Instilling Cultural, Ethical, Social, and Environmental Responsibility in Engineering Education and Practice – The National Academies' CESER Advisory Committee (Work in Progress, Examinations of Ethical Engineering/Environmental & Sustainability Concerns)

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Instilling Cultural, Ethical, Social, and Environmental Responsibility in Engineering Education and Practice – The National Academies' CESER Advisory Committee

introduction

This work-in-progress paper describes a nascent initiative that the National Academy of Engineering (NAE)—a component of the U.S. National Academies of Sciences, Engineering, and Medicine—is undertaking to raise awareness of, stimulate interest in, and inspire action on **c**ultural, **e**thical, **s**ocial, and **e**nvironmental **r**esponsibility in engineering (CESER). It outlines the history of the consideration of these impacts by the profession, cites some current efforts, summarizes NAE's earlier programs, and details the development, goals, and status of the new program.

Importantly, the paper also serves as a call for the membership of the ASEE to share their knowledge and experience, and provide their input on the effort at the 2024 annual conference. The CESER advisory committee is formulating its initial activities and would welcome input on suggested areas of focus and opportunities to bring attention to crucial issues through auspices of the National Academies.

background

The practice of engineering is more than the application of scientific, mathematical, and technical knowledge to design, develop, build, and maintain devices, systems, structures, and processes. It is a creative endeavor with profound cultural, ethical, and social dimensions, and with the great potential to do good or harm, however intentionally or unintentionally.

While it may seem as though considerations of such non-technical aspects of engineering are a relatively recent concern, they have in fact long been on the minds of practitioners [1]. Indeed, a set of papers published in 1922 put forward some remarkably modern-sounding concepts. Alexander Graham Christie, a Johns Hopkins University mechanical engineering professor and chair of a "Joint Committee on Ethics of American Engineering Societies" put forth a proposal for a common code of professional ethics that included (in the sexist language of the era) the following precept:

> He will interest himself in the public welfare, in behalf of which he will be ready to apply his special knowledge, skill, and training for the use and benefit of mankind [2].

Another participant in the Joint Committee stated in an accompanying paper that "[a]s the progress of the world, the comforts of man, and his ability to produce are so very largely due to the work of the engineer, his work is of the very greatest importance; he therefore naturally interests himself also in the public welfare [3]. And a third put it most plainly:

> The ultimate goal here is the flatfooted declaration that good engineering must be in the public interest and, contrariwise, that any engineering which is anti-social must be bad engineering [4].

These scholars, working in a world that was still recovering from the effects of the inaptly named "war to end all wars", recognized that "[t]he ethical practice of engineering is more than just the

successful accomplishment of one's task: the ethical engineer must consider whether the end product meets the greater needs of society" [1] and laid the groundwork for current explorations of the issue.

contemporary examples

Cultural, ethical, social, and environmental responsibility principles are already an integral part of many professional codes of conduct. Table 1 provides examples from three existing codes.

organization[s]	"CESER" principles
Engineering Council and the Royal Academy of Engineering (2014) [5]	• Protect, and where possible improve, the quality of built and natural environments. • Maximise the public good and minimise both actual and potential adverse effects for [engineeers'] own and succeeding generations. • Be aware of the issues that engineering and technology raise for society, and listen to the aspirations and concerns of others.
Engineers Australia (2019) [6]	• Engage responsibly with the community and other stakeholders. • Incorporate social, cultural, health, safety, environmental and economic considerations into the engineering task. • Balance the needs of the present with the needs of future generations in identifying sustainable outcomes consider all options in terms of their economic, environmental and social consequences.
World Federation of Engineering Organizations (2023) [7]	• Practise so as to enhance the quality of life in society. • Create and implement engineering solutions for a sustainable future. • Be mindful of the economic, societal and environmental consequences of actions or projects. • Promote and protect the health, safety and well being of the community and the environment

Table 1. Examples of cultural, ethical, social, and environmental responsibility principles in engineering codes of ethics

While the effect of these codes on practitioners' conduct is a separate question, it is clear that there is an awareness in the field that the broader impacts of engineering should be taken into account. The salient question is then how cultural, ethical, social, and environmental responsibility principles can be achieved in the world of practice where economic considerations may drive engineering decision-making and ingrained attitiudes can serve to exclude diverse perspectives from consideration.

related efforts by the U.S. National Academy of Engineering

The NAE has long recognized that engineers operate in a milieu where cultural, ethical, social, and environmental responsibility considerations are central elements of good practice. This recognition was operationalized in the Online Ethics Center (OEC), a digital repository of information on ethically significant issues in engineering, science, and research focused on providing resources to the academic community. The OEC had its beginnings in the 1990s and

first resided at the Massachusetts Institute of Technology before moving to Case Western Reserve University [8]. The NAE assumed stewardship for the repository in 2007. After administrating it for 13 years, it transitioned responsibility to the University of Virginia in 2020, where it is currently based.

