

Enhancing STEM Faculty Sustainability Curricular Competencies using the Engineering for One Planet Initiative

Dr. Nelson A. Granda, North Carolina Agricultural and Technical State University (CoST)

Nelson A. Granda Marulanda is an Assistant Professor in the Applied Engineering Technology department at the North Carolina Agricultural & Technical State University. Nelson has a BS in Electrical Engineering from the University of Puerto Rico at Mayaguez, a Masters in Manufacturing Engineering from the Polytechnic University of Puerto Rico, and a Ph.D. in Industrial and Systems Engineering from The University of Tennessee Knoxville. Before becoming a professor, he worked for several years in the Eolic and Aerospace industry. Nelson's research interest revolved around Sustainable Development through the triple bottom line and System Thinking approach. Nelson believes that education is the key to achieving a sustainable world.

Prof. Jasmina Burek

Dr. Jasmina Burek (she/her/hers) is an Assistant Professor in the Mechanical and Industrial Engineering Department at the University of Massachusetts Lowell (UML) and Principal Investigator at BUILDING RESilience through Knowledge (BUREK) Lab. Her research focuses on sustainability and resilience engineering. She develops decision-making models to measure and minimize environmental, social, and economic impacts (footprint assessment) of products, materials, buildings using life cycle assessment (LCA). She has over 15 years of LCA method application in areas of buildings, energy, and product supply chains. At UML, she is moving towards the research in resilient buildings and developing LCA method to account for it.

Dr. Yang Zhang, Western Carolina University

Dr. Yang Zhang is an Associate Professor in the School of Engineering + Technology at Western Carolina University. Dr. Zhang achieved his Ph.D. and M.S. degrees in Industrial Engineering from Texas Tech University. Dr. Zhang is passionate of conducting engineering education with innovative methods; he believes the best method for conveying the subject matter is the interest.

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Abstract

Efforts to strengthen sustainability mindsets across the engineering discipline are increasingly driven by diverse sectors, including accreditation bodies, industry, government agencies, and public advocacy. One initiative that has gained significant traction since 2021 is the Engineering for One Planet (EOP) initiative, catalyzed by The Lemelson Foundation in partnership with VentureWell. EOP provides the engineering education community with essential resources—such as teaching tools, funding opportunities, and professional support—to help transform engineering curricula and equip all engineers with the knowledge, skills, and mindsets needed to contribute to a healthy and sustainable world. In collaboration with ASEE, The Lemelson Foundation launched the EOP Mini-Grant Program to support activities that promote curricular innovation and foster sustainability competencies among engineering students. As part of this program, this paper presents the development and implementation of a faculty workshop designed to introduce and apply the EOP Framework across a range of institutional contexts, including community colleges, mid-sized teaching-focused universities, and mid-sized research institutions. The workshop was delivered in two two-hour sessions to maximize accessibility and engagement. The first session introduced participants to the EOP Framework and its core sustainability competencies. The second session guided faculty through the process of designing a curricular activity using their own teaching experience, supported by the Backward Course Design method.

This paper will present an assessment of the workshop's effectiveness, including participant feedback and insights gained during the curriculum development process. Findings highlight how faculty engaged with the EOP Framework, the challenges they encountered, and the strategies they employed to integrate sustainability into their courses. The results offer practical recommendations for scaling similar efforts and advancing sustainability education across diverse engineering programs.

Introduction

Efforts aimed at fostering sustainability-oriented mindsets across engineering disciplines have been increasingly motivated by stakeholders including accreditation bodies (such as ABET), industry leaders, governmental organizations, and the general public. Despite these motivations, a significant gap remains in the systematic integration of sustainability into core engineering technical curricula. Since 2021, the Engineering for One Planet (EOP) Initiative, spearheaded by The Lemelson Foundation and VentureWell, has emerged as a prominent framework to address this gap by providing the tools, grants, and institutional support necessary to revolutionize engineering education[1].

The core mission of the EOP initiative is to equip all engineers, regardless of their specific discipline, with the understanding, knowledge, and mindset required to ensure their professional

work contributes to a healthier and more sustainable world[2]. This necessitates a shift from viewing sustainability as an “add-on” topic to treating it as a foundational competency integrated through Systems Thinking. Previous research highlights that sustainable development is often a contested concept shaped by differing worldviews; however, in engineering, it is increasingly defined through the "Triple Bottom Line" balancing economic development, social equity, and environmental protection[3], [4], [5]. Systems Thinking, the central competency of the EOP Framework, requires engineers to view problems not as isolated components but as interconnected parts of a larger, dynamic whole. In the context of sustainability, this means evaluating how a technical solution interacts with environmental cycles, social structures, and economic markets over its entire lifecycle. By shifting from a linear to a systems-oriented perspective, faculty can help students identify unintended consequences and leverage points for more sustainable design outcomes.

