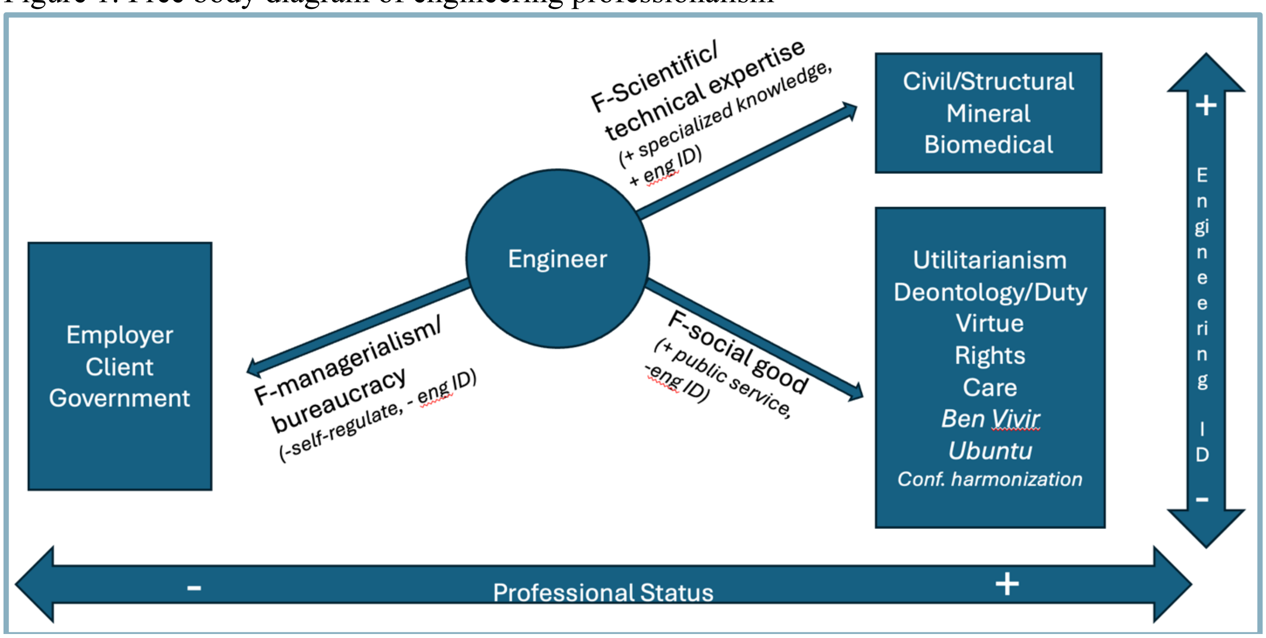
These five historic accounts of engineers' professional formation highlight salient socio-political tensions that we ignore at our peril, but they do so in a somewhat homogenizing way, foregrounding change over time and backgrounding heterogeneity within a specific period or field. As a result, they tend to mask the diverse archipelago that makes up this multi-disciplinary profession. In contrast, more recent depictions of engineers' professional practice afford more space for disciplinary distinctions [60]. Empirical studies examining engineering ethics in professional practice characterize public good in a variety of ways including appeals to health and safety [7, 37, 61-65], sustainability [52, 62, 66-68], Indigenous land rights [69-72], municipal infrastructure [37, 58, 61, 73], and medical wellbeing [21, 64, 74-77], with distinct foci across fields, industries, and disciplines. I focus on three disciplines in this literature review—civil, mineral, and biomedical engineering.

