



The Engineering for One Planet Framework

Sustainability-focused Learning Outcomes
for Engineering Education with AHEP4 Mapping



Powered by **The Lemelson Foundation**
Prepared in partnership with **Engineering Professors Council**
and **Engineers Without Borders UK**

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Overview

Engineering for One Planet (EOP) is an initiative to transform engineering education to reflect the growing importance of sustainability in all engineering functions. Catalyzed by **The Lemelson Foundation** and **VentureWell** – in collaboration with hundreds of sustainability stakeholders from across sectors, 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 EOP Vision

Sustainability is a core tenet of the engineering profession.



The EOP Goal

Transform engineering education to ensure all engineers are equipped with the skills, knowledge, mindsets, and understanding to protect and improve our planet and our lives.



A Tool for Change

Hundreds of faculty are using the EOP Framework for curricular change. The EOP Framework provides a common language to help faculty share teaching tools and learn from each other.

Commonly Asked Questions

What is the Engineering for One Planet Framework?

The **EOP Framework** is a practical tool for curricular supplementation and modification, comprising 93 sustainability-focused learning outcomes (core and advanced) in 9 topic areas that may be used as a menu for inclusion in engineering degree programmes.

- Systems Thinking
- Environmental Literacy
- Responsible Business and Economy
- Social Responsibility
- Environmental Impact Assessment
- Materials Selection
- Design
- Critical Thinking
- Communication and Teamwork

Hundreds of academics, engineering professionals, and other key stakeholders collaborated to identify these topic areas, and to develop associated learning outcomes, deeming them relevant for preparing all graduating engineers – regardless of subdiscipline – with the skills, knowledge, and understanding to protect and improve our planet and our lives. The EOP Framework focuses on what to teach, and you can find helpful tips and resources about how to teach these learning outcomes and to change curricula at the EOP website.

How is the EOP Framework structured?

The EOP Framework is structured around student learning outcomes under three main categories: 1) systems thinking; 2) knowledge and understanding; and 3) skills, experiences, and behaviors. Although “mindsets” are not explicitly categorized, acquisition of the EOP Framework learning outcomes also cultivates sustainability mindsets.

The educational goal categories of the **2010 Bloom’s Taxonomy** are used to organize and determine the level of proficiency of each outcome – Low (remember and understand), Medium (apply and analyze), and High (evaluate and create). The seven ABET student outcomes, as outlined in the **ABET Criteria for Accrediting Engineering Programs**, are mapped to the learning outcomes of the EOP Framework, where there is appropriate alignment. Where a learning outcome relates to the **United Nations Sustainable Development Goals** (SDGs) Goal 12: Ensure sustainable consumption and production patterns, this is also shown.

How can the EOP Framework help UK Engineering Educators?

The Lemelson Foundation, VentureWell, and Alula Consulting stewarded the co-development of the **EOP Framework** with hundreds of individuals mostly situated in the United States. Degree programmes accredited by Professional Engineering Institutions (PEIs) under licence from the UK Engineering Council (EngC) are required to meet the learning outcomes described in the Accreditation of Higher Education Programmes (AHEP) document. The learning outcomes in the current 4th edition

Commonly Asked Questions

of AHEP are given on pages 32-37 of this document. In collaboration with the UK's Engineering Professors Council and Engineers Without Borders UK, a mapping has been provided to show how the AHEP4 CEng learning outcomes may be mapped to the EOP Framework learning outcomes in the development of accredited engineering degree programmes.

What organizations are associated with this guide?

The **Engineering Professors Council** (EPC) is the representative body for UK engineering academics in higher education. Its primary purpose is to provide a forum to exchange ideas about engineering education, research, and other matters of common interest and to come together to provide an influential voice and authoritative conduit through which engineering departments' interests can be represented to key audiences such as funders, influencers, employers, professional bodies, and government. This EOP Framework guide was prepared in partnership with the EPC.

Engineers Without Borders UK (EWBUK) is working to reach the tipping point to ensure a safe and just future for all. Part of a global movement of over 30 EWB organizations who work across 89 countries, it inspires, upskills, and drives change in the engineering community and together takes action to put global responsibility at the heart of engineering. This EOP Framework guide was prepared in partnership with the EWBUK.

