2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
Paper ID #50040

From Framework to Classroom: Advancing Sustainability Integration through Faculty Professional Development

Ms. Allison Wolf, Arizona State University

Allison Wolf is a Project Manager in the College of Global Futures at Arizona State University. She focuses on integrating sustainability and environmental literacy into engineering curricula, with an emphasis on systems thinking and social dimensions of engineering practice. She has developed and facilitated professional development programs for faculty and K–12 educators, including initiatives aligned with the Engineering for One Planet Framework. Prior to her current role, she taught secondary science for seven years and worked on community-based environmental education projects.

Mariya Suleman, Arizona State University

Mariya Suleman is a Ph.D. student in the Engineering Education Systems and Design program at the Ira A. Fulton Schools of Engineering, Arizona State University. Her research focuses on integrating sustainability into engineering curricula, strengthening teaching assistants' instructional effectiveness through entrepreneurial mindset-based preparation, and examining the relationship between entrepreneurial mindset and engineering identity. She holds an M.Sc. in Applied Instrumentation and Control from Glasgow Caledonian University as a Commonwealth Shared Scholar and a B.S. in Electrical Engineering from Pakistan.

Dr. Medha Dalal, Arizona State University

Medha Dalal, Ph.D., is an Associate Director of Scholarly Initiatives and Assistant Research Professor of Engineering Education Systems & Design within the Ira A. Fulton Schools of Engineering at Arizona State University. Her career as an engineering educator and researcher focuses on addressing complex engineering education challenges by building capacity for stakeholders at the grassroots, while also informing policy. Her research seeks to transform and democratize engineering education by exploring ways of thinking, identifying effective professional development approaches, and uncovering pedagogical techniques that enhance students' engineering curiosity, engagement, and learning.

From Framework to Classroom: Advancing Sustainability Integration through Faculty Professional Development

Abstract

Sustainability challenges demand complex, systems-level problem solving by engineering graduates, yet sustainability remains peripheral in many engineering programs. Engineering faculty, central to curricular innovation, often confront challenges such as limited access to resources and adaptable teaching materials, overcrowded curricula focused on traditional technical content, and inconsistent coverage of social and ethical dimensions. To address these barriers, an 18-month faculty fellowship was launched at Arizona State University (ASU) to support the implementation of the Engineering for One Planet (EOP) Framework into engineering courses. The program engaged 21 engineering faculty, a postdoctoral student, and four graduate students through a layered professional development model featuring an orientation retreat, sequenced workshops, expert-led sessions, and sustained mentorship. Ongoing support was provided through monthly Community of Practice meetings and personalized guidance from mentors. Program impact was assessed via surveys and focus groups. Results indicate gains in participants' knowledge, confidence, and ability to integrate sustainability across undergraduate and graduate courses. Participants especially valued mentorship, peer support, and the practical guidance provided by the EOP Framework, although time constraints and student assessment remain ongoing challenges. The fellowship resulted in modifications to multiple courses, affecting approximately 7,880 students. The fellowship contributed to faculty development on EOP informed sustainability integration as well as active learning approaches. This study identifies practical strategies and persistent barriers for faculty development in sustainability, offering guidance for designing future professional development programs in engineering education.

Introduction

The accelerating climate crisis, resource depletion, and widening social inequities are reshaping the role of engineers. These changes demand a transformation in engineering education to prepare graduates for sustainable development [1], [2], [3]. Yet most programs prioritize technical and economic performance before considering environmental and social impacts. This limits engineers' ability to anticipate long-term consequences [3]. Sustainability is often absent or treated as peripheral, reducing opportunities for systems thinking and holistic problem-solving [1], [4]. Without deliberate integration, graduates risk entering the profession without the interdisciplinary skills and contextual awareness needed to address complex global environmental, economic, and social challenges [5], [6].

To meet these challenges, engineering curricula must be intentionally aligned with established sustainability frameworks and professional standards. The Accreditation Board for Engineering and Technology (ABET) requires graduates to evaluate the global, economic, environmental, and societal impacts of engineering solutions [7]. The United Nations Sustainable Development Goals (SDGs) call for coordinated global action to advance a just, sustainable future [8]. The Engineering for One Planet (EOP) Framework translates these expectations into 93 ABET- and SDG-aligned learning outcomes that embed environmental stewardship, social responsibility, and ethical practice across all stages of engineering education [9]. Embedding sustainability principles throughout the curriculum strengthens technical competence while fostering values, collaboration skills, and innovation capacity [10], [11], [12]. Without such alignment, engineering programs risk producing graduates unprepared for the interconnected technical, societal, and ecological demands shaping the profession's future.

Despite multiple calls, translating sustainability education frameworks into practice remains a significant challenge [6], [13], [14]. This difficulty is compounded by prevailing perceptions that equate sustainability primarily with environmental engineering, narrowing its perceived relevance and limiting meaningful integration across other disciplines [15], [16], [17]. In addition to these perception-related challenges, faculty also face persistent barriers such as limited access to high-quality teaching resources, practical case studies, and adaptable instructional materials [10], [14]. Overcrowded curricula that emphasize traditional technical content further restrict opportunities for interdisciplinary approaches [18], [19]. These constraints are reinforced by institutional factors such as limited administrative support, entrenched academic silos, and resistance to curricular change [14], [20]. Without a shared definition of sustainability, coverage is inconsistent, with social and ethical dimensions often overshadowed by environmental topics [18], [19]. Opportunities for faculty professional development and interdisciplinary collaboration, both essential for effective integration, remain scarce [6], [21]. These constraints highlight a pressing need for sustained, evidence-based faculty development that equips instructors to integrate sustainability with contextually appropriate approaches across diverse engineering disciplines.