As part of the EOP Mini-Grant program, this paper discusses the development and implementation of a professional development workshop designed to engage faculty from diverse academic environments, ranging from community colleges to research-focused universities. By utilizing Backward Course Design, the workshop assists faculty in aligning EOP competencies with their existing course learning objectives. This paper presents the design of the workshop and an assessment of its effectiveness as a tool for enhancing faculty sustainability curricular competencies, showcasing survey results that demonstrate its value as a beneficial model for professional growth.

Implementing these concepts requires faculty to move beyond traditional lecture-based instruction toward active learning strategies. For example, recent studies in engineering technology have demonstrated that pedagogical shifts, such as the Flipped Classroom approach, can significantly improve student engagement and outcomes[6]. Similarly, faculty professional development must transition toward hands-on, collaborative models that empower educators to redesign their courses effectively.

Background and Purpose

Despite substantial growth in sustainability topics within engineering education, the majority of engineering students do not receive comprehensive instruction in sustainability-focused concepts, tools, and methodologies[7], [2]. Educators perceive sustainability as a multifaceted subject, and many of them need to become more comfortable and acquainted with integrating sustainability into their teaching[5]. This gap has resulted in a lack of sustainability-focused curriculum development in engineering education, and graduates often lack sufficient sustainability knowledge when entering the workforce[8], [9]. Remarkably, less than 1% of the nearly 141,000 engineering graduates in the US specialize in environmental engineering [10]. The demand for engineers proficient in environmental, social, and economic sustainability is surpassing the available supply, with renewable and environmental job opportunities growing by nearly 250% over the past five years[11].

In 2019, the initial Engineering for One Planet (EOP) Framework was collaboratively developed with input from numerous stakeholders, including representatives from the engineering

education community. It was introduced as a catalyst to integrate sustainability principles into engineering curricula and programs[12], [13]. The Engineering for One Planet (EOP) Framework is not merely a research framework; it serves as a practical implementation tool for educators. Its purpose is to seamlessly integrate environmental and social sustainability concepts and tools into engineering courses, programs, and departments. The framework includes a meticulously curated list of 92 core and advanced sustainability-focused student learning outcomes, collaboratively developed by a diverse community of hundreds of experts representing various identities, lived experiences, geographical locations, and sectors; ranging from academia and industry to nonprofit organizations, government, and philanthropy[1].

In accordance with ABET's seven essential student outcomes, the EOP initiative and their resources equips faculty members with a curated set of competencies that every graduating engineer, regardless of their specific subdiscipline, should master[1], [14]. These competencies enable engineers to create, program, construct, and implement solutions that align with social and environmental sustainability[15]. The EOP Framework serves as a fundamental pillar of the EOP initiative, pioneering a comprehensive approach to shaping curricula, educational resources, and student encounters. It delineates the essential attributes of an engineer who is not only capable of safeguarding our planet but also nurturing the life it sustains[1]. A good summary of the EOP Framework can be seen in **Figure 1** as it show the competencies that are prioritized, all centered around systems thinking as the primary one.



Figure 1: Engineering for One Planet Framework Graphic. Adapted from the EOP Framework with the author permission[1] .

This work aims to; (i) provide an example of the development of a workshop for faculty using the EOP topics, (ii) describe the implementation process for a faculty workshop, (iii) provide details of a retrospective survey assessment, and (iv) present the insights of from the ASEE EOP MGP project “The Faculty Workshop”

Workshop Motivation

Research conducted at Oregon State University on the implementation of the Engineering for One Planet (EOP) Framework revealed that incorporating environmentally-responsible engineering concepts into first-year engineering courses led to heightened student enthusiasm for the field. This positive impact suggests the potential for enhancing student retention, particularly among historically underrepresented groups in engineering[16], [17].

Workshop Development

As part of the ASEE EOP MGP cohort II grantees, the authors team up to develop a workshop specifically designed to introduce and support faculty from diverse backgrounds and affiliations across various educational settings to the EOP framework, their resources and how to use them. The development of the workshop spanned across three months, from August to October. During this phase the authors met weekly to plan and develop the structure and content of the presentation to be used during the Faculty Workshop. During this time the team also met with the mentors every two weeks. The mentors were assigned to the team as part of the ASEE EOP MGP community. The meetings with the mentors were extremely useful to the team to resolved issues that arose during the development of the workshop. The mentors also support the development of the workshop as they provide feedback and suggestions during the development process.