OEC's resources may be accessed via https://onlineethics.org/. They include a number of collections of materials for use in engineering ethics education, including

- Cases for Teaching Engineering Ethics
- Cases from the NSPE Board of Ethical Review and Professional Ethics in Engineering Practice: Discussion Cases Based on NSPE BER Cases
- Essays on Ethics Instruction
- Ethical Dilemmas in Engineering Student Co-op Experiences
- IEEE Engineering Ethics Cases

The Center for Engineering Ethics and Society (CEES) was established in tandem with the OEC to disseminate the collection and develop new resources. This included workshops and studies aimed at highlighting issues of importance, examples of which are listed below:

- *Overcoming Challenges to Infusing Ethics into the Development of Engineers: Proceedings of a Workshop* (2017) [9]
- *Infusing Ethics into the Development of Engineers: Exemplary Education Activities and Programs* (2016) [10]
- *Emerging and Readily Available Technologies and National Security: A Framework for Addressing Ethical, Legal, and Societal Issues* (2014) [11]
- *Practical Guidance on Science and Engineering Ethics Education for Instructors and Administrators: Papers and Summary from a Workshop December 12, 2012* (2013) [12]

NAE's CESER program

CESER intends to build upon and expand NAE's long-standing commitment to the socially-responsible practice of engineering exemplified by OEC and CEES. The program is animated by two goals: to seamlessly integrate cultural, ethical, social, and environmental responsibility considerations into the practice of engineering, and to raise awareness of how engineering design and the engineering mindset can responsibly contribute to addressing society's greatest challenges. It aims to broaden the understanding of how such considerations are affected by the practice of engineering and draw attention to them through engagement with educators, community organizations, commercial firms, professional societies, governmental entities at all levels, and the general public.

CESER differs from the earlier efforts in its focus on convening activities that will feature diverse perspectives from outside the engineering profession, examine the broader impact of engineering practice on social and economic equity, and address the disproportionate negative effects that the products of engineering may have on already disadvantaged populations. The initiative will also expand the scope of this work to look not only at how engineers are educated on these issues but how that education can be effectively applied in a working world where entrenched practices, competing interests, and limited resources are at play. It thus fills the gap left by the conclusion of NAE's earlier initiatives and addresses a continuing need for attention to these issues.

The NAE is well-positioned to take on this role because of the unique position of the organization. The membership comprises more than 2,000 domestic U.S. and international members who are among the world's most accomplished engineers. Unlike the other two national academies—the National Academy of Sciences and National Academy of Medicine—half of the honorees must come from outside of the academic sector. The strong representation of commercial and non-profit professionals insures that NAE's perspective, outreach, and influence extend into multiple realms including the world of practice. Its standing as an internationally recognized advisory body allows it to draw attention to issues might otherwise fail to gain traction outside of the communities most directly affected them and stimulate action to address them.

The concept for CESER was developed in 2020, and—after a delay brought about by the COVID-19 pandemic—planning began in earnest in 2023 and an advisory committee to guide the effort was identified. That committee is composed of national thought leaders and subject matter experts from academia, the public sector, and industry. It is co-chaired by Charles Bolden— a retired United States Marine Corps Major General, former astronaut who crewed four Space Shuttle missions, and former Administrator of NASA—and Lisa Jackson—a former EPA Administrator and current Vice President of Environment, Policy and Social Initiatives for Apple, Inc. Table 3 lists the full membership of the committee as of April 2024.