Addressing this need, this paper describes a sustainability-focused faculty development program at a large university in the Southwestern United States. Funded by the Lemelson Foundation, the 18-month "Leading Environmentally Responsible Engineering: Engineering for One Planet Faculty Teaching Program" combined professional development, a sustained learning community, and mentoring support to explore the way that a multidisciplinary cohort of faculty interpreted and integrated the EOP Framework into the courses that they taught.

Background/Conceptual Framework

Integrating sustainability into engineering education requires attention to both what is taught and how it is taught. Structural frameworks define the knowledge, skills, and values that graduates should acquire, while pedagogical approaches determine how this learning is facilitated in classrooms. In the subsections below, we explain two frameworks that we adopted for this study: the EOP Framework and humanizing pedagogy theory. The EOP Framework addresses the 'what' by specifying sustainability learning outcomes aligned with ABET standards and global development goals [9]. Humanizing pedagogy approach addresses the 'how' by emphasizing dialogue, critical awareness, and the recognition of learners lived experiences [22]. Together, these frameworks show that preparing engineers for sustainability not only requires embedding clear outcomes but also adopting a pedagogy that supports learners as cocreators of knowledge. This dual focus places this faculty development program at the intersection of curricular reform and pedagogical innovation.

Engineering for One Planet (EOP) Framework

The EOP Framework is a structured curricular guide for embedding sustainability within engineering education [9]. The framework, developed with input from educators, industry leaders, and policy stakeholders, provides faculty and institutions with practical strategies to integrate sustainability into both undergraduate and graduate programs. It identifies nine thematic domains that outline the characteristics of sustainable engineering, including environmental literacy, social responsibility, and systems thinking [9]. Within these domains, 93 specific learning outcomes extend beyond technical expertise to emphasize interdisciplinary capabilities such as systems analysis, life cycle assessment, sustainable business practices, ethical and social responsibility, and policy engagement. Through its alignment with ABET criteria and the United Nations SDGs, the framework offers a shared structure for curriculum reform that ensures consistency across programs [9]. In doing so, the EOP Framework equips graduates with the ethical awareness, collaborative capacity, and contextual understanding necessary to advance sustainability in professional practice.

Humanizing Pedagogy

Humanizing pedagogy is an educational framework that centers dialogue, reflection, and learners lived experiences throughout the educational process. Freire [22] critiques the "banking model," which reduces students to passive recipients of information, and instead advocates for a problem-posing approach where teachers and learners co-create knowledge through active dialogue. This shift from transmission to co-construction develops *conscientização*, or critical awareness, enabling learners to recognize oppressive systems (such as unfair rules, practices, or structures that keep certain groups from having equal opportunities or a voice) and connect knowledge to their cultural and social contexts [23]. Freire expands this vision in his book *Pedagogy of Hope* (1992), describing learners as "unfinished beings" who grow through dialogue, solidarity, and mutual engagement. In his later work, Freire [24] further emphasizes the virtues of humility, hope, and collective responsibility as central to an educator's role. Extending Freire's legacy, del Carmen Salazar [25] characterizes humanizing pedagogy as an approach that rejects deficit perspectives and dehumanizing practices by affirming students' cultural and linguistic strengths, validating their identities, and cultivating classrooms built on trust and equity. As a framework, humanizing pedagogy positions education as a transformative process that prepares learners to engage responsibly with complex societal challenges using the co-development of knowledge.

Program Context

The program was guided by three objectives. First, participants were expected to learn about the EOP Framework and apply it to their own courses. Second, the program aimed to establish a learning community that functioned as a Community of Practice around EOP Framework integration. Third, the project team was expected to create a guide to disseminate the program's efforts and extend the program's reach beyond the initial cohort. This paper focuses on the first two objectives, which were constructed of a series of workshops and faculty celebrations, CoP meetings, and individual mentoring and classroom observations.

Workshops and Celebrations

Workshops provided the foundation for program learning, as they allowed the participants to meet in person and receive in depth training on the EOP Framework. The first workshop was held in January 2023 and consisted of a day and a half of training. It was intentionally held off-site to foster a sense of disengagement from normal faculty obligations and promote the opportunity to engage with other participants and the project team, as Del Carmen Salazar [25] notes, "trusting and caring relationships advance the pursuit of humanization." In this workshop, faculty learned about existing efforts at ASU to incorporate the EOP Framework, considered how their teaching philosophies aligned with sustainability, reviewed the framework, and planned for its implementation in Spring 2023. We sought to model humanizing pedagogy in this workshop by giving faculty time and space to consider how the EOP framework applied best to their individual classes and allowing each participant's lived experience to guide their implementation.

The second workshop, held in Summer 2023, reviewed participant efforts in the first semester of the program, incorporated peer exchange, and featured expert talks from faculty with experience embedding sustainability in engineering. The goal of this workshop was to review the progress that participants had made on integrating the EOP Framework and explore additional ideas for integrating the framework into their curriculum. From a pedagogical perspective, our goal was not to criticize or critique the progress that the participants had made, but rather to amplify faculty's prior efforts and consider additional opportunities for classroom integration. To support this process, we developed the EOP Evaluation Tool for the summer workshop, which helped faculty explore each learning outcome of the EOP Framework that they were utilizing in their classrooms so that they could consider how to further incorporate it [Appendix A]. Due to time constraints on faculty availability, we offered identical morning and afternoon sessions of the same material for the second workshop and invited faculty to participate in one session. We requested that all faculty attend a lunch held between the two workshops to ensure that the whole cohort had an opportunity to communicate.

The program culminated in a final celebration in February 2024 to highlight the EOP integration work accomplished by the participants over the course of the program. Participants were encouraged to share their learnings in any way that they wanted, with an emphasis on avoiding presentations that included slides and posters since the intention was to encourage participants to discuss their work with one another as co-creators of knowledge. Participants were also encouraged to invite a colleague to the celebration to help continue conversations about the EOP Framework after the end of the program. Faculty participated in a small workshop before the celebration where they used the EOP Evaluation Tool to reflect on their growth throughout the program.

