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Engineering needs a paradigm shift in values: becoming a planet serving profession

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Abstract

For two hundred years, engineering has been a society serving profession. Its professional societies' codes of ethics almost universally begin with "Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duty." More recent changes to the codes have introduced the concept of sustainable development. In this case, the usual definition of sustainable development is "to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs." While these statements have served the profession well for nearly fifty years, the planetary ecosystems have suffered dramatic and devastating damage. It is time to end this anthropocentric viewpoint and embrace a more meaningful set of statements. In this paper we propose to strengthen the definition of sustainability in current codes of ethics to a form that is more ecocentric to shift the focus of engineering to be a planet serving profession rather than a public serving profession. We conclude with a discussion on how such changes could impact engineering curricula.

Introduction

Significant reform in engineering education has been driven from top-down influences such as the professional societies through ABET accreditation, and with all the planetary crises occurring, we need another push from the top. We propose this begins with a restatement of our values as explicitly expressed in codes of ethics. In many codes of ethics, the profession states that it values human life and safety (Anthropocentrism). As the planet is threatened by disastrous climate changes, loss of biodiversity, ocean acidification, etc., a shift in focus from a primary value concern for human lives to valuing life more broadly has been proposed (biocentrism). Valuing all life, not just human lives, means valuing the 'infinite' propagation of life on the planet, whereas lives represent 'finite' concerns. We are not suggesting that individual human lives are not valuable but that they are one kind of life among many on this planet. Redefining collectivism beyond human beings is required. Typically, the idea of collectivism refers to a single species, 'it is not the individual that matters but the population.' The concept of collectivism now needs to value all life forms as a collective, 'it is not a single species that matters but all life forms.' The goal is to protect life on the planet into the future. This goal will lead to very different actions, often associated with the concept of sustainability but not always explicitly codified or put into action.

A further step from anthropocentrism is to place value on both biotic and abiotic components of the planetary environment (Ecocentrism). This approach places an explicit value on the entire ecosystem, e.g. all life in addition to all natural resources -including those that do not have obvious utility to humans. It is important to recognize that while much of the ecosystem may not provide direct utility to humans, it can be valued for its intrinsic value. As is the case with Biocentrism, Ecocentrism can appear to diminish the value of human life by placing it at the same level as everything in the ecosystem. Resolving these conflicts between anthropocentrism, biocentrism, and ecocentrism is a critical issue [1] that will be discussed later.

Brief History of Engineering Codes of Ethics

In an excellent essay by Mitcham [2], the author covers the history of the development and changes to engineering professional societies' codes of ethics in the United States. Mitcham divides the history into four phases and proposes a fifth phase. In the first phase, the implicit phase, from the founding of engineering schools to the institution of the first professional societies in the late 1800s, there is no explicit mention of ethics, but rather an implicit notion of loyalty to other engineers, and loyalty to the client or the employer. The transmission of this loyalty was accomplished through apprenticeship and by example.

In phase two, ethics as loyalty, which lasted from the late 1800s to the 1940s, loyalty to other engineers and loyalty to the client or employer were explicitly stated in what became to be known as each professional engineering society's code of ethics. In the U.S. this was the ASCE, the ASME and the AIEE, the precursor of the IEEE. Each of these codes was adopted and published in the early 1910s. Each of the codes could be printed on one page. Mitcham labeled phase three the ethics of efficiency. Here the primary development was the idea that engineers represented the leadership in technological progress, i.e., the 'high priests' of technology, surely not a way to include public responsibility. Following a series of legal actions against engineers, including a series of DC-10 crashes, the Three-mile Island nuclear incident, and the Bay Area Rapid Transit system, changes had to be made to engineering codes of ethics.

Mitcham denotes phase four as public safety, health, and welfare. Engineering professional societies are organizations of individual members. In 1931, the Engineering Council for Professional Development, the ECPD, was founded. The ECPD is not an organization of individuals but rather an organization of organizations, that is, the engineering professional societies are the members of ECPD. The ECPD undertook the writing of a unified professional code of ethics for the member organizations. This code's first statement was "Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duty." The National Society of Professional Engineers, (NSPE), adopted the ECPD's code even before it was adopted by the ECPD. In 1980, the ECPD's engineering education function was incorporated into the Accreditation Board for Engineering and Technology (ABET). Through ABET, engineering ethics became a more common element in the certification of engineering education programs. In the 1990s, ABET introduced EC 2000 which changed the accreditation process from input measurements to output measurements along with a required continuous quality improvement cycle. Ethics education was again included in the subfields to be included in the engineering education process. Mitcham concludes this historical discussion by introducing a phase five, the move from individual ethics (micro ethics) to an ethics that includes group and institutional policy ethics (macro ethics). He argues that the space shuttle Challenger accident prompted this new phase. As far as most engineering codes of ethics are concerned, this phase seems not to have been implemented by any professional entity even though Mitcham makes an excellent case for such inclusion.

