

2023

## Engineering For One Planet: Resources For Infusing Sustainability And Leadership Competencies Across All Engineering Disciplines

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### Recommended Citation

Cooper, C., Anderson, C., & Milligan, M. (2023). Engineering For One Planet: Resources For Infusing Sustainability And Leadership Competencies Across All Engineering Disciplines. European Society for Engineering Education (SEFI). DOI: 10.21427/R11C-Q394

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**ENGINEERING FOR ONE PLANET: RESOURCES FOR INFUSING  
SUSTAINABILITY AND LEADERSHIP COMPETENCIES ACROSS  
ALL ENGINEERING DISCIPLINES**

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**Conference Key Areas:** *Addressing the challenges of Climate Change and Sustainability, Embedding Sustainability and Ethics in the Curriculum*

**Keywords:** *Sustainability, EOP Framework, EOP Teaching Guides, EOP Network*

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## ABSTRACT

[Engineering for One Planet \(EOP\)](#) is an initiative to transform engineering education and equip all future engineers across all disciplines with the fundamental skills and principles of social and environmental sustainability.

Catalyzed by [The Lemelson Foundation](#) and [VentureWell](#) in collaboration with hundreds of sustainability advocates across sectors, the EOP initiative envisions a world in which all engineers play a critical role in ensuring that the solutions of today do not become the problems of tomorrow, restoring and regenerating our environment, and improving lives for all.

EOP is accelerating curricular transformation by supporting faculty change efforts and fostering collaboration among stakeholders across sectors. Experts from academia, civil society and government co-developed the EOP Framework in 2020, including an adaptable and adoptable menu of core and advanced sustainability and leadership learning outcomes. Five universities pilot tested the EOP Framework in curricular changes over two years, and the EOP Framework was revised in 2022. In 2023, EOP launched companion teaching guides with step-by-step guidance and free teaching resources for integrating learning outcomes from the EOP Framework.

To date, more than 120 faculty have used the EOP Framework to generate curricular changes in dozens of diverse engineering disciplines and programs, impacting thousands of students. EOP makes its teaching tools available for free and is designed for flexible adoption and adaptation to encourage rapid expansion of sustainability into engineering education.

This presentation will enable participants to learn about the resources available through EOP, gain ideas from successful curricular change approaches and get involved in EOP's growing global community.

# 1 INTRODUCTION

## 1.1 Rationale

Sustainability has been identified across all sectors, from government to industry to academia, as a top priority, especially as it relates to developing leading edge solutions to national and global challenges (e.g. climate change), protecting nature and the environment, ensuring environmental justice, and advancing human health, welfare and prosperity. Large industrial firms from across the globe are prioritizing sustainability and recognizing its importance to future national competitiveness and growth, leading to gaps between the demand for green skills and the supply of talent [1]. A recent study with nearly 7000 student respondents from around the world found that 90% of students were concerned about the effects of climate change, and felt that sustainable development should be universally taught in higher education yet only 26% of respondents felt their coursework was covering these issues in depth [2]. The environmental challenges we face are increasingly complex and severe, and disproportionately impact historically marginalized and low-income communities due to longstanding systemic injustice and discrimination. The demand for STEM graduates and green skills are both rapidly increasing, requiring an escalation of sustainability-infused STEM education.

Successfully addressing global challenges requires fundamental and systemic change in how we define the role of engineering and engineers, collectively prepare the 21st century workforce, and develop cutting-edge technological solutions that are not only more sustainable but net zero and even regenerative. It also requires fundamental and systemic change in who will want to become an engineer, graduate as a trained engineer, and pursue a career as a professional engineer. It is imperative that people from communities that bear the brunt of the negative impacts of climate change and environmental degradation are able and encouraged to share their perspectives, knowledge, and lived experiences as engineering leaders and problem-solvers [3],[4].

Engineering education operates within a complex system of interdependent stakeholders and policies, all of which exert forces on education but do not work in unison. Among these stakeholders are professional engineers, engineering employers, professional engineering societies, engineering education accreditation bodies, government regulators and consumers. Efforts to change engineering education, such as the Engineering for One Planet initiative, must acknowledge, account for, understand, and engage the interests of diverse stakeholders and foster collaboration.