Chance and her colleagues interviewed nine civil engineers in England and found their sense of professional duty revolved around notions of health, safety, and environmental protection, with particular attention to the health and safety of construction workers [7, 37]. Jose et al. point out similar trends, but begin by framing civil engineering as the original "public good" discipline responsible for building, repairing, and providing access to basic services such as water, shelter, transportation, and communications [78]. In contrast to the clear public service foundation of civil engineering, engineers in the natural resource and extractive sectors need to work harder to demonstrate public good. As such, it is not surprising that researchers who study ethical issues faced by mining engineers take a more critical and less interpretivist approach. For instance, Gupta used an international dataset of environmental, social, and governance indicators to respond to his provocative, dichotomous question, "are oil and gas firms more likely to engage in unethical practices than other firms?" and found that they were not [79]. Maslen and her colleagues asked a more open-ended question and found that Australian pipeline engineers used technical language to defend against broader public safety obligations, referring to this phenomenon as "moral muteness" [64]. Finally, taking a more organizationally contextualized approach, Smith found that a small but critical group of engineers in the US mining industry attempted to enact social and ethical responsibility but lacked the decision-making authority within their organizations to make this happen [52]. Smith's findings remind us to take organizational context into account before making claims about the ethical commitments of engineers working in a particular industry. Finally, biomedical engineers in many jurisdictions are still struggling to attain professional recognition and visibility given their interdisciplinary background in biology, medicine, and engineering, making it difficult to identify durable patterns in their ethical commitments. So far, however, the most prominent ethical issues in this emerging field include patient health, the protection of clinical research subjects, and societal debates about artificially extending human life [76]. As Monzon points out, the absence of established professional standards in this interdisciplinary field makes it challenging to identify, much less teach applied ethics to his students [75]. While professional recognition challenges appear greater for biomedical than mineral or civil engineers, newer fields are less likely to be burdened by the vestiges of prior generations, leaving them more open to reimagining professional ethics in their respective fields. This possibility feels especially promising in fields drawing on both technical and non-technical disciplines, where interdisciplinary dissonance may unmask powerfully vested but previously tacit authority structures.

The small, but emerging body of literature on contemporary ethical priorities in civil, mineral, and biomedical engineering disrupts the assumed homogeneity in the engineering profession, but it may result in the reification of disciplinary stereotypes or essentialist assumptions about the individuals who pursue each of these disciplines. That is not my intention. We cannot assume that civil engineers working in municipal infrastructure are more committed to the public good than mineral engineers working in the oil and gas industry or biomedical engineers working for large pharmaceutical companies. If the historic accounts of engineers' professional formation and contemporary analyses of engineers' ethical commitments in the three disciplines reviewed above teach us anything, it is that context matters. As a relatively novice engineering ethics researcher, I need to transcend the micro-political perspectives of individual engineers and pay attention to the socio-political, historical, and cultural contexts in which engineers work as well as the disciplinary traces and pressures faced by engineers in distinct workplaces, industries, and sectors at a particular time and place [21, 80-85]. In this paper, I listen for these contextual traces by critically examining conceptions of public good articulated on the messaging systems of eight engineering organizations through a conceptual framework rooted in Larson's sociological analysis of professionalization [5].

Conceptual Framework:
The conceptual framework I adopt in this paper blends Larson's sociological analysis of professionalization [5] with Layton's historic account of scientific and business authority in the engineering profession [1] in a metaphorical free body diagram, using Faulkner's notion of "nuts and bolts" engineering identity [86] and Cruz et al.'s critical analysis of engineering ethics education [87]. Please see figure one for an illustration of this framework.

Figure 1: Free body diagram of engineering professionalism



Before diving into the theoretical roots of this figure, I offer a brief explanation of my underlying assumptions. Foundational to this image is the sociological tension between human agency and social structure. I view engineers as neither free agents nor objects living their lives according to a structurally determined script. Rather, I view them as individuals with some level of decision-making authority upon whom three institutional forces act, 1) managerialism enacted by employers, clients, and the government, 2) scientific training shaped by discipline-specific university programs, and 3) ethical commitments shaped by early growing up experiences and formal non-technical education. The diagram illustrates these three external forces using arrows and the related institutions using boxes. The agentic aspect of the diagram will be fleshed out in the next phase of this project when I interview early career engineers. The two axes are also based on sociological notions of professional identity and professional status. In contrast to the dominant messaging engineering students receive in their first week of class, I do not believe we can assume that engineering (or any other occupation) is a profession. Like all other occupational groups, engineers must continually demonstrate professional status and perform professional identification. Beginning with the vertical axis, ethnographic analyses of engineers in a range of professional workplaces suggest that they are more closely identified with the profession when they are doing "nuts and bolts" technical work than when they are leading, managing, or engaging in ethical decision making [86]. This explains why I placed disciplinary training near the top of the diagram and managerial and ethical forces closer to the bottom. Finally, for the horizontal axis, I draw on functionalist notions of professional status that depend on a specialized knowledge base, commitment to public good, and self-regulation. The disciplinary training box and ethical box are to the right because they reflect two of the three professional status requirements (specialized knowledge base and commitment to public good), while the managerial box is on the left since employers, clients, and government policies restrict the extent to which an individual engineer or even engineering as a profession may self-regulate. In the next two paragraphs I use sociological theories to blur the seemingly static nature of my explanation.