James [3] has performed an analysis of Engineers Australia's (EA) code of ethics in a manner similar to Mitcham's history of U.S. professional engineering societies' codes of ethics. However, in the case of Australia, they have only one professional society that encompasses all engineering disciplines. The development of EA's code of ethics parallels the development in the U.S. in both time and content. The environment was introduced in 1972 and further extended in subsequent drafts of the code through 2022 with words indicating awareness of sustainable development.

Following this brief history, we surveyed several professional societies' codes of ethics, representative of the English-speaking world, for references to the values expressed towards all life and the ecosystem.

Review of Code Content

Codes of ethics serve as professional guides for the behavior of practicing engineers. Professional codes of ethics (in the USA) and Codes of Conduct in many other countries can be viewed through multiple lenses. Hayes [4] makes a distinction between codes of ethics and codes of conduct. According to Hayes codes of ethics "ensures that members exercise sound judgement" while codes of conduct "…specify expected employee actions." By reviewing engineering codes, they can be categorized as a combination of both types -therefore we will consider them equivalent.

A more important distinction made by Hayes is the difference between compliance-based codes of ethics and value-based ethics. Most of the texts focus on behavior of the professionals, e.g. relationship with clients, and only practicing in areas of your trained expertise. Our interest is looking through the lens of values expressed towards the environment. In this study, the text from each code was reviewed and only the text related to the environment, ecosystems, and sustainability were selected. The following are the codes we reviewed:

- ASCE [4]
- ASME [5]
- ICE [6]
- NSPE [7]
- IEEE [8]
- Engineers Australia [9]

Each text section was reviewed to determine the values in these codes, Table 1.

Table 1: Code Texts Related to Environment

Organization	Text
ASCE	Engineers: a. adhere to the principles of sustainable development. b. consider and balance societal, environmental, and economic impacts, along with opportunities for improvement, in their work. c. mitigate adverse societal, environmental, and economic effects; and

	d. use resources wisely while minimizing resource depletion.
ASME	Engineers shall consider environmental impact and sustainable development in the performance of their professional duties.
ICE	All members shall show due regard for the environment and for the sustainable management of natural resources.
NSPE	Engineers are encouraged to adhere to the principles of sustainable development in order to protect the environment for future generations.
IEEE	to hold paramount, the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might …
Engineers Australia	4.1 Engage responsibly with the community and other stakeholders a. be sensitive to public concerns b. inform employers or clients of the likely consequences of proposed activities on the community and the environment c. promote the involvement of all stakeholders and the community in decisions and processes that may impact upon them and the environment 4.2 Practice engineering to foster the health, safety and wellbeing of the community and the environment a. incorporate social, cultural, health, safety, environmental and economic considerations into the engineering task 4.3 Balance the needs of the present with the needs of future generations a. in identifying sustainable outcomes consider all options in terms of their economic, environmental and social consequences b. aim to deliver outcomes that do not compromise the ability of future life to enjoy the same or better environment, health, wellbeing and safety as currently enjoyed.

Each of the texts in Table 1 uses the terms ‘sustainable development’ and ‘environment’ as the key words toward their value of the planet. It is difficult to place these statements into any of the philosophical frameworks discussed above. The problem lies in the vagueness of the terms used. For example, sustainable development has many definitions. Engineers Australia is the most explicit regarding sustainability as shown in Table 1. One concept that is implicit in the use of the term sustainability is the protection of choices of future generations. Even here there is a vagueness as to whose future generations are meant. It seems safe to assume human generations are implied. Engineers Australia is the most explicit by indicating ‘future life’ without indicating what species of life.

The next aspect of concern to us was the motivation expressed related to the values provided in the codes. Two possible motivations are intrinsic and extrinsic concern for the environment writ large. As we described above, values regarding the environment tend to be vague and lack explication. Any mention of the intrinsic value of non-human life or non-biological objects does not get mentioned.