CoP Meetings

Between workshops, monthly CoP meetings from March 2023 to January 2024 sustained momentum, creating a forum for participants to share progress, exchange ideas, and reflect on challenges. These working sessions covered a variety of topics (see table 1) and invited multiple guests to present, including representatives from Siemens and assessment experts from ASU's Learning and Teaching Hub (LTH). These sessions were held either in a hybrid or fully remote format to accommodate faculty schedules. Over the summer, CoP meetings were not hosted because faculty often have other responsibilities and roles that drastically change their schedules. Instead, one of the Co-PIs mentored the faculty individually in preparation for the summer 2023 workshop.

Month	Topic	Attendance
March 2023	Collaborative Working	14
April 2023	Siemens and Sustainability	7
September 2023	Gamifying Teaching	12
October 2023	Assessment Tools and Strategies	10
November 2023	Final Celebration Preparation	9
December 2023	Office Hours	0
January 2024	Office Hours	1

Table 1. Overview of CoP meeting topics and attendance (March 2023–January 2024)

Mentorship and Observations

As mentioned, one of the Co-PIs met with the participants over the summer of 2023 and was needed throughout the entirety of the program. This mentorship provided individualized support and feedback tailored to disciplinary contexts for faculty participants to design sustainability-focused classroom activities. The program team also worked in conjunction with the LTH to offer classroom observations to interested faculty. Three faculty members requested observations, and the team used the COPUS observation protocol [26] to provide feedback. Observers met with those faculty after their observations to provide both general feedback and EOP Framework-related feedback.

Discipline	Accepted Participants	Program Completion
Aerospace Engineering	1	1
Automotive Engineering	1	1
Biomedical Engineering	2	2
Chemical Engineering	2	2
Civil Engineering	1	1
Computer Systems Engineering	3	2
Engineering Education	4	1
Environmental Engineering	3	2
Graphic Information Technology	2	0
Introductory Engineering	3	3
Materials Science and Engineering	2	1
Mechanical Engineering	2	2
Total	**26**	**18**

Table 2. Participant profile by department/discipline and program completion.

Methods

Participant profile

A total of 22 faculty members from the engineering college participated in the fellowship (Table 2). They were recruited via emails and announcements in the college's digital newsletter. We specifically contacted (via email) new to the university faculty to encourage them to apply for the program. Participants applied to the program by completing a short application form that collected information on the courses they taught and why they were interested in participating in the program. Faculty did not need to get permission from their supervisors to participate. Seventeen faculty members and one graduate student completed the program. While we cannot speculate

Teaching Role	Participants
Assistant professor	9
Associate professor	8
Professor of practice	1
Adjunct Faculty	1
Full professor	2
Postdoctoral student	1
Graduate student	4

Table 3. Participant teaching roles.

on the reason why some participants chose not to complete the fellowship, the postdoctoral student and three of the graduate students had their advisor move to another university, which likely impacted their participation. Participants' teaching experience ranged from less than one to over thirty years.

Data collection and analysis

Data was collected primarily through surveys, which included surveys after each day of the two workshops and after the final celebration, to understand participant's perspectives and experiences. Surveys asked participants about their feelings toward the program activities, perception of their understanding of sustainability, and integration of the EOP Framework into their classrooms through both closed- and open-ended questions. A focus group was conducted with three participants who could make the time. The focus group lasted 60 minutes and asked participants about their perceptions of the program and the implementation of the EOP Framework. Quantitative data were analyzed for descriptive statistics to examine changes in participants' knowledge, integration of the EOP Framework, and perceptions of program usefulness. Open-ended survey questions, written reflections, and a post-program focus group data were analyzed qualitatively to understand participants' experiences and perceived impacts of the program. Thematic analysis aimed to identify recurring patterns related to confidence, collaboration, application of the EOP Framework, and implementation challenges.

Findings

Quantitative results indicated substantial gains in faculty knowledge of the EOP Framework, measured on a five-point scale (1 = "none," 2 = "a little," 3 = "moderate," 4 = "a lot," and 5 = "a great deal"). Average knowledge ratings increased from between *none* and *a little* before participation to *moderate* and *a lot* after the program (1.21 at program start to 4.0 at completion), demonstrating an improvement in understanding and application of the framework (see Figure 1).

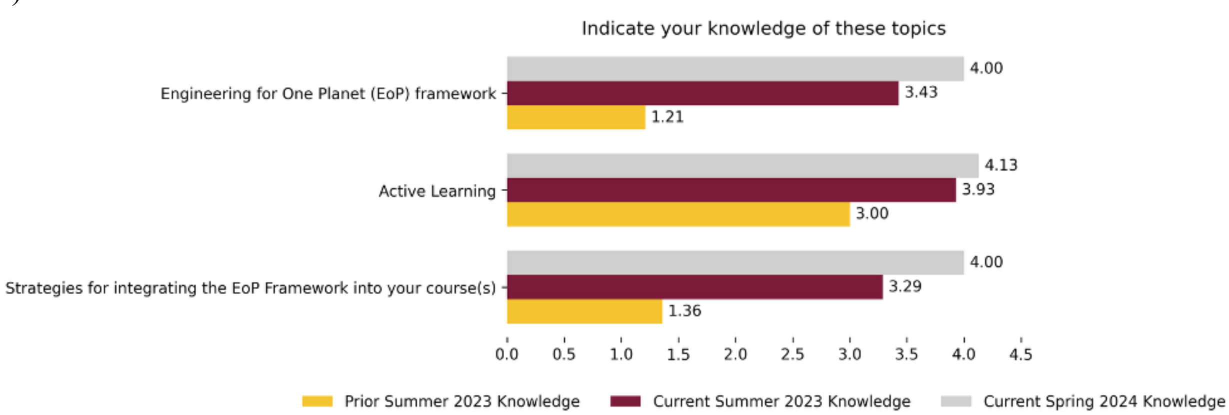


Figure 1. Mean self-reported knowledge of the EOP framework, active learning, and strategies for integrating EOP across three time points: prior Summer 2023, end of Summer 2023, and end of Spring 2024.