The overarching theoretical umbrella for my analysis is based on Larson's notion of professionalization as an ongoing political process requiring regular demonstrations of inclusion. Larson's *Rise of the Professions* traces the political and economic processes through which occupations such as medicine, law, and engineering organized themselves to attain market power at the turn of the 19th century during the "great transformation" from aristocratic rule to industrial capitalism [5]. In contrast to functionalist analyses of professions which *statically* lay out key attributes necessary to classify an occupation as a profession—a knowledge base acquired through specialized training, the right to self-regulation, and service to society—Larson characterizes professionalization as a *dynamic* process of organized advocacy and public relations that is only ever temporarily achieved. Not only is professional status temporary, but it may also be achieved on a continuum rather than a discrete checkbox system [5]. For example, according to Larson, engineering failed to achieve the professional status of the medical profession at the turn of the 19th century partly because engineers' services were heavily mediated by employers who purchased their labour. Moreover, the economic component of their work was measured by the "will it pay" test, overriding any independent self-regulatory agency engineers could otherwise have derived from their specialized knowledge base. These barriers to full, permanent professional status contain a threat and an anchor. Managerial authority threatens the self-regulatory feature of professionalization, while scientific and technical authority anchors engineers to a specialized knowledge base. The dynamic nature of the free body diagram I have drawn in figure 1 indicates the degree of professionalization on the x-axis, setting the stage for my analysis.

Interestingly, and perhaps predictably, these two forms of authority—managerial and technical—form the basis of Layton's historic analysis of the engineering profession in the United States from 1900-1945 [1]. Of the many tensions shaping engineers' professional formation in the

United States over the past century, Layton found that the contrasting forces of business and science were especially durable, with historic differences by discipline and era. On the first page of his book, he notes that “the engineer’s problem has centered on a conflict between professional independence and bureaucratic loyalty” (p.1). The historically durable tension between managerial and scientific authority in engineers’ professionalization, characterized as a barrier to full professionalization by Larson and an irreconcilable tension by Layton, may persist in engineers’ professional messaging systems today making these two concepts useful anchors to consider as I examine professional organizations’ explicit messaging about social good. Faulkner’s more recent ethnographic analysis of engineering workplaces points to the gendered nature of this tension between nuts and bolts (real) engineering identity, and managerial work on two levels [86]. First, touching on the fissure between professional norms and practices, she notes that dualist thinking rooted in traditional nuts and bolts (coded masculine) vs social (coded feminine) identities conflict with the reality of engineers’ work. Second, when it comes to research participants’ social locations, Faulkner’s empirical work confirms that women tend to be penalized for these inevitable technical to managerial transitions more heavily than men [86]. In other words, gender dynamics show up in two places on this figure—first by being tapped for middle management at higher rates than men, women show up at the low professional status end of the x-axis, and to the extent that they are positioned in social rather than technical roles, they show up at the low professional identity end of the y-axis.

Larson, Layton, and Faulkner include public service and social good as required features of professionalism, but none of them define “social good.” To conceptually clarify this important feature of engineers’ work, I turn to Cruz et al.’s chapter on engineering ethics [87] in the recently published *International Handbook of Engineering Ethics Education* [88]. Engineering ethics textbooks published in Canada and the United States tend to centre four ethical theories located squarely in the western cannon—Mill’s utilitarianism, Kant’s deontology, Aristotle’s virtue ethics, and Locke’s rights ethics [4, 89]. This cannon limits morality to theories authored by white, European men who respectively centre the individual actor’s character, intentions, behaviours, or the consequences of their actions. Utilitarian notions of morality revolve around decisions that maximize benefits for the greatest number, deontological notions of morality foreground an actor’s intention to behave in ways that could be universalized as “good” if codified and practiced by all, virtue ethics centre an actor’s character, and rights ethics highlight an actor’s refusal to infringe on the life, liberty, and dignity of others [4]. Many other ethical theories exist, but they tend to either be omitted from engineering education, or selectively included when there is time, curricular space, or instructor will.