Since the target population of the workshop were faculty who does not have or have very little previous knowledge about the EOP framework and their resources the team developed the following high-level topics of interests plan to be presented and discussed during the time of the two workshop dates.

- ✓ Introduction to the EOP initiative and the ASEE EOP MGP, including background and funding sources.
- ✓ General introduction to Sustainability and why it is important in the engineering courses.
- ✓ Showcase the EOP framework and the free available resources
- ✓ Introduction to the Backward Course Design Methodology
- ✓ Examples of previous EOP implementations
- ✓ Developing an idea for the use of the EOP framework in the participant courses
- ✓ Advertising the next ASEE EOP Mini-Grant Program cohort.

Workshop Implementation

The recruitment for faculty participants started five weeks before the first session of the workshop. In order to attract participants, there was a monetary stipend offer to participants who

completed the workshop. The team developed a brochure (figure 2), which was distributed and promoted across their own institutions. As part of the goal of this workshop was to involve faculty who teaches introductory engineering courses the team actively invite engineering faculty from North Carolina Community Colleges via the engineering pathways consortium which regulate the Associate in Engineering degree in the state.

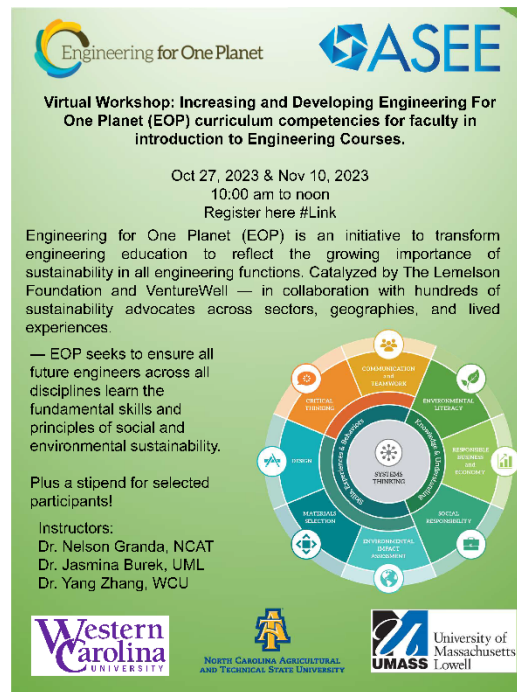


Figure 2: Flyer for Engineering for One Planet Workshop

Faculty recruitment was an area that was challenging for the project as not many participants register for the workshop in the first few weeks of the enrollment period. In order to address this issue, the team re-advertised the workshop expanding to other institutions outside of the three institutions where the authors are faculty members. In table 1 we can see the participants' institution demographics. There was a total of 12 participants enrolled and a total of 9 participants who attended the workshop.

Table 1: Participant institution demographics

Institution	registered	attended
Community College	3	3
4+ year primarily teaching institution	1	1
4+ year primarily research institution	8	5

During the registration form, questions regarding motivation, commitment and previous knowledge of the EOP initiative were asked. These questions were developed with the purpose of helping the project team select the participants assuming a big turnout of faculty interested in

participating in the workshop. Table 2 shows the type of questions used during the registration survey. The team had set the capacity of stipend committed participants to 13 and invite all other registered participants as not-stipend recipients to attend the workshop. The capacity of the workshop was defined based on the funding available to provide stipend.

Table 2 Registration survey questions

Question	Type
What is your motivation to participate on the workshop?	Open Ended
Are you willing to participate in both sessions of this workshop?	Yes/No
What course(s) you are teaching or you will teach in the future, that you want to use the Engineering for One Planet Framework?	Open Ended
Are you willing and commit to integrate EOP framework into your course(s)?	Yes/No
Are you willing to complete a survey about this workshop?	Yes/No
If a survey for your student about your EOP framework integration is prepared by the workshop presenter, are you willing to distribute the survey to your students?	Yes/No

While there was no need to restrict participation to the workshop these questions still were helpful with understanding the motivation of the participants. Since we have a low turnout of registrants we expected that the majority of the responses regarding motivation were highly related to sustainability topics. Some of the answers of the registered participants to the question *What is your motivation to participate on the workshop?* are presented in table 3.