The **Engineering Council** (EngC) is the UK regulatory body for the engineering profession. The EngC sets and maintains the internationally recognised standards of professional competence and ethics that govern the award and retention of engineering titles, including Chartered Engineers (CEng). This ensures that employers, government, and wider society –both in the UK and overseas– can have confidence in the knowledge, experience, and commitment of professionally registered engineers and technicians. This guide has been developed with input from accreditors from UK Professional Engineering Institutions licenced to EngC.

The **Accreditation of Higher Education Programmes** (AHEP) sets the standard for accreditation of degrees which demonstrate the knowledge and understanding required of registered engineers and technicians. The 18 learning outcomes in AHEP4 have been mapped to the EOP Framework showing where the EOP Framework learning outcomes may be related in the development of a degree programme.

ABET is a nonprofit, non-governmental organization that defines accepted attainment standards that prepare graduates to enter the professional practice of engineering across programs in the US and around the world. This EOP Framework and this guide are mapped to the seven ABET student outcomes, as outlined in the **ABET Criteria for Accrediting Engineering Programs**, where there is appropriate alignment. Mapping for the EOP Framework was conducted in collaboration with ABET Program Evaluators.

The EOP Framework

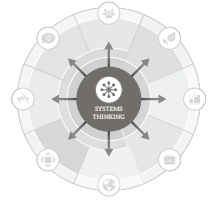
All learning outcomes are linked to the UN SDGs. However, throughout the EOP Framework the identifier  is used to denote when an EOP Framework learning outcome is directly tied to the SDG Goal #12. The identifier  is used to denote when an EOP Framework learning outcome is directly tied to an **ABET** student outcome as described in Criteria 3. The identifier  is used to denote where an AHEP4 learning outcome may be used to relate to an EOP Framework learning outcome.

The EOP Framework lists “what” graduating engineers should know and be able to do. For companion guides on “how” to teach the core outcomes in the EOP Framework, visit the [EOP website](#).





Systems Thinking



CORE

1. Explain interconnectedness (e.g., intersecting, related and/or connected systems; human actions and global environmental and social impacts and consequences; synergies and rebound effects) and how all human-made designs and activities rely upon and are embedded within ecological and social systems ○ (4) ○ (1,4-9,11,17)
2. Identify dynamic impacts between and among different parts of the system (i.e., social, environmental, and economic considerations) ○ (4) ○ (1,2,4-9,11,14)
3. Apply relevant concepts from required disciplines to the study of real-world problems and their solutions with empathic and ethical consideration for communities/societies, environmental justice, and cultural awareness ○ (2,4,7) ○ (2,5-8,11,15)
4. Create solutions that consider the scale of the activity relative to the planetary system boundaries (i.e., carrying capacities) ○ (2) ○ (1,2,4-9,13)
5. Create designs that include communities/societies, environmental ecosystems, and the life they sustain while keeping systems dynamics concepts in mind (e.g., feedback loops, complex cause-effect chains, cascading effects, inertia, tipping points, legacy, resilience, adaptation, energy systems and flows, etc.) ○ (2,4) ○ (2,4-9,11,13)

ADVANCED

1. Identify system archetypes (i.e., the tragedy of the commons), ecosystem services, and key concepts in system dynamics and their impacts on communities/societies ○ (4-9,11)
2. Design solutions for real-world problems in partnership with communities using human-centered design and system dynamics, including feedback loops, tipping points, and system resilience ○ (2) ○ (2,4-9,11,13,14)
3. Create visual system maps (e.g., causal loop diagramming, system dynamics simulations, etc.) ○ (3,5-7,12,17)
4. Apply Life-Cycle Assessment (LCA) at various scales of length (local and global effects), time (acute and chronic effects), and impacts (second and third order impacts, time-delayed impacts, etc.) ○ (2) ○ (2-9,12-14)