Cruz et al. identify eight ethical theories in their chapter including the four named above. They also name Noddings’ ethics of care rooted in relational morality [90, 91], *sumac kawsay*, a Quechuan expression translated into Spanish as *buen vivir* rooted in interconnected good living [69], *Ubuntu*, a South African ethical concept loosely translated as “I am because we are,” rooted in communitarianism, reconciliation, and interdependence [92, 93], and a series of Confucian virtues locating actors in a web of duties, social roles, and responsibilities marked by harmonization within a relational social order [94]. In contrast to the first four ethical theories which foreground the individual moral agent, the latter four share a relational or communitarian approach. Additionally, none of these four is attributed to a single white, European man—their sources are either attributed to communities, spiritual traditions, or in the case of care ethics, two white women living in the United States. These eight conceptions of social good are not comprehensive, but they will help me analyze promotional materials on the websites of engineering organizations by foregrounding specific ethical principles. Drawing on four dynamic conceptual tensions presented in my framework—functional vs socio-political conceptions of professionalization [3, 5], managerial vs scientific authority [1], technical vs social engineering identities [86], and agentic vs relational notions of social good [4, 87], I now turn my attention to the following two research questions:

- RQ1: How do civil, mineral, and biomedical engineering associations in Canada and the United States integrate notions of ethics, equity, and "public good" into their vision statements, mission statements, and origin stories?
- RQ2: How does this compare with discursive traces of two historically powerful forces in the profession—business and science?

Methods:

I respond to these questions through a combined thematic content analysis [95-97] and critical discourse analysis [98] of origin stories, vision and mission statements on eight professional engineering associations cutting across three industries in two national contexts. The websites I have chosen to include are:

1. Engineers Canada (EC) https://engineerscanada.ca/,
2. National Society of Professional Engineers (NSPE) https://www.nspe.org,
3. Canadian Society for Civil Engineering (CSCE) https://www.csce.ca/,
4. American Society of Civil Engineers (ASCE) https://www.asce.org/,
5. Canadian Institute for Mining, Metallurgy, and Petroleum (CIM) https://www.cim.org/,
6. American Institute of Mining, Metallurgical, and Petroleum engineers (AIME) https://aimehq.org/,
7. Canadian Medical and Biological engineering society (CMBES) https://www.cmbes.ca/, and
8. Biomedical engineering society (BMES) https://www.bmes.org/.

The first two are national engineering associations in Canada and the United States, while the final six are disciplinary associations located in each of the two national contexts. I chose Canadian and US-based organizations since I am a Canadian presenting this paper to US-based engineering educators, and I chose structural, mineral, and biomedical engineering since they appeared at different historical periods [2] and have been documented as representing a diversity of ethical priorities: employee and public safety for structural engineers [7, 58, 78, 99], land rights and ecological impact for mining engineers [52, 68, 79, 100-103], and patient health for biomedical engineers [74-77, 104-106].

My analytic strategy combines a thematic content analysis [95-97] of promotional materials published by eight engineering organizations with the third dimension of Fairclough's critical discourse analysis—social practice [98]. I began by generating tabular comparisons of origin stories, vision and mission statements organized by national and disciplinary context, then examined how the discursive threads or narratives weaving through the messaging systems of engineers' professional organizations maintained or disrupted social power relations, ideologies, and institutional practices around the promise of public service. I have chosen to analyze origin stories, vision and mission statements because they are standard features of engineering association websites, facilitating my comparison of national and discipline-specific organizations. While none of these features contain direct answers to the question "what do we mean by public good," origin stories contain implicit values of organizational founders, while vision and mission statements are deeply curated, pithy, public facing messages about organizational values and priorities. If professional engineering organizations truly intend to hold the public paramount, evidence of this intention must surely show up on their outward facing messaging systems.

Findings

Consistent with Layton's analysis of American Engineers' ethical commitments in the early to mid 1900s [1] and Larson's sociological analysis of the rise of the professions, I found an amplification of scientific and economic themes in the messaging systems of all eight sample organizations, with explicit pleas for enhanced professional recognition. That is, the origin stories, mission, and vision statements of all eight engineering organizations framed the public as a perceptual lens through which to demonstrate professional worthiness, while asserting the beneficial impact of members' knowledge creation, mobilization, and innovation as a public service outcome. To be sure, I did notice some national and disciplinary distinctions.

Other than the obvious discrepancy of scale, one minor national difference between the messaging systems of Canadian and American engineering associations may be attributed to jurisdictional distinctions between the way engineers are organized on either side of the border. Canadian and American engineers are similarly regulated by decentralized legislation at the state/provincial/territorial level, but licenced engineers in Canada are organized by provincial/territorial regulators while engineering graduates in the United States (whether licensed or not) tend to join disciplinary organizations. In terms of numbers, it may surprise readers to learn that despite Canada having approximately $1/10^{th}$ the number of graduating engineers as our Southern neighbour, Engineers' Canada (EC) has a larger membership than the National Society of Professional Engineers (NSPE). This is a function of the EC structure which includes provincial and territorial regulators as constituent associations of the national body. In contrast, discipline-based organizations in the US (eg. ASCE, AIME, ASME, IEEE, and AIChE) are not constituent members of NSPE, nor are they limited to members working in the United States. This may incline US-based engineers to identify more closely with their discipline (scientific authority) than Canadian counterparts. Please see table 1 for the origin stories and membership numbers of all eight organizations included in the sample.