Table 3 Responses to motivation question

participant	Response
1	Creating curriculum to increase sustainable energy practices both in manufacturing and services
2	To learn the fundamental skills and principles of social and environmental sustainability, especially in the sustainable design, construction, and operation of built environments.
3	Professional Development.
4	Through this workshop, I am expecting to learn the skills and principles of social and environmental sustainability and how to measure/improve the sustainability performance of various manufacturing processes.
5	I would like to incorporate sustainability into the courses that I teach.
6	I am interested in developing a new sustainability course and incorporate sustainability modules in the current courses I teach
7	To learn about sustainability and how to effectively integrate it in my curriculum.
8	Learn about Engineering for One Planet and see how can I use it in my engineering Colleges
9	Building sustainability practices into our courses, specifically junior and senior level Engineering Technology courses.

After the registration closed, communication via email with the registered participants was initiated. The email contained detail information regarding workshop, the link to access the videoconference meeting and also included the latest version of the EOP Framework for the participants to review and have easily available during the workshop.

The workshop was presented over two sessions of 2-hours on Fridays one week apart. This timeframe was decided to increase the interest of participants as is known Faculty members are busy and finding availability for long periods of time is challenging. Table 4 and Table 5 shows the agenda with approximate time for each session.

Table 4 Agenda session 1 (Day 1)

Workshop session 1 agenda and topics	Approx. time
Welcome and introductions	10 min
Introduction to EOP Framework	20 min
Introduction to the backward course design	20 min
Break	10 min
Examples and paper discussions	10 min
Expanding on Social Sustainability topics	10 min
Questions and Answers- <i>Discussion about EOP</i>	10 min
Ideation time - <i>participants share ideas of where EOP framework can be used</i>	15 min
“thinking assignment” - <i>all participants brainstorm of implementing EOP framework in their own courses and start working with the EOP and the Goal of the BCD method.</i>	10 min
Closing remarks and reminders for next session	5 min
Total time of workshop session 1	120 min

Table 5 Agenda Session 2 (Day 2)

Workshop session 2 agenda and topics	Approx. time
Welcome and ice-breaker	10 min
Open Discussion: Questions from last session	10 min
Open Discussion: Lets talk about your Ideas	30 min

Break	10 min
Let's Plan: How to bring the Idea to action	30 min
Let's Plan: What challenges I need to overcome to successfully implement the Idea	15 min
Feedback from instructors to each participants Idea	35 min
Next steps and Closing remarks	5 min
Total time of workshop session 1	120 min

Workshop Assessment

In order to assess impact of the workshop an assessment survey was developed by the authors and provided to all the participants at the end of the second session of the workshop. Giving that the number of participants were very limited, statistical analysis of this responses were not performed. The survey style used in this activity was a retrospective survey, where the assessment instrument is provided only once at the end of the activity to be assessed, but it asks the participants to reflect on their experience and knowledge prior, and after the activity, in this case at the Faculty Workshop they just completed. This style of survey has been used and validated at Professional Development conferences and after-school programs[18]. In our case, this style of the survey was chosen since it can provide insightful information with one survey as well as to reduce the survey burden that impact us during and after the COVID 19 pandemic. Instead of a pre-and post-survey, the participants were only inquired to respond to one survey assessment. It is expected that the use of this style of surveying can increases the willingness of the participants to submit responses. In our case we had an 88.9% response rate which mean that only one of the nine participants did not respond to the survey.

The survey was developed in Qualtrics and a QR code was provided with time scheduled in the agenda to respond at the end of the second session of the workshop. The responses to the survey were anonymous, but giving the low number of participants complete anonymity was not possible. Some demographics regarding role and program were collected. Table 6 shows the teaching area of the survey respondents. Another demographic question was the faculty role, primarily teaching faculty, primarily research faculty or administrator. For this question all responses were *primarily teaching faculty*.

Table 6 Teaching area of participants

Teaching area	# Respondents
Science Program	1
Technology Program	3
Engineering Program	4
Mathematics	0
Non-STEM program	0

The responses to the impact assessment survey are presented in the tables 7 to 11. The response to the first question asking if the participants have any previous knowledge or interaction with the EOP framework show that the majority of the participants did not know or were not aware of the EOP initiative or framework before the workshop, this validate the importance of the workshop.