Integration of the framework also increased significantly: in summer 2023, 15% of participants had not yet implemented EOP concepts and 54% had done so only “a little,” while by spring 2024, all participants reported at least some integration, with 50% indicating “a moderate amount” and 25% “a lot” (see Figure 2a). Workshops and activities were rated as “moderately” or “very” useful, and 100% of fellows stated they were at least “somewhat likely” to integrate the framework in future courses (see Figure 2b). The fellowship supported the redesign of 37 courses, impacting approximately 7,880 students, 13% of whom were graduate students.

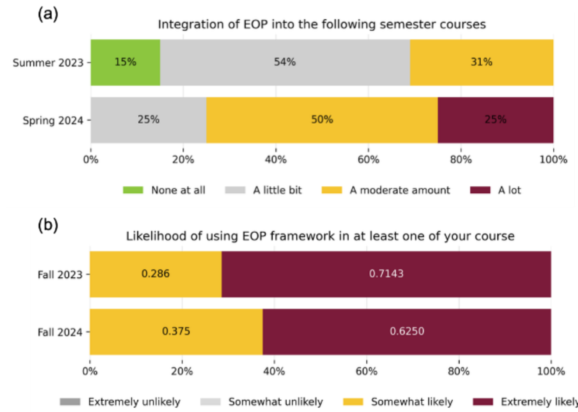


Figure 2. (a) Participants’ reported level of integration of the EOP framework into their courses in Summer 2023 and Spring 2024. (b) Participants’ reported likelihood of using the EOP framework in at least one course in Fall 2023 and Fall 2024.

Faculty reported greater confidence in teaching sustainability and incorporating it in engineering disciplines, including in areas beyond their expertise. Participants described the program as reinforcing their professional identity and collaboration skills. One fellow stated, “I can teach something even if I’m not an expert… reinforced my belief that I work better when I collaborate with others.” Collaboration and community emerged as central themes, with participants emphasizing the importance of mentorship and the CoP in promoting shared learning and mutual support: “Having opportunities to meet and work with other faculty on the issues in the EOP saved me time and improved the quality of my work.” Faculty also identified the EOP Evaluation Tool as a valuable mechanism for structured reflection and course alignment, though several suggested that it should be introduced earlier in the fellowship. Common challenges included limited time for course redesign, difficulty in assessing student learning, and the need for more case studies and peer examples. Overall, qualitative findings indicated high satisfaction and professional growth, with participants describing the fellowship as transformative in strengthening their teaching and commitment to sustainability.

Discussion

The findings suggest that the fellowship achieved its central goal of building faculty capacity to integrate the EOP Framework into engineering courses. Faculty self-ratings of EOP Framework knowledge increased from a mean of 1.21 (“none/a little”) to 4.0 (“a lot”) on a 0–5 scale. Participants also reported increased integration of EOP concepts from “none/a little” in early surveys to predominantly “moderate” or “a lot” by Spring 2024. The substantial growth in participants’ knowledge and confidence indicates that sustained, framework-aligned professional development is necessary to move sustainability from a peripheral topic to a core engineering competency [1], [4]. The breadth of adoption across levels and disciplines was also consistent with the EOP initiative's vision of vertically and horizontally integrated sustainability learning outcomes across programs, rather than isolated elective experiences.

Another key finding concerns the professional development model itself: the layered structure of workshops, a cohort-based CoP, targeted mentoring, and the EOP Evaluation Tool were consistently described as both useful and motivating. Participants expressed strong satisfaction with learning in a cohort rather than independently. These results resonate with literature on faculty learning communities and communities of practice, which highlights sustained peer interaction, iterative design, and just-in-time mentoring as key mechanisms for changing teaching practice [27].

Several limitations temper these conclusions. Most notably, although the cohort included faculty from a range of ranks, we did not systematically collect or analyze years of teaching experience. As a result, we cannot determine whether the fellowship differentially supported early-career versus more experienced instructors, or whether observed gains were influenced by prior exposure to sustainability or pedagogical training. In addition, the evaluation relied on self-report data from a relatively small group from a single institute. Even with these caveats, the converging quantitative and qualitative evidence indicates that a cohort-based, EOP-aligned faculty fellowship can meaningfully advance sustainability integration addressing ABET and SDG expectations around social and environmental impact [28].

Overall, the combination of structured workshops, regular community engagement, and personalized mentoring created a multi-layered model of professional development. Program design provided both structure and flexibility: structure through sequenced workshops and clearly defined objectives, and flexibility through iterative adaptation based on peer feedback. The integration of professional development, peer learning, and mentorship enabled faculty to experiment with and refine their approaches in ways that linked new information to prior knowledge and promoted critical reflection [25]. Participants were also in consistent contact with program leads, who supported the development of new lessons through the co-creation of solutions for the classroom environment.

This work informed the development of an NSF-funded project expanding the model across other institutions. While work remains to better understand effective practices for the integration of sustainability into the classroom, utilizing periodic in-person working retreats and monthly CoP meetings to build a culture of collaboration seems to be one of the means to make a difference. In addition, inspired by the work done with graduate students throughout this project, the Lemelson Foundation also funded a workshop to train graduate students and postdoctoral researchers with interests in teaching careers on the EOP Framework so that they can carry the work forward into their future classrooms.