Table 1: Origin stories and membership numbers of organizations in sample

Discipline	Canada	US
Engineering National	**Engineers Canada (EC)** Established in 1936 to bring provincial regulatory bodies into greater harmony. It is the national organization of the provincial and territorial associations that regulate the practice of engineering in Canada and license the country's P.Eng members (300,000 members)	**National Society of Professional Engineers (NSPE)** Established in 1934 by a group of PEs dedicated to the non-technical concerns of licensed engineers. It is the only national organization committed to addressing the professional concerns of licensed PEs across all disciplines (31,000 members)
Civil	**Canadian Society of Civil Engineering (CSCE)** The Canadian Society for Civil Engineering (CSCE) was founded in 1887, but its history can be traced back to the establishment of civil engineering as a separate discipline in France in 1716. CSCE is a not-for-profit organization that	**American Society of Civil Engineering (ASCE)** Founded in 1852 by a dozen civil engineers as the American Society of Civil Engineers and Architects. In 1868, architects formed their own prof society, and ASCE adopted current

	aims to improve the civil engineering profession and the public's perception of it. (5000 members)	name. Represents licensed civil engineers in more than 177 countries. (160,000 members)
Mining	**Canadian Institute for Mining, Metallurgy, and Petroleum (CIM)** Incorporated in 1898 by an Act of the Parliament of Anada as the Canadian Mining Institute by individuals in the mining industry seeking a vehicle or lobbying for safety laws, workers' protection, and the communication of ideas. (10,000 members)	**American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME)** Founded in 1871 by 23 mining engineers to preserve their collective knowledge and experiences for the benefit of future engineers, it is one of five founder societies (along with ASCE, ASME, IEEE, AIChE). (200,000 members)
Biomedical	**Canadian Medical and Biological Engineering Society (CMBES)** Founded in 1965 by the inventor of the pacemaker, the CMBES organizes biomed engineering conferences and established clinical standards of practice. The society's aims are: scientific/educational (advancing theory and practice) and professional (connecting engineering, biology, and medicine) (300 members)	**Biomedical Engineering Society (BMES)** Incorporated in 1968 in response to the emerging need to provide a society offering equal status to representatives with both biomedical and engineering interests. It is a nonprofit organization established to promote and enhance biomedical engineering knowledge worldwide. (5000 members)

Engineers Canada and the National Society of Professional Engineers in the United States were established around the same time (1936, 1934 respectively) with slightly different mandates—EC to harmonize provincial regulatory bodies and NSPE to address the non-technical advocacy concerns of professional engineers across national and disciplinary contexts. Both adopt national advocacy rather than tightly regulatory roles, partly because they lack legislative authority over their membership.

When it comes to the six disciplinary organizations, the two Civil Engineering societies (CSCE, ASCE) and two mining engineering institutes (CIM, AIME) were established in the mid to late 1800s with the CSCE discursively claiming the 1716 establishment of civil engineers in France as an organizational antecedent. The origin stories of disciplinary organizations on either side of the border are similar, with civil engineering organizations established to enhance public recognition though high professional standards, and mining organizations lobbying for worker protection. Moving from the four traditional associations to the two interdisciplinary ones, Canadian and American biomedical engineering societies (CMBES and BMES) were founded in the late 1960s to enhance public recognition of members straddling three disciplines—engineering, biology, and medicine. Their priorities connect professional advocacy with education. The main difference between Canadian and American disciplinary societies has to do with reach. Canadian associations organize Canadians while American associations solicit international membership.

When it comes to "social good" or "holding the public paramount," none of the origin stories shed light on these ethical priorities suggesting that all eight organizations were initially established for other ends. Instead of being positioned as an important participant or recipient of social good, the public is viewed as an audience to be convinced of engineers' professional contributions and value, stated most explicitly by the CSCE's aim to "improve the civil engineering profession and the public's perception of it." The public may also be implicitly treated as a passive beneficiary of scientific innovation and knowledge mobilization, as illustrated by the BMES' objective to "promote and enhance biomedical engineering knowledge worldwide." We now turn our attention to the vision and mission statements of sample organizations outlined in table 2.