Environmental Literacy



CORE

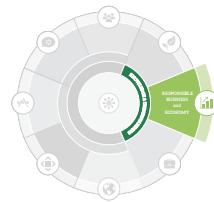
1. Recognize opportunities (i.e., social, economic, and environmental benefits, etc.) to solve environmental challenges ○ (2,4) ● (2,5-8,11,18)
2. Explain whole life-cycle and closed-loop systems thinking as related to the impact of their work (e.g., understanding of life-cycle burdens of design alternatives) ○ (4) ● (2,4-9,13,14,17)
3. Discuss key global ecosystem services (i.e., water, carbon, energy, and nitrogen cycles, as well as nutrient cycling, soil formation, pollination, waste decomposition, etc.) and how they are interconnected ○ (2,4) ● (1,4-8,13,17)
4. Explain the nature and role of energy in the world, our daily lives, and in engineering practices (e.g. is energy literate) ○ (2,4) ● (1,4-5,7-8,13,17)
5. Examine data about environmental issues (e.g., climate change, energy and water use, scarcity and pollution, air quality, waste management, toxicity, etc.) including consideration for past/current/future and local/regional/global impacts ○ (2,6) ● (2-5,7,8,11,13,14)

ADVANCED

1. Explain abiotic assets (e.g., fossil fuels, minerals, metals), flows (e.g., wind and solar energy), and biotic natural capital (e.g., ecosystems) ● (1,4-8,13,17)
2. Describe key ecosystem services and functions including provisioning services, regulating and maintenance services, cultural services, and supporting services (e.g., material cycles, energy cycles) ● (1,4-8,11,13,17)
3. Apply environmental laws, ethics, and policies at the regional, national, and global levels, and consider ethical, social, environmental justice, and cultural implications beyond current environmental compliance and political boundaries ○ (2, 4) ● (2,4-11,14,15)
4. Apply key ecosystem services and functions to their design solutions ○ (2) ● (1,2,4-8,13,15)
5. Weigh energy-use decisions based on an understanding of impacts and consequences ○ (2,4) ● (2,4-9,11,13-15,18)



Responsible Business and Economy



CORE

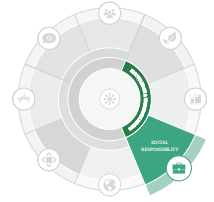
1. Recognize opportunities and demand for more inclusive and sustainable business models, such as models that leverage product durability (e.g., renting, upgradeability, repairability, modularity, resale, etc.), protect consumers and their privacy, reflect the interests and needs of diverse users and consumers, and reflect ethical considerations (4) (4-11,14,15,18)
2. Examine risks and opportunities related to changing social, economic, political, and ecological systems on their work (e.g., extended costs, value, trade-offs, partnerships, regulations, policies, etc.) (2,7) (2,4-10,14,15,18)
3. Demonstrate awareness that different revenue and business models can positively or negatively influence environmental and social systems as a result (e.g., shared ownership models, service models, leasing with take-back instead of asset sales for planned obsolescence, employee-owned, public-private partnerships, business-NGO collaboration models, etc.) (4-9,15,18)
4. Demonstrate awareness of alternative forms of capital beyond financial resources (including natural, human, social, and physical) and awareness of emerging economic systems intended to promote environmental and social responsibility in economic thinking (e.g., Doughnut Economics, circular economy, etc.) (4-8,11,18)
5. Weigh the near- and long-term costs and value of their work to the environment and society through the sustainable use of resources and engagement with stakeholders (2,5) (2,4-9,11,14,18)

ADVANCED

1. Explain alternative business, revenue, and entrepreneurship models (e.g., B Corps, product service systems, sharing economy platforms, cooperatives, indigenous practices/sensibilities, etc.) (4-8,15,17)
2. Explain sustainable use and disposal practices to consumers (4,5,7,8,11,17)
3. Locate funding sources for public infrastructure (4,7,8,11)
4. Apply International Organization for Standardization (ISO) management systems (e.g., Environmental, Health, and Safety (EHS), Global Reporting Initiative (GRI), etc.) as tools to enable systematic integration of sustainability impact management into business practices (2) (3-9,11,13-15)
5. Judge supply chain agents, vendors, etc., from environmental, social, and Diversity, Equity, Inclusion, and Justice (DEIJ) perspectives (2,4-9,11,13-15,18)
6. Weigh economic trade-offs in sustainability efforts; these economic trade-offs may happen for a variety of stakeholders within each unique value chain, so students must be able to identify, quantify, and compare the financial trade-offs in sustainable initiatives (2,4-9,11,14,15,18)