member	professional position
Charles F. Bolden*	Founder & CEO Emeritus, The Charles F. Bolden Group LLC
Lisa Perez Jackson*	Vice President of Environment, Policy and Social Initiatives, Apple, Inc.
Lili Cheng	Corporate Vice President, Microsoft AI and Research Division, Microsoft Corporation
Glen T. Daigger	Professor of Engineering Practice, University of Michigan; President and Founder, One Water Solutions, LLC
Shanna R. Daly	Arthur F. Thurnau Professor of Mechanical Engineering and Miller Faculty Scholar, University of Michigan
Joyelle J. Harris	Director, Engineering for Social Innovation Center, Georgia Institute of Technology
Michael C. Hiles	Senior Vice President and Chief Science Officer, Cook Biotech
Juan C. Lucena	Director, Humanitarian Engineering Undergraduate Programs and Outreach; Professor of Engineering Studies in the Department of Engineering, Design, & Society, Colorado School of Mines
Barry L. Shoop	Dean, Albert Nerken School of Engineering, The Cooper Union for the Advancement of Science and Art

*Co-Chair

Table 3. Members of the NAE Cultural, Ethical, Social, and Environmental Responsibility in Engineering Advisory committee as of April, 2024

Among the committee's initial efforts was to establish CESER's mission and vision statements:

Mission

To understand and promote cultural, ethical, social and environmental responsibility in engineering in partnership with practitioners, educators, students, industry leaders, governmental entities and through engagement with the general public.

Vision

An engineering education and practice in which cultural, ethical, social and environmental responsibility is fully integrated in everything engineers do.
A world in which engineering professionals understand, value and take responsibility for the cultural, ethical, social and environmental implications of our work.

These admittedly ambitious goals are motivated in part by past failures in engineering practice that have led to societal ills and injustices. These include

- **Cultural Insensitivity**: Disregard of cultural norms in engineering projects can result in decision-making and designs that run contrary to belief systems and practices and result in the destruction of cultural heritage. [13]
- **Ethical Dilemmas**: The development and deployment of technologies such as surveillance systems or autonomous weapons raise concerns about privacy, autonomy, and human rights violations. [14, 15]
- **Social Inequities**: Engineering decisions that neglect the social context and needs of marginalized communities can exacerbate social inequalities, disproportionately benefiting certain groups while displacing or disenfranchising others. [16]
- **Environmental Degradation**: Engineering projects that prioritize short-term economic gains over environmental sustainability have contributed to pollution, habitat destruction, deforestation, and climate change. [17]

Such issues will be addressed through engagement with a spectrum of interests, including those that have traditionally been considered outside of the realm of engineering practice such as anthropologists, ethicists, ethnographers, sociologists, and communication scholars. The committee will also seek to have stakeholders like the communities and populations affected by engineering decision-making involved in its work.

The committee anticipates that its upcoming activities will include webcasts, workshops, and collaborations on topics of interest. Should the opportunity be presented, larger more typical National Academies undertakings like consensus reports would be spun off from the advisory committee. It and committee staff are current working with the National Academies' Committee on Human Rights[1] and with the UK Royal Academy of Engineering[2] on potential projects. More information on these and other activities will be presented at the conference, once plans of action have been finalized. Among the other issues that might be addressed in future projects are:

- What are the best ways to detect and prevent biases—cultural and otherwise—in software; in particular, algorithms developed via machine learning?

[1] https://www.nationalacademies.org/chr/committee-on-human-rights
[2] https://raeng.org.uk/

- How should insights from other disciplines like social science inform the solution to engineering problems? Do social scientists have a role on engineering teams? What are the potential downsides to such an approach?
- What are the unique ethical challenges that the various engineering disciplines face and what does say about how they should be trained and should practice to better deal with them?
- How can the engineering mindset and approach to problem-solving inform innovation in developing solutions to problems outside of the sphere of engineering: in medicine, delivery of social services, ….
- How can product end-of-life considerations—disposal or recycling, for example—be better made a part of engineering design?

To be clear, though, this is a nascent effort with many details of the committee's work yet to be defined and challenges in stimulating students and practicing engineers to factor CESER concepts into their work to be surmounted. This work-in-progress paper is intended to not only raise awareness of the CESER initiative in the ASEE community but to solicit the community's input on its direction and course. Feedback is requested on areas that the committee should direct attention to, including poorly explored and unrecognized issues, missing perspectives and voices, weaknesses in past efforts to be avoided, and opportunities to stimulate positive change in engineering education and practice. Outside of the 2024 annual meeting, the committee may be reached via CESER@nae.edu.

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