Conclusion

This work suggests that a faculty fellowship model grounded in the EOP Framework and humanizing pedagogy can move sustainability from the curricular margins toward a shared, program-level responsibility. By coupling retreats, a community of practice, and targeted mentoring, the program supported substantial gains in faculty knowledge and confidence as well as concrete course redesigns that reached thousands of students, while also surfacing persistent challenges related to time, assessment, and large-enrollment contexts. These findings complement and extend the wider EOP initiative by demonstrating how institutional supports, practical teaching resources, and explicit sustainability learning outcomes can be operationalized through a cohort-based professional development model. Overall, this study offers a replicable model and set of design principles for universities seeking to embed sustainability as a core dimension of engineering education.

Acknowledgement

We would like to thank the Lemelson Foundation for funding this work, with special thanks to program PI Molly Cashion and Co-PIs Darshan Karwat and Adam Carberry. Thank you to the College Research and Evaluation Services Team, specifically Wendy Barnard, for collecting data from the IRB-approved surveys.

References

[1] F. S. Crofton, ‘Educating for sustainability: opportunities in undergraduate engineering’, J. Clean. Prod., vol. 8, no. 5, pp. 397–405, Oct. 2000, doi: 10.1016/S0959-6526(00)00043-3.
[2] M. J. Martin et al., ‘The climate is changing. Engineering education needs to change as well’, J. Eng. Educ., vol. 111, no. 4, pp. 740–746, Oct. 2022, doi: 10.1002/jee.20485.
[3] W. H. Vanderburg, ‘On the Measurement and Integration of Sustainability in Engineering Education’, J. Eng. Educ., vol. 88, no. 2, pp. 231–235, Apr. 1999, doi: 10.1002/j.2168-9830.1999.tb00439.x.
[4] D. N. Huntzinger, M. J. Hutchins, J. S. Gierke, and J. W. Sutherland, ‘Enabling Sustainable Thinking in Undergraduate Engineering Education’.
[5] M. Sattler et al., ‘Integrating Sustainability Across the Curriculum: Engineering Sustainable Engineers’, in 2012 ASEE Annual Conference & Exposition Proceedings, San Antonio, Texas: ASEE Conferences, Jun. 2012, p. 25.809.1-25.809.28. doi: 10.18260/1-2--21566.
[6] Q. Zhang, L. Vanasupa, J. Mihelcic, J. Zimmerman, and S. Platukyte, ‘Challenges for Integration of Sustainability into Engineering Education’, in 2012 ASEE Annual Conference & Exposition Proceedings, San Antonio, Texas: ASEE Conferences, Jun. 2012, p. 25.294.1-25.294.10. doi: 10.18260/1-2--21052.
[7] ‘Criteria for Accrediting Engineering Programs, 2025 - 2026’, ABET. Accessed: Aug. 11, 2025. [Online]. Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2025-2026/

[8] ‘United Nations’. Accessed: Aug. 12, 2025. [Online]. Available: https://sdgs.un.org/goals#
[9] Engineering for One Planet, "EOP Framework," [Online]. Available: https://engineeringforoneplanet.org/wp-content/uploads/EOP_Framework.pdf. [Accessed: Jan. 15, 2026].
[10] R. D. Burke et al., ‘Faculty Perspectives on Sustainability Integration in Undergraduate Civil and Environmental Engineering Curriculum’, J. Prof. Issues Eng. Educ. Pract., vol. 144, no. 3, p. 04018004, Jul. 2018, doi: 10.1061/(ASCE)EI.1943-5541.0000373.
[11] L. Gutierrez-Bucheli, G. Kidman, and A. Reid, ‘Sustainability in engineering education: A review of learning outcomes’, J. Clean. Prod., vol. 330, p. 129734, Jan. 2022, doi: 10.1016/j.jclepro.2021.129734.
[12] D. Wilson, ‘Exploring the Intersection between Engineering and Sustainability Education’, Sustainability, vol. 11, no. 11, p. 3134, Jun. 2019, doi: 10.3390/su11113134.
[13] S. Parry and E. Metzger, ‘Barriers to learning for sustainability: a teacher perspective’, Sustain. Earth Rev., vol. 6, no. 1, p. 2, Jan. 2023, doi: 10.1186/s42055-022-00050-3.
[14] O. K. Sabri, ‘Rethinking sustainability in engineering education: a call for systemic change’, 2025.
[15] E. P. Byrne and J. J. Fitzpatrick, ‘Chemical engineering in an unsustainable world: Obligations and opportunities’, Educ. Chem. Eng., vol. 4, no. 4, pp. 51–67, Dec. 2009, doi: 10.1016/j.ece.2009.09.001.
[16] K. F. Mulder, J. Segalàs, and D. Ferrer-Balas, ‘How to educate engineers for/in sustainable development: Ten years of discussion, remaining challenges’, Int. J. Sustain. High. Educ., vol. 13, no. 3, pp. 211–218, Jul. 2012, doi: 10.1108/14676371211242535.
[17] J. Segalàs, D. Ferrer-Balas, and K. F. Mulder, ‘What do engineering students learn in sustainability courses? The effect of the pedagogical approach’, J. Clean. Prod., vol. 18, no. 3, pp. 275–284, Feb. 2010, doi: 10.1016/j.jclepro.2009.09.012.
[18] N. Andrade and D. Tomblin, ‘Engineering and Sustainability: The Challenge of Integrating Social and Ethical Issues into a Technical Course’, in 2018 ASEE Annual Conference & Exposition Proceedings, Salt Lake City, Utah: ASEE Conferences, Jun. 2018, p. 30402. doi: 10.18260/1-2--30402.
[19] K. Sammalisto, A. Sundström, and T. Holm, ‘Implementation of sustainability in universities as perceived by faculty and staff – a model from a Swedish university’, J. Clean. Prod., vol. 106, pp. 45–54, Nov. 2015, doi: 10.1016/j.jclepro.2014.10.015.
[20] J. C. Sanchez-Carrillo, M. A. Cadarso, and M. A. Tobarra, ‘Embracing higher education leadership in sustainability: A systematic review’, J. Clean. Prod., vol. 298, p. 126675, May 2021, doi: 10.1016/j.jclepro.2021.126675.
[21] K. MacGregor, ‘Engineering the way out of global sustainability crises’, 2024. [Online]. Available: https://www.universityworldnews.com/post.php?story=20241105081146488
[22] P. Freire, Pedagogy of the oppressed, 30th anniversary ed. New York: Continuum, 1970.
[23] P. Freire, EDUCATION FOR CRITICAL CONSCIOUSNESS. 1974.
[24] P. Freire, ‘Letters to those who dare teach’, 1998.