There are some who propose an approach to resolving what they see as an unnecessary conflict between the concept of intrinsic and extrinsic values. Frantz, et al. [10] make the point that what is needed is an ‘overarching good’ to focus on that subsumes both intrinsic and extrinsic values -

for them it is valuing God. While God may motivate some, others will prefer a more secular 'greater good.' An area to explore for this greater good is a more detailed concept of what is meant by 'future generations' [11] and to consider the entire ecosystem as having intrinsic value.

Moore and Nelson [12] present a collection of essays promoting the need for a moral impetus regarding human actions aimed at the future of the planet. In their Introduction essay [13] they put forward the argument that caring for the future of the planet is a moral obligation for human behavior. The essays in Moore and Nelson's book clearly lean heavily towards an ecosystem approach. They put forth three reasons for moral action to protect the planet based on: 1) the consequences of acting or failing to act, 2) on doing what is right, and 3) virtue. Each of the reasons value the entire planet. This may fly in the face of the arguments that the 'centrisms' are mutually exclusive in what is valued. This is counterproductive and, in the end, 'the greater good' needed is the realization that what is good for humans is good for all lifeforms and good for the planet. David Orr [14] also promotes the concept of caring for the planet as being a moral concern. His statement below aligns with reason 1) above concerning consequences of human actions/inactions:

> …if disrupting Earth's cycles and natural systems is not wrong, nothing is wrong. In the face of self-imposed existential threats, we will need the kind of moral **realignment** that precedes improvements to public opinion, law, politics and **technology** [emphasis added] [14]

Table 2 outlines how the various 'centrisms' express values towards, human and non-human life, along with abiotic aspects of the planet. Early engineering codes of ethics/conduct focused on the anthropocentric approach with the values shown. Recently, the concept of sustainability has gained momentum and entered many current engineering codes of ethics/conduct. With this new awareness, a shift to other aspects becomes important such as non-human life and planetary resources. They mostly became important as they serve utilitarian value to maintain life. Sustainability often refers to preserving resources such that future generations will have the ability to make their own choices. No concern for the intrinsic value of these entities is mentioned. A next possible step is the approach referred to as biocentrism. Here the focus is that all life has intrinsic value and therefore should be respected and protected. This approach is typically associated with wildlife professionals. Neither biocentrism nor ecocentrism show up in current engineering codes. Both sustainability and biocentrism associate utilitarian values to abiotic elements as shown below. The most inclusive approach is ecocentrism. This approach attaches intrinsic value to all components of the planet.

Table 2: Values

Approach	**Values**
Anthropocentric	Human Life -intrinsic Other Life-ignored Abiotic elements -ignored
Introduction of Sustainability	
	Human Life -intrinsic Other Life-utilitarian Abiotic elements -utilitarian

Biocentrism	Human Life -intrinsic Other life -intrinsic Abiotic elements -Utilitarian
Move to a Planetary view	
Ecocentrism	Human life -intrinsic Other life -intrinsic Abiotic elements -intrinsic

Recommendations

Modification to Codes

Engineers and engineering have produced amazing increases in the standard of living for most people on the planet over the past two hundred years. However, this increase in living standards has come at great price for planetary ecosystems. It is time for engineers and engineering to take responsibility for these societal and ecosystem changes. Once we accept that we have an ethical responsibility to the future [12], then engineering codes are a logical place to be explicit about an ethic about the future. The current use of the term sustainability still implies a utilitarian approach to the future. Codes of ethics/conduct need to explicitly defend the intrinsic value of the entire ecosystem -biotic and abiotic.

One rather easy way would be for the engineering professional societies to change from an anthroprocentric statement of valuing human welfare and safety to a more general ecocentric value of serving the planet. Placing such a statement in the codes of ethics/conduct of the professional societies would through accreditation processes cause the statement to enter engineering education programs. If you examine the young people entering college today, many have already chosen a lifestyle reflecting a more planetary focus by embracing vegetarianism or a vegan diet [15]. Our students have also embraced reuse through thrifting, recycling and campus-wide composting. It is possible that our students are ahead of us on this front.

The path forward clearly requires a realignment of values from being anthropocentric to ecocentric. That does not mean that the future of humanity takes a back seat to everything else. To start, here is that vague sustainability statement that is so often stated:

> Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs [16].