## 1.2 Background

Beginning with research efforts in 2017, the [Engineering for One Planet](#) (EOP) initiative was officially launched in 2020. EOP is a coalition of hundreds of organizations and individuals seeking to transform engineering education to prepare all future engineers with the sustainability and related professional skills and knowledge that are increasingly required in engineering professions. Catalyzed by The Lemelson Foundation and VentureWell —two US-based non-profits created by the late Jerry Lemelson who was a prolific US inventor with over 600 US patents— the EOP initiative aims to engage stakeholders to infuse fundamental environmental

and social sustainability topics across academic engineering curricula, programs, departments, and institutions.

With input from hundreds of experts in academic, industry and civil society, the EOP initiative has published the EOP Framework [5], a menu of student learning outcomes that all graduating engineers should acquire to ensure they are equipped to protect and improve our planet and our lives. Designed to be widely adaptable, the EOP Framework is mapped to ABET accreditation requirements [6], the United Nations Sustainable Development Goals (UN SDGs) [7], Bloom's Taxonomy [8], and simplifies the task of infusing sustainability and related professional skills into a broad range of engineering courses and programs. The EOP Framework serves as a platform for curricular change and has become a cornerstone of the EOP initiative.

## 2 METHODOLOGY

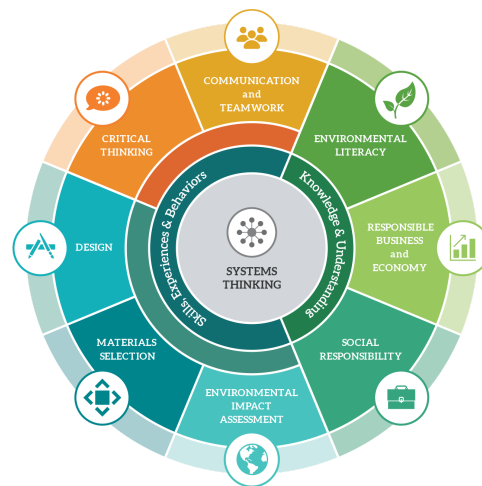
The EOP initiative has been developed and is evolving through collaboration among hundreds of sustainability advocates across sectors—from academia, industry, nonprofits, governmental agencies, accrediting bodies—geographies, and lived experiences. EOP seeks to ensure all future engineers across all disciplines learn the fundamental skills and principles of social and environmental sustainability. The results of a thematic assessment through in-person interviews and conversations with engineering practitioners and educators [9], [10] and the results of the EOP Literature Review Report [11] demonstrate the need for a sustainability implementation tool such as the EOP Framework as follows: engineers play a critical role in creating a healthy, flourishing world, and their work has outsized impacts on our world. Engineers must possess sustainable mindsets, skill sets, and professional preparation. This is necessary because the industry demands it and to ensure that the engineering solutions of today do not become the problems of tomorrow. However, many of today's graduating engineers are not learning sustainability-focused concepts, tools, and methodologies through their engineering educational training. Therefore, there is a need to intentionally incorporate these concepts into engineering education.

Numerous activities have taken place since the launch of the EOP initiative in 2020. Today, the EOP initiative utilizes three interrelated strategies to transform engineering education and ensure all engineers are equipped to design, build, and create in environmentally and socially sustainable ways: 1) EOP Teaching Resources: to facilitate curricular change, assessment, and peer learning (e.g., [EOP Framework](#) [5] and two companion teaching guides; [Quickstart Activity Guide](#) [12] and [Comprehensive Guide to Teaching Core Learning Outcomes](#) [13]) 2) Catalytic Grants: to foster curricular change through funding and mentorship (e.g., EOP Pilot Grant Program (PGP) and the [American Society for Engineering Education \(ASEE\) EOP Mini-Grant Program \(MGP\)](#), and 3) Collaborative Community: to support collective action across sectors to accelerate change (e.g., EOP Network).

### 2.1 Strategic Action 1: EOP Teaching Resources

[The EOP Framework: Essential learning outcomes for engineering education](#) (Fig. 1), first launched in 2020 and revised in 2022, is a cornerstone of the EOP initiative, the first of its kind to guide coursework, teaching tools, and student experiences that

define what it means to be an engineer who is equipped to protect and improve our planet and our lives [5]. The EOP Framework is not a research framework but a practical implementation tool that supports educators in integrating environmental and social sustainability concepts and tools into engineering courses, programs, and departments. It provides faculty with a vetted menu of student learning outcomes that every graduating engineer, regardless of subdiscipline, needs to acquire to design, code, build, and implement solutions that are socially and environmentally sustainable.