[25] M. del Carmen Salazar, ‘A Humanizing Pedagogy: Reinventing the Principles and Practice of Education as a Journey Toward Liberation’, Rev. Res. Educ., vol. 37, no. 1, pp. 121–148, Mar. 2013, doi: 10.3102/0091732X12464032.
[26] M. K. Smith, F. H. M. Jones, S. L. Gilbert, and C. E. Wieman, ‘The Classroom Observation Protocol for Undergraduate STEM (COPUS): A New Instrument to Characterize University STEM Classroom Practices’, CBE—Life Sci. Educ., vol. 12, no. 4, pp. 618–627, Dec. 2013, doi: 10.1187/cbe.13-08-0154.
[27] K. Peña, M. Dalal, and J. M. Andino, ‘Board 123: Work in Progress: A Case Study of a Community of Practice Model Fostering Faculty Scholarship of Teaching and Learning of the Entrepreneurial Mindset’, presented at the 2024 ASEE Annual Conference & Exposition, Jun. 2024. Accessed: Jan. 07, 2026. [Online]. Available: https://peer.asee.org/board-123-work-in-progress-a-case-study-of-a-community-of-practice-model-fostering-faculty-scholarship-of-teaching-and-learning-of-the-entrepreneurial-mindset
[28] V. Matthew, C. Anderson, C. Cooper, and S. Lipkin-Moore, ‘Integrating Sustainability into Engineering Education: Building a Pathway to Scale’, in 2023 ASEE Annual Conference & Exposition Proceedings, Baltimore , Maryland: ASEE Conferences, Jun. 2023, p. 43779. doi: 10.18260/1-2--43779.

Appendix A: EOP Evaluation Tool

Engineering for One Planet

Name: ____________

Course: ____________

Teaching Evaluation Tool

Powered by The Lemelson Foundation
Prepared in partnership with Arizona State University

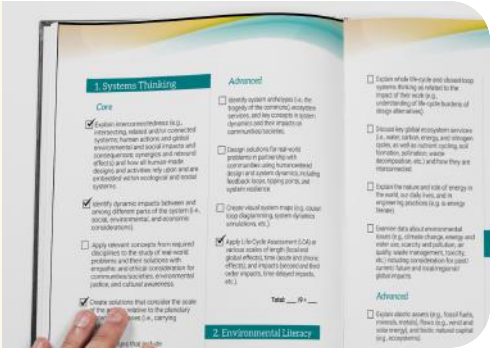
About

This tool was designed to assess the integration of the Engineering for One Planet (EOP) Framework into the classroom. Its purpose is to identify content strengths and weaknesses in relation to the EOP framework. It can be used to assess programs, courses, or activities.

Directions

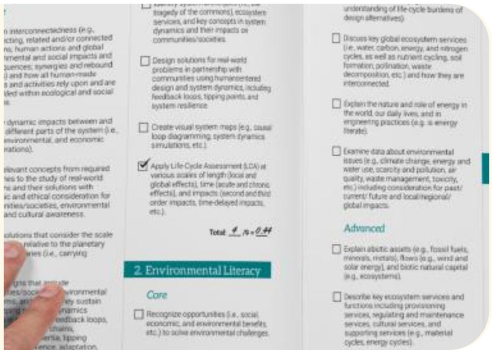
Step 1

Use pages 3-10 to evaluate your strengths in incorporating the EOP framework. For each of the 9 topics, check the boxes next to the learning outcomes that you are successfully incorporating into your classroom.



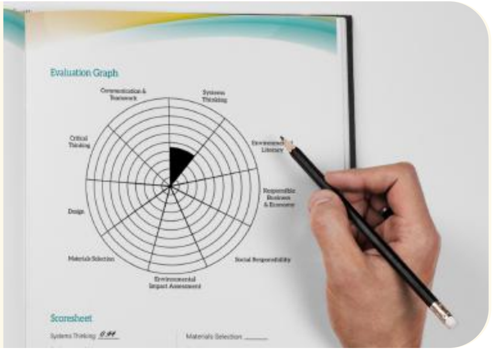
Step 2

Tally the number of check marks you have for each topic and divide that number by the number of learning outcomes in that section (there is a place to do this for each section). For example, if you have 4 check marks in the Systems Thinking section, your averaged total is approximately 0.44.