Immediately the statement places the sustainability in an anthropocentric context. As Orr [14] indicates in the quote above, the motivation/perspective/philosophy needs to be *realigned,* and technology is not the sole answer. This realignment will require hard work. To get started at least two changes are needed:

1. The statement on sustainability must be modified to reflect an ecocentric value, and
2. Engineering, if it is going to participate in any leadership role, must embrace this realignment as a professional responsibility, writ large, by moving away from the current codes of ethics focused on individual behavior.

Here are two attempts for step 1).

> Humanity has the ability to make development sustainable to ensure that it meets the needs of the present while minimizing the negative impacts on the Earth's cycles and natural systems
>
> Humanity must ensure its future without compromising the Earth's cycles and natural systems.

The first attempt is meant to be just that a first attempt with the goal of avoiding thinking that humanity is no longer a priority. In the second attempt, the values expressed represent a long-term goal where humanity is an equal priority. The time has come to be more explicit in valuing humanity within the broader context of the planetary system of the Earth. This type of realignment of values should be incorporated into the rhetoric about sustainability within the engineering profession. Instead of using the term sustainability within the many codes, the first statement could be incorporated.

Step 2 above presents a bigger challenge. Our goal is to encourage dialog amongst engineers towards developing this long-term goal.

Curricular Implications

The driving question must be: Are we doing the right job? After this is answered, then the question of: Are we doing the job right? can be addressed. Future engineers need to be prepared to answer both questions. Current curricula tend to focus on the second question, e.g. sustainable development and design. As argued above, even this preparation tends to be based on an anthropocentric ethic. Future engineers will be less prepared to answer the first question about doing the right job unless curricular changes occur.

Wiek, et al. [17] originally described 5 required competencies in sustainability: 1) systems-thinking, 2) anticipatory, 3) normative, 4) strategic, and 5) interpersonal. Brundiers, et al. [18] refined these competencies and added: 6) integrated problem-solving. One of the refined competencies is 3) normative is recommended to be referred to as values-thinking.

The refined competency [18] of values-thinking includes: "*to be able to differentiate between intrinsic and extrinsic values in the social and natural world.*" Along with systems-thinking, values-thinking is a major subject of this paper. Our goal is to broaden the value system to be based on ecocentrism, not the more limited anthropocentrism and biocentrism values.

Systems-thinking is a good starting point to consider curricular changes. Wiek, et al. [17, 19] defined systems-thinking as covering society, environment, and economic systems, across both local and global scales. Engineering programs often focus on systems of engineered artifacts. While these systems are important, as they address the question of doing the job right, the question of the right job requires preparation in other systems, e.g. planetary and biological systems. While Wiek does not use the term 'ecocentrism,' preparing future engineers must address the broader systems in ecocentrism.

To broaden engineers' system thinking we reviewed courses available at our home institution, Colorado State University (CSU). Below is an example from the geology department that comprises a main course along with two required concurrent courses [20]. These courses clearly value a broad range of Earth systems. This type of course would be a great addition to engineering curricula. A major curricular problem would be the number of credits associate with this set of courses. There is a total of five credits along with a prerequisite course to be added to an already crowded curriculum.

> **GEOL 313 Earth Systems Credits: 2 (2-0-0)**
> **Course Description:** Exploration of interactions and feedback between the geosphere, atmosphere, hydrosphere, and biosphere and how they promote a hospitable climate on Earth over geological time. Emphasizing systems thinking, students learn Earth System science tools, including the rock record, geochronology, proxy data, and modeling. Drawing from geologic examples, explore how perturbations are used to probe Earth System mechanics, including potential responses to human-induced greenhouse gas emissions.
> **Prerequisite:** (GEOL 110 or GEOL 120 and GEOL 121 or GEOL 121 and GEOL 122 or GEOL 121 and GEOL 124 or GEOL 150) and (GEOL 154).
> **Registration Information:** Must have concurrent registration in GEOL 312 and GEOL 314. Required field trips.
>
> **GEOL 312 Earth's Surface Credits: 2 (2-0-0)**
> **Course Description:** Examine Earth's surface from bedrock to treetops. Earth's surface is a constantly evolving layer where rock, soil, water, air, and living organisms interact to shape the landscape, regulate natural habitats, determine the availability of life-sustaining resources, and affect the magnitude and frequency of natural hazards. Gain a coherent introduction to the processes and interactions governing this vital interface.
>
> **GEOL 314 Earth's Surface Laboratory Credit: 1 (0-2-0)**
> **Course Description:** Covers foundational skills in Earth Systems science. Skills in scientific reasoning, conceptual and computational modeling, quantitative data analysis and reasoning, and field analysis will be developed. Geological information, including quantitative reasoning, will be collected, synthesized, modeled, analyzed, and interpreted in class and presented orally and verbally and through active learning activities.