Table 2: Vision and Mission Statements in Sample Organizations

Discipline	Canada	US
Engineering—National	**Vision**: To advance Canadian engineering through national collaboration (EC) **Mission**: To uphold the engineering profession's integrity and honour and to inspire public confidence by: regulating engineering, promoting excellence, advocating for the public, supporting engineers, increasing diversity, and collaborating nationally (EC)	**Vision**: To create a world where the public can be confident that engineering decisions affecting their lives are made by qualified and ethically accountable professionals (NSPE) **Mission**: To foster licensed professional engineers in service to society (NSPE)
Civil	**Vision:** To promote advances in civil engineering, including geotechnical, structural, hydrotechnical, environmental, transportation, and surveying and geomatics engineering (CSCE) **Mission**: Not-for-profit learned society created to develop and maintain high standards of civil engineering practice in Canada and to enhance the public image of the civil engineering profession (CSCE)	**Vision**: Engineered and natural systems work in harmony for the benefit of humanity (ASCE) **Mission**: Lead the civil engineering profession to sustainably advance and protect the health, safety and welfare of all (ASCE)
Mining	**Vision**: The trusted authority and collective source for advancing mineral industry knowledge, guidelines and best practices (CIM) **Mission**: Cultivate knowledge, best practices, and innovation to support our members, improve awareness of the minerals and metals industry in society and evolve the sector responsibly. (CIM)	**Vision**: To honor our legacy as a valued partner with our member societies (AIME) **Mission**: To support our member societies (AIST, SME, SPE, and TMS) and to provide member societies with national visibility and representation within the larger engineering and scientific community. (AIME)
Biomedical	**Vision**: To be the national society and professional home for medical and biological engineering in Canada (CMBES) **Mission**: To advance and promote the theory and practice of engineering sciences and technology to medicine and biology, serving as a forum for information exchange between healthcare professionals, scientists, and the general public. (CMBES)	**Vision**: Health and wellness for all through engineering innovation (BMES) **Mission**: To promote a collaborative and inclusive community to advance human health through education, discovery, and translation. (BMES)

If we conceptualize a vision statement as an aspirational future state and a mission statement as an articulation of an organization's key purpose, it stands to reason that any organization intending to hold the public paramount will include explicit messaging about social impact on their public facing websites. My initial content analysis resulted in five overlapping themes:

1. Professional advocacy to advance the industry and enhance the public image of the profession (EC, NSPE, CSCE, CIM, AIME, CMBES)
2. Advance knowledge and best practices to benefit humanity (health, safety, welfare, and sustainability) through innovation (EC, NSPE, ASCE, CIM, BMES)

3. Increase diversity and inclusivity within the profession (EC, ASCE, CIM, BMES)
4. Inspire public confidence through high standards and regulation (EC, NSPE, CSCE)
5. Establish an organizational home for learning and information exchange, connecting members across disciplines with the public (CMBES, BMES)

The second most common of these themes explicitly takes public interest into account, pairing social impact with knowledge creation, innovation, and best practices. This theme reinforces Layton's historic argument about the durability of scientific authority in engineers' professional formation [1]. The first, fourth and fifth themes position the public as an audience to be inspired, foregrounding information exchange, standards, and regulation. This finding reflects Larson's observation that professional status is a dynamic process, involving ongoing negotiation [5]. Finally, the third theme indirectly supports public welfare by aiming to diversify the profession. To the extent that this diversification intention is successful, the organizations in question may increase the likelihood that professional engineers demographically reflect the full spectrum of communities impacted by their design.

If we consider the social practice element of Fairclough's critical discourse analysis [98], it is worth asking how the narratives weaving through the messaging systems of engineers' professional organizations maintain or disrupt social power relations, ideologies, and institutional practices around the promise of public service. All five themes invoke the "public" in many ways—most by reinscribing dominant narratives of scientific and economic authority as public impact precedents, some by conserving existing institutional practices of member regulation for public protection, and two by laying the foundation for equitable next steps through membership diversification and sustainable design principles.

Discussion and conclusions

Recall the two research questions that drove this inquiry:

- RQ1: How do civil, mineral, and biomedical engineering associations in Canada and the United States integrate notions of ethics, equity, and "public good" into their vision statements, mission statements, and origin stories?
- RQ2: How does this compare with discursive traces of two historically powerful forces in the profession—business and science?