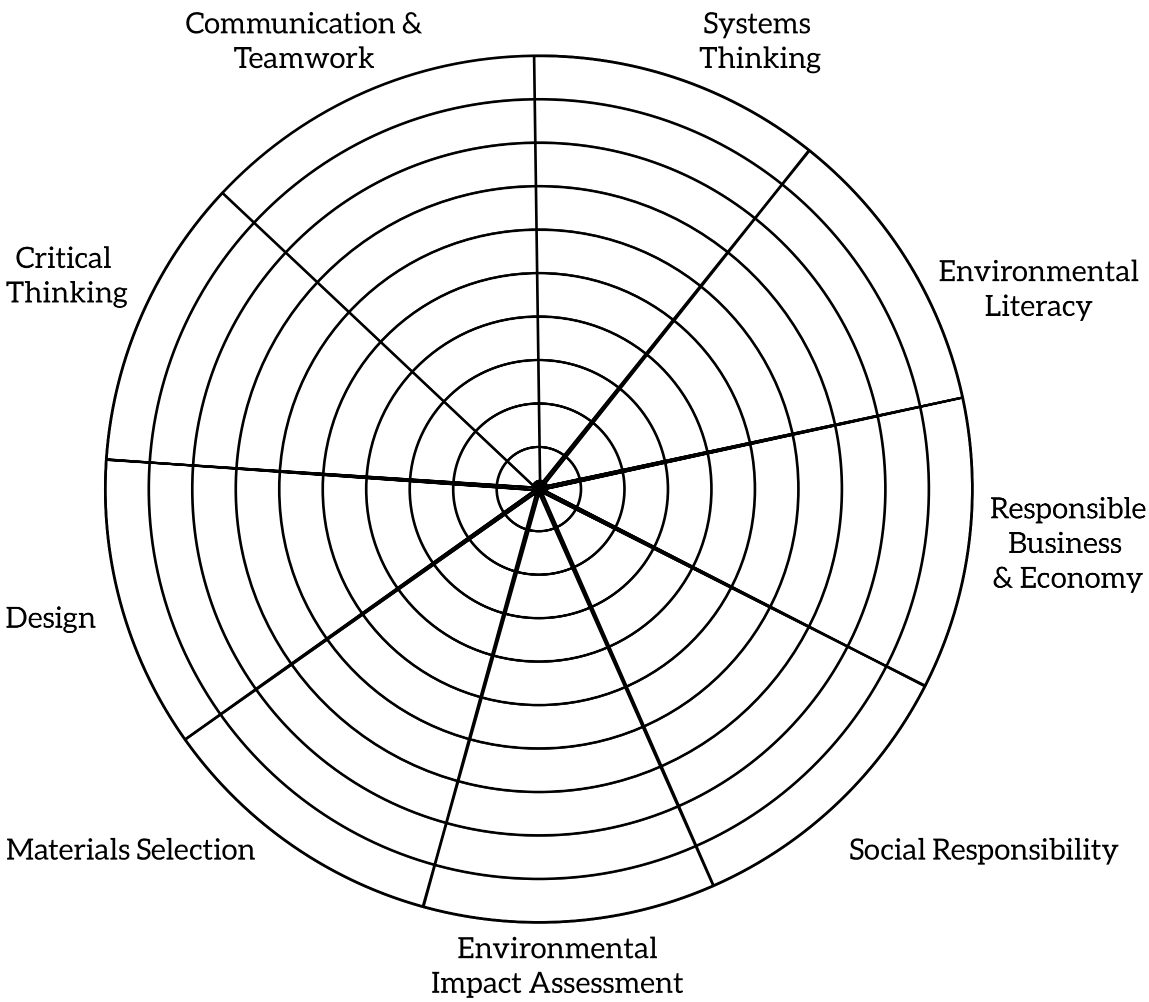


Step 3

Place your averages in the Scoresheet section and use those numbers to shade in the radial chart on the next page, starting from the center and shading out. The radial chart is divided into tenths. You will shade about 44% of the graph for the Systems Thinking section.



Evaluation Graph



Scoresheet

Systems Thinking: ________

Environmental Literacy: ________

Responsible Business & Economy: ________

Social Responsibility: _______

Environmental Impact Assessment: _________

Materials Selection: ________

Design: ________

Critical Thinking: ________

Communication & Teamwork: ________

1. Systems Thinking

Core

- [ ] 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.
- [ ] Identify dynamic impacts between and among different parts of the system (i.e., social, environmental, and economic considerations).
- [ ] 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.
- [ ] Create solutions that consider the scale of the activity relative to the planetary system boundaries (i.e., carrying capacities).
- [ ] 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.).

Advanced

- [ ] Identify system archetypes (i.e., the tragedy of the commons), ecosystem services, and key concepts in system dynamics and their impacts on communities/societies.
- [ ] Design solutions for real-world problems in partnership with communities using humancentered design and system dynamics, including feedback loops, tipping points, and system resilience.
- [ ] Create visual system maps (e.g., causal loop diagramming, system dynamics simulations, etc.).
- [ ] 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.).

Total: ____ /9 = ____

2. Environmental Literacy

Core

- [ ] Recognize opportunities (i.e., social, economic, and environmental benefits, etc.) to solve environmental challenges.

- [ ] 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).

- [ ] 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.

- [ ] Explain the nature and role of energy in the world, our daily lives, and in engineering practices (e.g. is energy literate).

- [ ] 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.

Advanced

- [ ] Explain abiotic assets (e.g., fossil fuels, minerals, metals), flows (e.g., wind and solar energy), and biotic natural capital (e.g., ecosystems).

- [ ] Describe key ecosystem services and functions including provisioning services, regulating and maintenance services, cultural services, and supporting services (e.g., material cycles, energy cycles).

- [ ] 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.

- [ ] Apply key ecosystem services and functions to their design solutions.

- [ ] Weigh energy-use decisions based on an understanding of impacts and consequences.

Total: ____ /10 = ____

3. Responsible Business and Economy

Core

- [ ] 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.

- [ ] 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.)

- [ ] 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.).

- [ ] 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.).

- [ ] 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.

Advanced

- [ ] Explain alternative business, revenue, and entrepreneurship models (e.g., B Corps, product service systems, sharing economy platforms, cooperatives, indigenous practices/ sensibilities, etc.).

- [ ] Explain sustainable use and disposal practices to consumers.

- [ ] Locate funding sources for public infrastructure.

- [ ] 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.