Another system that is important is the biotic system as we advocate for the valuing of all life, not just human life. Below is a course taken from CSU's biological science major [21]. In a recent presentation at EESD 2025 in London [22], we argued that biology courses should provide "an understanding of wildlife behavior and the needs of flora habitat needs. Basic biological science courses will be insufficient." The LIFE 320 course below is an example of a potential type of course that could address the biotic systems-thinking that supports the broader ecocentrism we advocate. As with the geology course discussed above, the same issue of number of credits resulting from prerequisite courses can be problematic.

LIFE 320 Ecology Credits: 3 (3-0-0)
Course Description: Interrelationships among organisms and their environments using conceptual models and quantitative approaches.
Prerequisite: (BZ 110 or BZ 120 or LIFE 103) and
(MATH 141or MATH 155 or MATH 160).

As a contrasting example, we explored systems-related courses provided by CSU's School of Global and Environmental Sustainability [23]. At the second-year level (GES 201 Systems Thinking in Sustainability) the course content is: "Build competencies in systems thinking, quantitative and qualitative modeling." At the third-year level (GES362 Systems Thinking and Sustainability) the course content comprises:

> Building competence in systems thinking. Core activities include using quantitative and qualitative modeling, exploring the history of systems analysis in sustainability, and deepening the understanding of the concept of environmental sustainability and what it means for systems change.

Both courses have an emphasis on the pragmatic use of system thinking skills with no explicit mention of values. They are the only two systems-thinking courses listed for this program. As such, these courses do not provide the content we support.

Staying with using our home institution, CSU, we looked for philosophy courses that may address the ecocentrism recommendation made herein. Below are two versions of an Environmental Ethics course that are available [24]. Upon a close reading, the elements of ecocentrism values included are highlighted in bold text. What is not clear is the definition of the natural world. We posit the natural world includes the entire planet, independent if it only has extrinsic value. These are the types of courses that need be incorporated into engineering curricula. Engineering ethics courses are more likely based on anthropocentrism-values.

PHIL 345: Environmental Ethics (multiple sections)
McShane (TR 12:30-1:45) In this class, we will discuss debates about the moral status of the natural world. This includes questions about what moral obligations we have to people in other parts of the world, whether **nonhuman animals have rights**, whether we have any **moral obligations to animals, plants, species, or ecosystems**, what environmental justice consists in, and what sorts of policy implications our answers to these questions might have. [emphasis added]

Easley (TR 9:30-10:45; TR 2-3:15) In this class, we will analyze and apply philosophical perspectives on the **value of the natural world** and what **obligations we might have to the natural world.** Topics will include theories of the **moral worth of persons, animals, plants, and other natural objects**; historical, religious, and cultural influences on conceptions of nature; alternative accounts of **human relationships and responsibilities to nature**; and the connection between moral and political values and economic policies. [emphasis added]

Discussion and Conclusion

In this paper we advocate for engineers to shift their foundational philosophy from an anthropocentric world view to a more ecocentrism-valued world view. To accomplish this shift, we start by recommending changing codes of ethics/conduct to reflect values based on ecocentrism. As a starting point, an example new definition for sustainability was offered for inclusion in the codes.

Curriculum is the other component of the preparation of engineers that needs to reflect this change in values. As examples, we looked at two common sustainability competencies where a shift in values is necessary; systems-thinking and values-thinking [18]. For systems-thinking we presented example courses from geology (GEOL 312, 313, 314) and biological sciences (LIFE 320) that have content dealing with systems reflecting the entire planet. Also shown were examples that we deem limited (GES 201, 362) as they focused primarily on the techniques of systems processes, valuable skills, but do not explicitly address values. Then, to address the values-thinking competency, a philosophy course on environmental ethics was presented that focuses on an ecocentrism-valued approach. While our curriculum argument is limited by using examples from one university, the courses provide the type of content that would support our ecocentrism argument. One main hurdle to overcome with these curricular changes is the potential addition of significant credit hours for already loaded engineering curricula.

In conclusion, a major shift in fundamental values of the engineering profession is promoted herein. This shift may be difficult to implement in the short term, but steps toward it need to be started -the future of the planet is at stake!

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