To respond to the first question, all eight associations in the sample addressed social responsibility through their vision and mission statements, but not through their origin stories, suggesting that change is possible, if a little slow. The two civil engineering societies focused on health, safety, and sustainability, the two mineral engineering institutes integrated notions of responsible industrial development and technical stewardship into their visions, and the two biomedical engineering societies foregrounded health and wellness. These public service promises reflect theoretical alignment with deontological duty ethics (civil and mining) and the ethics of care (biomed). While some touched on diversity, inclusion, and sustainable design, none raised equity or social justice in their vision or mission statements.

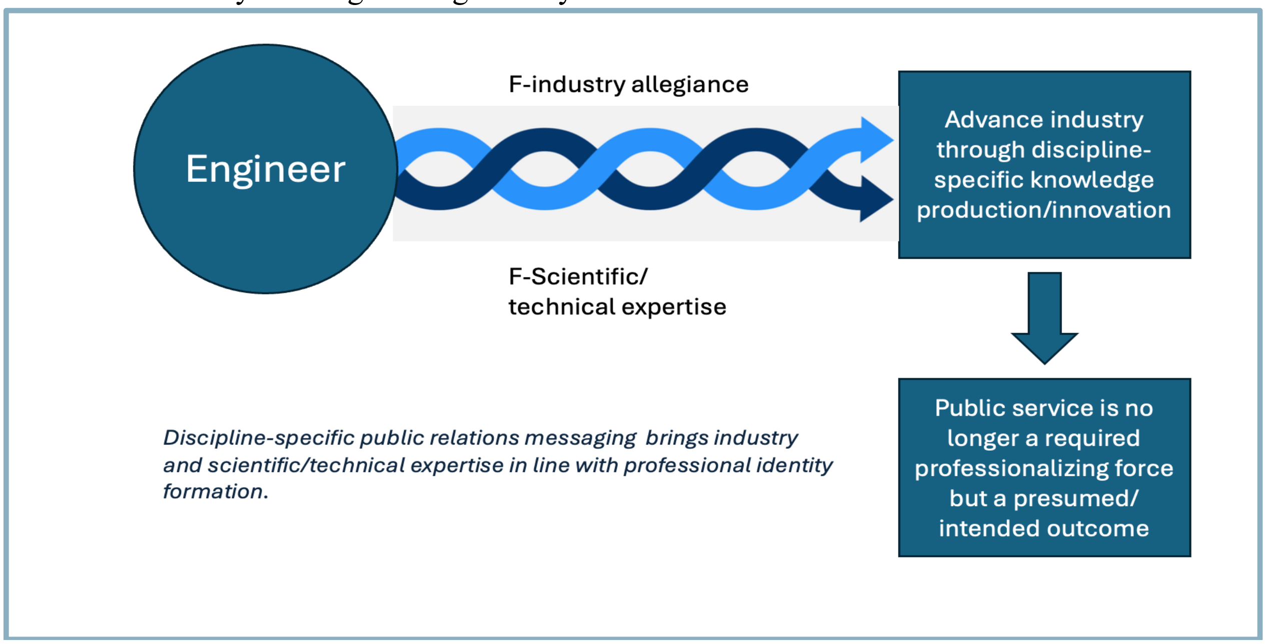
One possible explanation for the omission of equity is the persistent messaging system tying public good to business and science. In contrast to our initial sociologically informed free body diagram in which business and science were pulling in opposite directions, the invocation of public good in most engineering organizations' websites connected the two. Stated differently, when we do not begin with a critical sociological conception of professionalism, it is possible for the PR messaging systems of engineering organizations to connect engineers' industrial advancement ambitions with technical specialization, using the economic translation of creativity into "innovation." As one astute reviewer suggested, my challenge separating public service from capitalism may be the product of a techno-optimist standpoint held by many engineers [107, 108]—the ideological belief (in full force following Trump's recent election) that significant social problems can be solved through technological development. With this techno-capitalist reframing, the advancement of knowledge and best practices may be characterized as simultaneously benefiting industry and humanity. It is very difficult to disentangle public service from capitalism when social good is framed as an indirect product of industrial expansion. This analytic challenge may help explain Layton's historic finding about the durability of business and scientific authority in the engineering profession in the early to mid 1900s, and Larson's argument that professional status is a dynamic, socio-political process that is always only tentatively achieved. The fact that all eight engineering organizations in both Canada and the United States, across three distinct disciplines envisioned their mission in primarily public relations, if not exactly public service, terms (eg. enhancing the public image of the profession) demonstrates Larson's point. If professional status could be permanently secured, it would not be necessary for engineers to collectively prioritize public image enhancements more than a century after establishing member-based organizations.