Social Responsibility



CORE

1. Identify the United Nations Sustainable Development Goals (SDGs) (2) (4,5,7,8,18)
2. Recognize and be empathetic to ethical implications relative to the social impact of their work (4) (6-9,11,14,15)
3. Describe how engineering activities directly and indirectly cause positive and negative social/cultural impacts throughout the design life-cycle, both to workers producing the products (i.e., labor practices, livelihood, health, etc.) and to communities, society, and non-human life (i.e., resources acquisition, waste production and management, traditional/cultural methodologies, etc.) (2,4) (1,2,4-9,11,14,15,17,18)
4. Recognize that some communities (e.g. communities of color, rural communities, etc.) have historically been negatively impacted and/or intentionally marginalized, and continue to be disproportionately negatively impacted by engineering activities (2,4) (4-9,11,18)
5. Explain the role of social responsibility and environmental justice in the engineering profession (i.e., policies, laws, social justice, etc.) (4) (4-9,11,15,17,18)
6. Identify cultural, local, and global implications and influences in the context of their work (e.g., cultural expressions and sensitivities, services and goods procurement, heritage site appreciation) as well as equity awareness (e.g., gender, race, ethnicity, class, etc.) (2,4) (4-9,11,15,18)
7. Create robust, dynamic, and resilient systems and transdisciplinary stakeholder networks (2,3,5) (5-8,11,13,14)

ADVANCED

1. Recognize the breadth of social and environmental justice issues, indigenous rights, laws, policies, and commitments (e.g., Global Compact (GC)) (4) (4-9,11,14,15,18)
2. Recognize social and cultural implications related to local, regional, and global materials and energy use (e.g., land changes, surface and groundwater use and pollution, air pollution, energy production and use, toxins, labor rights, land tenure, etc.) as a global citizen (4) (4-9,11,14,15,18)
3. Recognize that impacts are disproportionately borne by low-income and marginalized groups (4) (4-9,11,18)



Environmental Impact Assessment



CORE

1. Explain high-level environmental impact assessments (e.g., basic Life-Cycle Assessments (LCAs) and life-cycle hazards; i.e., how they work, what information they require, how to incorporate their findings into their work) ○ (2) ○ (1,2,4-8,13,17)
2. Recognize current eco-labelling systems and certificates (i.e., EPEAT, Energy Star) for sustainable production and consumption ○ (4,5,7-9,13-15)
3. Interpret broader energy, climate, water, wastewater, air pollution, and land-use implications of their work by conducting basic environmental impact assessments (e.g., Life-Cycle Assessments, carbon footprints, etc.) ○ (6,7) ○ (1-9,11,13,14)
4. Question complex or contradictory information to make decisions among trade-offs (i.e., What is the cost of the decision? Who and what will be most impacted by the decision? Are marginalized communities part of the decision?) ○ (2,4) ○ (2,4-9,11,12,14,15,18)

ADVANCED

1. Discuss relative impact reduction vs. absolute impact reduction (e.g., greenhouse gas (GHG) emissions) ○ (2,4-9,14,17)
2. Judge Environmental, Health, and Safety (EHS) standards data (e.g., chemical hazard assessments, how to research chemical safety, etc.) and specifications for inputs, outputs, and performance levels of engineered products and services ○ (2) ○ (2,4-9,11,13-15,18)



Materials Selection



CORE

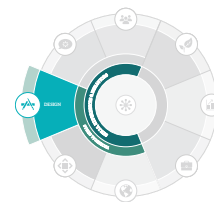
1. Identify potential impacts of materials (e.g., embodied energy, emissions, toxicity, etc.) through the supply chain — from raw material extraction through manufacturing, use, reuse/recycling, and end of life — with a focus on minimizing negative impacts to the planet and all people (i.e., especially those who have been intentionally marginalized) (2,4) (1,2,4-9,11,13,14,18)
2. Recognize current environmental assessment research and gaps in research (6) (2,4,5,7-9,11,13-15,18)
3. Critique the environmental and social impacts of designs created by others (6) (2,4-9,11,13-15,17,18)
4. Compare materials properties (e.g., chemical, physical, and structural properties) and performance aligned with end-use application (2) (1-9,12-14)
5. Design with lower impact, natural materials (e.g., earth, bamboo, agro-waste, etc.) with an aligned degree of knowledge of industrial materials (e.g., iron, steel, aluminum, etc.) (2) (1,2,4-9,12-14)
6. Select materials for design alternatives and trade-offs that enable a long functional lifetime, have net zero greenhouse gas emissions impact, either minimal or no environmental and social harm, or are restorative to social, cultural, and environmental ecosystems (2) (1,2,4-9,11-15)