- [ ] Judge supply chain agents, vendors, etc., from environmental, social, and Diversity, Equity, Inclusion, and Justice (DEIJ) perspectives.

- [ ] 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.

Total: ____ /11 = ____

4. Social Responsibility

Core

- [ ] Identify the United Nations Sustainable Development Goals (SDGs).

- [ ] Recognize and be empathetic to ethical implications relative to the social impact of their work.

- [ ] 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.).

- [ ] 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.

- [ ] Explain the role of social responsibility and environmental justice in the engineering profession (i.e., policies, laws, social justice, etc.)

- [ ] 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.)

- [ ] Create robust, dynamic, and resilient systems and transdisciplinary stakeholder networks.

Advanced

- [ ] Recognize the breadth of social and environmental justice issues, indigenous rights, laws, policies, and commitments (e.g., Global Compact (GC)).

- [ ] 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.

- [ ] Recognize that impacts are disproportionately borne by low-income and marginalized groups.

Total: ____ /10 = ____

5. Environmental Impact Assessment

Core

- [ ] 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).

- [ ] Recognize current eco-labelling systems and certificates (i.e., EPEAT, Energy Star) for sustainable production and consumption.

- [ ] 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.).

- [ ] 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?).

Advanced

- [ ] Discuss relative impact reduction vs. absolute impact reduction (e.g., greenhouse gas (GHG) emissions).

- [ ] 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.

Total: ____ /6 = ____

6. Materials Selection

Core

- [ ] 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).

- [ ] Recognize current environmental assessment research and gaps in research.

- [ ] Critique the environmental and social impacts of designs created by others.

- [ ] Compare materials properties (e.g., chemical, physical, and structural properties) and performance aligned with end-use application.

- [ ] 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.).

- [ ] 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.

Advanced

- [ ] 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.

- [ ] Discuss sustainability reports and data (e.g., Global Compact, Global Reporting Initiative, etc.) to draw upon leading research.

- [ ] Explain the implications of the of impacts of material consumption at scale.

- [ ] 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).

- [ ] Identify innovation gaps in existing materials options and how to help spur appropriate research and development.

- [ ] Apply systems perspective and calculate embodied energy of materials to make informed decisions.

- [ ] Evaluate Environmental, Health, and Safety (EHS) (e.g., ecotoxicity, chemical hazard assessments, etc.) and green chemistry aspects of materials.

- [ ] 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).

Total: ____ /14 = ____

7. Design

Core

- [ ] Execute technical analyses to choose strategies that maximize the positive and minimize the negative environmental and social impacts in order to achieve design goals.

- [ ] Design for the environment and society based on discipline-specific technical skills (e.g., lightweighting, design for repairability and durability, design for upgradeability, design for disassembly, flexibility, and reuse, design for part or whole recovery, etc.).

- [ ] Compare materials properties (e.g., chemical, physical, and structural properties) and performance aligned with end-use application.

Advanced

- [ ] 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.
- [ ] Recognize local craft traditions, indigenous knowledge systems, and vernacular practices, and innovate inclusive and regenerative solutions and processes.
- [ ] Implement stakeholder user experience/participatory studies (e.g., design thinking, humancentered design) and social impact assessments to meet user needs in responsible, novel, improved, ethical, and sustainable ways.
- [ ] Design with approaches that incorporate whole life-cycle and systems thinking.
- [ ] 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.
- [ ] Design with systems dynamics concepts in mind (e.g., feedback loops, complex cause-effect chains, cascading effects, inertia, tipping points, legacy, resilience, adaptation, etc.).
- [ ] Create solutions for use with alternative business models and emerging economic contexts.

Total: ____ /10 = ____

8. Critical Thinking

Core

- [ ] Define problems comprehensively with consideration of consequences, unintended and intended.
- [ ] Report being a self-aware and reflective practitioner with values, empathy, and guardianship of one's environment.
- [ ] Report understanding that their values are both shaping, and being shaped, by the designs, technologies, innovations, etc., they create and scale.
- [ ] 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.
- [ ] Examine norms, biases, and values that underlie one's behaviors (i.e., normative thinking and cognitive dissonance).

- [ ] Critique complex ethical and values-based choices, employing empathy when evaluating conflicts of interest, trade-offs, and uncertain knowledge and contradictions within problem constraints.

Advanced

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

Total: ____ /13 = ____

9. Communication and Teamwork

Core

- [ ] Communicate through audience-specific written, graphic/visual, oral, and interpersonal communication skills.
  - 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.
- [ ] Develop leadership potential and capability.
  - 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.

- [ ] Demonstrate ability to work within and function well on teams and across disciplines.
  - 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.
- [ ] Demonstrate self-awareness and understanding of unconscious bias.
- [ ] Prioritize projects, schedules, and time, and manage people equitably and inclusively.
- [ ] 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.

Advanced

- [ ] 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.
- [ ] Develop and maintain relationships through interpersonal skills.
  - 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.
- [ ] Investigate solutions to individual, institutional, and systemic bias.
- [ ] Apply systematic, disciplined, and collaborative project management methodologies in order to effectively manage teams and themselves.
- [ ] Demonstrate ability to interact with, collaborate on, and lead multidisciplinary teams, effectively representing an engineering perspective in a comprehensible manner through project-based work.

Total: ____ /11 = ____

Reflection

Reflect on your incorporation of the EOP framework. What surprised you? Are there areas you would like to work on? How does incorporating the EOP framework benefit the engineering field?

Next Steps

Consider areas of the chart where you could incorporate more of the EOP framework. Go back and review those learning outcomes to evaluate how you might more closely align your course content to the framework.

Designed by Aditi Gupta for the Engineering for One Planet Fellowship through the Walton Sustainability Teachers' Academies at Arizona State University.

Engineering for One Planet

Powered by The Lemelson Foundation
Prepared in partnership with Arizona State University

Arizona State University