**Fig. 1.** Engineering for One Planet Framework Graphic [12]. Adapted from EOP Framework.

The EOP Framework fills a gap in curricular development by detailing core environmental and social sustainability learning outcomes, as well as related leadership skills, that would enable all engineering graduates to be prepared to protect and improve our planet and our lives. It was co-created by a community of hundreds of experts from a range of identities, lived experiences, geographies, and sectors, including academia, industry, nonprofit, government, and philanthropy.

The EOP Framework comprises nine topic areas: Systems Thinking, Environmental Literacy, Responsible Business and Economy, Social Responsibility, Environmental Impact Assessment, Materials Selection, Design, Critical Thinking, Communication and Teamwork. Each topic area has a list of core and advanced student learning outcomes that are measurable and mapped to ABET’s engineering accreditation requirements which are delineated through seven student outcomes in Criterion 3, which include sustainability competencies [6], as well as to the UN SDGs [7] and Bloom’s Taxonomy [8].

Additionally, to better support faculty efforts to integrate the EOP Framework and sustainability-focused content into engineering courses and programs, two companion teaching guides were launched in 2023. The [Quickstart Activity Guide](#) outlines step-by-step and timed learning activities for one core learning outcome from each of the nine topic areas [12]. The [Comprehensive Guide to Teaching Core Learning Outcomes](#) provides learning activities to achieve each of the 46 core learning outcomes over the nine topic areas of the EOP Framework [13]. Both teaching guides and the EOP Framework are available for online and for free at [www.engineeringforoneplanet.org](http://www.engineeringforoneplanet.org).

## **2.2 Strategic Action 2: Catalytic Grants**

Lemelson has funded three EOP grant programs, driving curricular changes and generating teaching tools, assessment tools and insights to help other faculty and institutions with similar efforts: 1) The EOP Pilot Grant Program (PGP) and 2) The American Society of Engineering Education (ASEE) EOP Mini-Grant Program (MGP), described below, and the 3) EOP Institutionalization Grant Program.

The PGP was designed to test the EOP Framework between 2020-2022. The program awarded seed grants to five US-based institutions (up to \$40,000 each supported by community of practice meetings) to test the integration of learning outcomes from the EOP Framework in diverse curricular offerings.

Funded by Lemelson and launched in 2022, the MGP's first cohort awarded seed funding (\$8,000 and mentorship) to 13 US-based schools, five of which are Minority Serving Institutions (MSIs) [14]. In 2023, the EOP MGP awarded 14 grants and is expected to award grants to approximately 12 additional schools in 2024.

Lemelson has also funded larger "institutionalization" grants to expand integration of sustainability at a number of higher education institutions and is engaging other funders to support EOP-related curricular changes.

## **2.3 Strategic Action 3: Collaborative Community**

Due to the complex nature of the engineering education system, stakeholders identified the need for sustained collaboration to drive top-down and bottom-up approaches to transforming engineering education. The creation of the EOP Network in 2021 was a response to this need. This impact network seeks to foster collaborative actions among its membership of students, faculty members, higher education leaders, as well as industry, nonprofit, and government professionals. The network is voluntary, non-hierarchical, and self-governed, and it is supported by a paid network manager who facilitates member collaboration and project teams, plans and delivers events, and ensures the network operates effectively.

Other examples of collaboration through the EOP initiative include: the 2022 EOP Scaling for Impact Workshop supported by the National Science Foundation (NSF), and the development of an [open-sourced Sustainability Toolkit](#) to support United Kingdom-based educators in integrating sustainability into engineering education. A steering group including EOP representation and led by the UK's Engineering Professors Council (EPC) is co-creating the Sustainability Toolkit, which is funded by Siemens and the Royal Academy of Engineering.

# **3 RESULTS**

## **3.1 EOP Teaching Resources**

Since its launch in 2020, the EOP Framework has been shared with thousands of academic and industry professionals in the US and around the world through presentations, reports, articles, and grantee activities. Examples of conferences in which EOP was shared include the ABET Annual Symposium, ASEE Engineering Deans Institute, ASEE Annual Conference, Annual Colloquium on International

Engineering Education (ACIEE), International Symposium on Sustainable Systems and Technology, and several other academic conferences.