ADVANCED

1. Implement tools and resources for identifying potential social and environmental impacts of materials supply chain throughout the entire life-cycle — from raw material extraction through processing, manufacturing, use, reuse/recycling and end of life — with a zero waste and restorative perspective (2) (3-9,11-14)
2. Discuss sustainability reports and data (e.g., Global Compact, Global Reporting Initiative, etc.) to draw upon leading research (7) (2-9,11,13-15,17,18)
3. Explain the implications of the of impacts of material consumption at scale (2,4,5,7-9,13,17,18)
4. Recognize materials composition and that macro materials include those with structural properties (e.g., concrete, metals, plastics, etc.) and functional properties (e.g., chemicals and solid/liquid/intermediary states), and that substances of concern can be bound up in engineered products and materials (often micro materials, chemicals, and nanoparticles) (2) (1,2,4-9,13-15)
5. Identify innovation gaps in existing materials options and how to help spur appropriate research and development (2,4,5,7-9,13,15,18)
6. Apply systems perspective and calculate embodied energy of materials to make informed decisions (2) (1,2,4-9,13,14)
7. Evaluate Environmental, Health, and Safety (EHS) (e.g., ecotoxicity, chemical hazard assessments, etc.) and green chemistry aspects of materials (2) (1,2,4-9,11-15,18)
8. Weigh trade-offs that guide selection of design-appropriate materials (e.g., technical considerations including strength, weight, cost, toxicity, extraction impacts, material compatibility, and thermal properties, among others) (2) (1,2,4-9,11,13-15,18)



Design



CORE

1. Execute technical analyses to choose strategies that maximize the positive and minimize the negative environmental and social impacts in order to achieve design goals (2,6) (2-9,11,13-15)
2. Design for the environment and society based on discipline-specific technical skills (e.g., light-weighting, design for repairability and durability, design for upgradeability, design for disassembly, flexibility, and reuse, design for part or whole recovery, etc.) (2) (1,3-9,11-14)
3. Create long-term approaches for tackling environmental problems (e.g. climate mitigation and adaptation) or preventing negative environmental and/or social impacts including creative solutions within supply chains (6) (5-11,13-15)

ADVANCED

1. Recognize local craft traditions, indigenous knowledge systems, and vernacular practices, and innovate inclusive and regenerative solutions and processes (4-8,11,13,14)
2. Implement stakeholder user experience/participatory studies (e.g., design thinking, human-centered design) and social impact assessments to meet user needs in responsible, novel, improved, ethical, and sustainable ways (2) (4-9,11,13,14,16,18)
3. Design with approaches that incorporate whole life-cycle and systems thinking (2) (2,4-9,11,13,14,18)
4. Develop creative trans-disciplinary ideas and solutions in engineering contexts along with social and cultural values (e.g., habitat, construction, and health that is attuned to and respectful of social values, etc.) by working across disciplines (2,4,5) (2,4-9,11-15,18)
5. Design with systems dynamics concepts in mind (e.g., feedback loops, complex cause-effect chains, cascading effects, inertia, tipping points, legacy, resilience, adaptation, etc.) (2) (1,4-10,13-15)
6. Create solutions for use with alternative business models and emerging economic contexts (2,4-9,13-15)



Critical Thinking



CORE

1. Define problems comprehensively with consideration of consequences, unintended and intended
○ (1,2,4) ● ○ (2,4-9,11,14,15,18)
2. Report being a self-aware and reflective practitioner with values, empathy, and guardianship of one's environment ○ (4) ● ○ (5-9,11,16-18)
3. Report understanding that their values are both shaping, and being shaped, by the designs, technologies, innovations, etc., they create and scale ○ (4) ○ (5,7-9,11,14,16-18)
4. Recognize that every person has a role in sustainability, and has the right and need to be informed about the environmental/social/economic impacts of the products they purchase, consume, and discard ○ (4) ● ○ (4-9,11,15,18)
5. Examine norms, biases, and values that underlie one's behaviors (i.e., normative thinking and cognitive dissonance) ○ (4) ● ○ (5,7-9,11,14,16,18)
6. Critique complex ethical and values-based choices, employing empathy when evaluating conflicts of interest, trade-offs, and uncertain knowledge and contradictions within problem constraints ○ (4) ● ○ (2,4-9,11,14-18)