Table 7 Participant response to Q1

Have you heard about Engineering for One Planet (EOP) before participating in the workshop?	
Yes	25%
No	75%

Table 8 Participant response to Q2

How do you categorize your familiarity with the Engineering for One Planet Initiative	Before	After
Not familiar at all	50%	0%
Slightly familiar	0%	0%
Moderately familiar	25%	50%
Very familiar	0%	25%
Extremely familiar	25%	25%

Table 8 shows and increase in familiarity with the EOP initiative, this was expected as the main topic of the faculty workshop was to introduces and explain how to use the EOP Framework in the classroom.

Table 9 Participant response to Q3

I believed that teaching sustainability concepts in my courses is?	Before	After
Extremely difficult	0%	0%
Somewhat difficult	25%	0%
Neither easy nor difficult	50%	25%
Somewhat easy	0%	50%
Extremely easy	25%	25%

Tale 9 shows that the participants change their belief that incorporating sustainability concepts in their classroom is difficult. The shift in participant belief, from viewing sustainability as "somewhat difficult" to "somewhat easy", is particularly noteworthy. This change suggests that the workshop successfully demystified the EOP Framework by shifting the focus from "adding new content" to "re-aligning existing objectives" through systems thinking. By providing free, curated resources and support, the workshop lowered the barrier to entry, allowing faculty to see sustainability as a manageable technical competency rather than an overwhelming add-on.

Table 10 Participant response to Q3

After completing this workshop, do you find the EOP framework and resources beneficial in your future curriculum design?	%
None at all	0%
A little	0%
A moderate amount	25%
A lot	25%
A great deal	50%

Table 10 shows that the workshop was successful in conveying the message that teaching sustainability concepts is not difficult, especially if using the free EOP resources.

Table 11 Participant response to Q4

Based on your previous teaching experience, how many total students on average you anticipate being enrolled in the courses you plan to integrate into the EOP framework in the next academic year?	Average	Minimum	Maximum
students	72.67	29.00	220.00

Table 11 shows the indirect impact of this faculty workshop. Future work is expected in following up with the workshop participants to measure impact in their students.

Concluding thoughts and lessons learned

The development, implementation and assessment of a short faculty workshop is not an easy endeavor. The work and support from all members of the team (authors) was essential to the successful deployment of this project. The responses of the participants to the survey showed a very significant and positive learning experience. We can realize a significant improvement towards incorporating sustainability concepts in introductory courses by engaging and supporting more faculty with resources to create changes in their courses.

The implementation process revealed that faculty recruitment remains a significant hurdle for sustainability-focused professional development. Initially, the team relied on internal institutional networks, but a low initial turnout necessitated a pivot to broader consortia, such as the engineering pathways consortium for community colleges. This suggests that "sustainability" may still be perceived as a niche topic by some faculty, requiring more targeted outreach that emphasizes how the EOP Framework aligns with existing ABET outcomes to reduce the perceived burden of curriculum redesign.

From the demographics of teaching area, we find that faculty outside of engineering and technology areas were interested in the EOP framework. After follow up with the science faculty who participated in the workshop we see a big opportunity to include and engage with science

faculty specially those who teach core general education courses like Chemistry, Physics and Biology to engineering students.

Furthermore, the organizers observed that the "Backward Course Design" methodology was essential in bridging the gap between abstract sustainability concepts and practical classroom application. Faculty participants were most engaged during the "Ideation time" when they could brainstorm specific leverage points in their own syllabi. A key lesson for future iterations is to provide even more time for peer-to-peer feedback, as the diverse institutional backgrounds, ranging from research-heavy universities to community colleges, offered a rich variety of pedagogical perspectives.

Scaling and Future Recruitment Strategy

The difficulty in recruitment, resulting in only 12 registrants and 9 attendees highlights a gap between the recognized importance of sustainability and faculty availability. To scale future efforts to more participants, the following strategies are proposed:

- ✓ **Institutional Integration:** Rather than relying on individual outreach, partnering with University "Centers for Teaching Excellence" or "Offices of Sustainability" could provide a more formal platform for recruitment.
- ✓ **Discipline-Specific Marketing:** The initial brochure was distributed broadly; future efforts should include targeted messaging for specific departments (e.g., "Sustainability Biology or The Engineering of Green Chemistry") to demonstrate immediate relevance.
- ✓ **Asynchronous Options:** Given that faculty members are busy, offering a "flipped" workshop model with recorded introductory sessions followed by a single intensive 2-hour synchronous "Action Planning" session may increase accessibility.
- ✓ **Incentive Alignment:** While a stipend was offered, explicitly aligning workshop completion with professional development credits or annual review criteria would likely drive higher engagement among early-career faculty.

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