Through the PGP, five diverse US universities pilot tested the EOP Framework in curricular changes that reached nearly 6000 students. In 2022, the EOP Framework was revised to incorporate feedback from pilot grantees and other stakeholders during an open commenting period. Over 600 comments were resolved that led to key modifications to the EOP Framework, including: defining and emphasizing sustainability as both social and environmental, revising outcomes to be measurable and tracked to Bloom's Taxonomy, aligning the EOP Framework learning outcomes to specific ABET student outcomes, and making a stronger connection to Diversity, Equity, Inclusion and Justice (DEIJ). The feedback also led to the development of two new EOP Framework companion teaching guides.

The EOP Framework has also been used to advance sustainability efforts internationally. Two examples include: use as a framing device where EOP learning outcomes were mapped to all courses in a new sustainable systems in engineering transdisciplinary degree program at the University of Calgary, and as a key resource to guide the development of the aforementioned Sustainability Toolkit for engineering education in the UK.

### **3.2 Catalytic Grants**

As previously noted, the two-year PGP enabled five universities to pilot test the EOP Framework in curricular changes. PGP awardees found significant value in the EOP Framework and shared several key findings that can assist others seeking to make similar changes. In total, grantees integrated learning outcomes from the EOP Framework to develop or modify a total of 61 courses. Of these, 50 were required engineering courses, far exceeding the minimum goal of one course per institution, and impacting nearly 6,000 students in only 2 years [15].

The first cohort of the MGP concluded in January 2023 with an online, public symposium featuring poster presentations by all participating schools about their efforts and impact during the program. In total, awardees used sustainability-focused learning outcomes from the EOP Framework to develop or modify over 30 courses, reach over 1600 students, and train more than 30 faculty in less than a year.

### **3.3 Collaborative Community**

In 2022, there was an open application period to join the EOP Network with a focus on intentionally broadening the participation of applicants from groups traditionally marginalized in engineering, including women and people of colour. A review committee selected 32 new members to join the EOP Network, expanding the network from 40 to 72 members. There is significant national and international demand to join the EOP Network. EOP Network members convened in person for the first time in October 2022 on the Boeing campus in Seattle, Washington. Participants formed team projects to pursue a variety of projects, including: developing a conference toolkit to support EOP outreach efforts, a guide to prepare students for sustainability-focused industry interviews, establishing an industry internship, conducting a funder landscape analysis, and establishing an EOP evaluation plan with key performance indicators.



The NSF-funded EOP Scaling for Impact Workshop engaged 100 stakeholders from various sectors and backgrounds to collaboratively identify approaches for taking the EOP initiative to scale. A report will be publicly disseminated in 2023.

## **4 SUMMARY AND ACKNOWLEDGMENTS**

### **4.1 Summary**

Environmental and social sustainability have been identified across all sectors, from government to industry to academia, as critical for the health of our planet and lives. Through the vast reach and scope of engineering activities, engineers have the potential to positively address social and environmental challenges and/or to inadvertently contribute to future problems. To protect and improve our planet and our lives, all engineers must be prepared with fundamental skills in sustainability. Currently, most engineering graduates have limited exposure to sustainability in higher education. Transforming the engineering education system is complex and requires the collaboration of people and organizations across sectors including academia, industry, accreditation bodies, as well as the communities disproportionately impacted. The EOP initiative's vision is that sustainability will be a core tenet of the profession. To achieve this vision, sustainability must be infused throughout engineering education. Since its official launch in 2020 with support from The Lemelson Foundation, the EOP initiative has evolved and made significant strides to enable stakeholders to co-create the initiative's core tools and strategic roadmap and to spur curricular changes that have reached thousands of students. Together, the growing, international EOP community is helping drive curricular changes to infuse sustainability into engineering education and the engineering profession to ensure that all engineers are prepared to address today's challenges while seeking to maximize the positive and avoid the potential negative impacts in the future.

### **4.2 Acknowledgements**

The authors would like to acknowledge and thank the contributions of the hundreds of stakeholders that have provided feedback, ideas, and their valuable time to advise the EOP strategy, co-create the EOP Framework, inform the development of the two EOP Framework companion teaching guides, collaborate in the EOP Network and contribute to numerous other events and activities over the years. The authors would also like to acknowledge and thank The Lemelson Foundation, VentureWell, Alula Consulting, the National Science Foundation, the Kern Family Foundation and Boeing for their roles supporting these efforts.

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