ADVANCED

1. Discuss varying standpoints with empathy for different perspectives, opinions, views, etc. (i.e., normative thinking) ○ (3) ● ○ (4-9,11,14,16-18)
2. Identify issues and actions of environmental and social priority ○ (1,2,5) ● ○ (4-9,11,14,15,18)
3. Implement relevant qualitative and quantitative research into decision-making processes ○ (6,7) ○ (1-9,13-15,18)
4. Distinguish the consequences of one's actions and how to deal with risks and changes (i.e., apply the precautionary principle) ○ (4) ● ○ (1,2,5-10,13-15,18)
5. Compare the pros, cons, and tradeoffs of incremental vs. radical innovations ○ (1,2,4-9,13-15,18)
6. Prioritize appropriate solutions based on the context of the problem, in collaboration with other stakeholders and experts ○ (3) ● ○ (2,4-9,11,14-16,18)
7. Evaluate possible, probable, and desirable futures for diverse people, societies, and cultures, to create their own visions for the future (i.e., futures literacy) ● ○ (2,4-11,14,15,18)



Communication and Teamwork



CORE

1. Communicate through audience-specific written, graphic/visual, oral, and interpersonal communication skills (3,5) (4,5,15-17)

- Demonstrate ability to sell, pitch, and explain ideas and advance learning
- Demonstrate ability to work well with others, across organizations, disciplines, and cultures
- Advocate for underrepresented and intentionally marginalized or excluded groups
- Support organizational and societal change
- Develop team effectiveness

2. Develop leadership potential and capability (5) (8,12,15-17)

- Recognize team member strengths/weaknesses
- Demonstrate contributions to group problem-solving and effectiveness
- Evaluate team effectiveness
- Support followership
- Support team member performance, growth, and wellness

3. Demonstrate ability to work within and function well on teams and across disciplines (5) (5,8,11,12,15-17)

- Demonstrate ability to effectively communicate on teams
- Demonstrate active participation
- Demonstrate initiative and proactive problem-solving
- Demonstrate ability to participate in group decision-making
- Demonstrate ability to share workload

4. Demonstrate self-awareness and understanding of unconscious bias (5) (7,8,11,12,14-18)

5. Prioritize projects, schedules, and time, and manage people equitably and inclusively (5) (5,8,11,12,14-17)

6. Champion sustainability-focused values and approaches (e.g., to management, procurement, marketing, etc.) to maintain the integrity of design criteria across environmental and human dimensions (5) (7-9,11,14-17)



Communication and Teamwork



ADVANCED

1. Explain technical and engineering concepts, assumptions, and evidence (e.g., Life-Cycle Assessment (LCA) outcomes) to the public and to clients/customers to influence understanding and acceptance of environmental, social and cultural considerations, impacts, and decision-making ○ (3) ● (1,4,7,8,11-17)
2. Develop and maintain relationships through interpersonal skills ○ (3) ● (8,11,12,15-18)
 - Cultivate emotional intelligence
 - Identify and relate to different perspectives
 - Demonstrate ability to engage in conflict constructively (i.e., gains alignment to move forward, resolves differences, etc.)
 - Demonstrate understanding of power dynamics and the systemic oppression that supports them
 - Value effective listening, and be willing to be influenced and changed by the views of others
3. Investigate solutions to individual, institutional, and systemic bias ○ (4) ● (4,7-9,11,12,14-18)
4. Apply systematic, disciplined, and collaborative project management methodologies in order to effectively manage teams and themselves ○ (5) ● (6,8,11,12,14-17)
5. Demonstrate ability to interact with, collaborate on, and lead multidisciplinary teams, effectively representing an engineering perspective in a comprehensible manner through project-based work ○ (3) ● (5,8,11,12,15-18)



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