Leaving vision and mission statements aside for a moment, the tentative settlement of a dynamic professionalization process makes the free body diagram I shared in figure one a potentially useful way for engineering ethics researchers to reveal the professional advocacy functions of engineering organizations. To rehearse the argument made by many critical engineering education researchers, engineering organizations are not neutral actors [51, 72, 87, 109-125]. My analytic revision of Figure 1 to Figure 2 reflects the power of PR messaging on engineers' professional associations rendering three items invisible—the two professionalization axes, and the ethical theory box. Please see figure 2 below.

If professional status is assumed and professional identity is left unquestioned, as was the case in all eight engineering organizations' websites, we no longer need to imagine which forces erode engineers' professionalism or identity formation. We can simply mask the x and y axes of figure 1 and convert public service from a condition to a consequence of professionalization. Stated differently, Layton's observation that "the engineer's problem has centered on a conflict between professional independence and bureaucratic loyalty" (p.1) dissolves if engineers stop viewing economic, managerial, and governance forces as existential threats to professionalism or restrictions to self-regulation. The power of discipline-based international engineering organizations to tie engineers' specialized training to specific transnational industries, institutionally intertwines global industrial allegiance with technical expertise. These neoliberal slips make it easy to forget that professionalism was socially constructed by its adherents and thus remains perpetually unsettled, casting it instead as an irreversible accomplishment.

When we treat the critical question—"are engineers professionals?" as a rhetorical slight rather than an open-ended inquiry, we liberate engineering associations from the requirement to follow through on their public service commitments. Given the broader socio-economic context of capitalist democracies like Canada and the United Sates, it should be no surprise that "public service" is presented as an intended outcome of industrial advancement. In other words, the techno-optimist [107] belief that technical processes will lead to better outcomes for everybody releases engineering organizations from adding teeth or accountability measures to the public paramountcy clauses in their ethical codes. They can have their "nuts and bolts" identities and professional status too.

Figure 2: The power of industry-infused public relations messaging to integrate technical and economic authority into engineering identity



Implications and next steps

The distinction between functionalist and critical conceptions of professionalization is important when we consider the relationship between professional ethics and equity. If we adopt the functional characterization of professional status, we may view the public paramountcy clause in engineers' ethical codes as aspirational but difficult to achieve. That is, we may forgive engineers (or any occupation) for limited social progress so long as they hold the public paramount or claim public service as a natural consequence of technical excellence. If, however, we adopt a critical perspective of professionalization as a dynamic socio-political process, regularly under threat, we will find it easier to characterize anemic public service language as an adaptive PR requirement that never needs be achieved. This critical conceptualization of professional formation as a dynamic process regularly under threat enables us to separate rhetoric from reality, thereby explaining why the public paramountcy clause lacks legislative teeth compared to discursively lower priority employment clauses.

As rhetorical "promises," it may not be surprising that vision statements on all eight professional engineering association websites included some mention of social good, social responsibility, or social impact—with slight differences across industry contexts. Organizations of civil engineers prioritized health, safety, and sustainability, those in the extractive industries prioritized industrial development and technical stewardship, and those in the biomedical sector prioritized health and wellness. What can we do to ensure that these rhetorical promises hit the ground in ways that actually hold the welfare of specific publics paramount? One strategy is to start with the ethical theories raised by Cruz and his colleagues in their recent chapter on engineering ethics education through a critical view [87]. We may move beyond the normative ethical philosophies prioritized by engineering ethics textbooks to envision what public service would entail when it embodies an ethic of care [90, 91], *buen vivir* [69], *ubuntu* [92, 93], or Confucian harmonization [94]. It would be much more difficult for engineers to retain a techno-optimist standpoint in the face of these communal ethical anchors.

The next phase of this study will compare the rhetorical promises of engineering organizations' as articulated on their websites to the everyday realities of early career engineers in construction, natural resource, and biotechnical industries. How would everyday ethical practice look for engineering graduates who hold a techno-optimist perspective compared with those who hold a communitarian ethical commitment? What supports and constraints may they face in a range of engineering workplaces? What sense do they make of their relationships to their employers, to their industries, and to their professional organizations? By documenting the gap between institutional rhetoric and engineers' deeply contextualized early career realities, we may be better positioned to move this critical analysis into the realm of professional practice.

Relevance ASEE-Ethics:
This paper touches on focal topic #2 named in the ASEE-Ethics Division's call for papers: Examinations of ethical engineering in ***industry and applied*** contexts.

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