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Bridging the Green Skills Gap: Engaging Undergraduate Students as Changemakers in Engineering Education

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Bridging the Green Skills Gap: Engaging Undergraduate Students as Changemakers in Engineering Education

Abstract

Universities and colleges nationwide increasingly recognize the importance of integrating sustainability into engineering education to address pressing national and global sustainability challenges and the associated green skills gap. As a result, we are seeing a growing number of sustainability-focused offerings on campuses. Unfortunately, most of these offerings are extracurricular or are solely found within the civil and environmental engineering curriculum and thus are unavailable to students from other majors. To address the green skills gap, engineering education must undergo a significant transformation in order to equip all engineers, no matter their discipline, with the knowledge and skills needed to design and implement sustainability-focused solutions. Engineering for One Planet (EOP) is an initiative to address the green skills gap by providing tools, resources, and funding to support the integration of social and environmental sustainability into engineering education. From the outset, EOP recognized the importance of student voices and thus welcomed students to the EOP Advisory Board and the EOP Network. However, faculty have been the chief actors in EOP curricular change efforts, with students tending to only serve as beneficiaries and learners.

This paper proposes a deeper involvement of students in the curricular change-making process and an emphasis on ensuring that student voices are heard. Referencing insights from primary and secondary research into effective changemaker programs, this paper emphasizes the importance of viewing students as customers and co-creators in engineering education's transformation. A bottom-up, student-led approach to curricular change will bring additional capacity to new and existing change efforts. It will complement faculty change initiatives by incorporating fresh and innovative perspectives, providing faculty with a first-person understanding of what engages students and which skills students need and want for their future careers. This paper presents the EOP Student Ambassador Program design and details the training process and support mechanisms to prepare students to drive curricular change. Also discussed are the timeline and selection criteria for ambassadors, as well as the emphasis on collaboration among students, faculty, and other stakeholders to promote the alignment of curricular change with real-world sustainability demands. The program is scheduled to launch in September 2025.

Introduction

Around the world, there is an increasing urgency to address sustainability challenges, from biodiversity loss, to water scarcity and pollution, to the impact of climate change, to social inequality. The recent 1.5°C climate milestone is just a subset of these global challenges [1]. While numerous sustainability obstacles exist, several initiatives are working to address these

challenges, including the NSF Big 10 Ideas, Grand Challenges, and the United Nations' Sustainable Development Goals (SDGs) [2], [3]. While these initiatives serve as an important call to action, collectively, they fail to activate and prepare a sufficient number of individuals to address these global challenges [4]. This trend has been shared in the 'LinkedIn Green Skills Report' each year since 2022. The report captures the shortage of skilled workers needed to support the green energy transition, i.e. the green skills gap [5], [6], [7].

Engineering educators are increasingly recognizing that the engineering curriculum does not sufficiently address the sustainable engineering skills gap [8]. Indeed, it has been reported that 99% of non-civil engineers graduate with no coursework discussing sustainability [9]. Recent initiatives are working to address this directly. At the administrative level, ABET accreditation includes sustainability in its criteria to encourage the integration of sustainability in thousands of engineering programs across the globe [10], [11]. The Engineering for One Planet (EOP) initiative uses four interrelated approaches to support the integration of sustainability into the engineering curriculum: (1) the EOP Framework, which provides a comprehensive menu of vetted learning outcomes capturing technical and professional skills needed to practice engineering sustainably [12]; (2) open source teaching guides with classroom activities that faculty can adopt and adapt in their own classrooms [13]; (3) funding for faculty capacity building through collaborations with the American Society for Engineering Education and the National Science Foundation; and (4) supporting cross sector collaborations and systems change through the EOP Network.

While EOP is making great strides, as described above, most efforts to date are faculty centric. Additionally, curricular change efforts are traditionally seen as the domain of faculty and academic administrators. As such, change efforts fail to take into consideration students' perspectives about the curricular content that will help prepare them for a sustainability-focused career. These efforts also fail to tap into the energy, creativity and fresh ideas that students might bring to the curricular change process [14].

In this work-in-progress, we discuss how we evaluated other student changemaker programs that help undergraduate students learn about sustainability, e.g. Engineers for a Sustainable World (ESW) [15] and Engineers without Borders (EwB) [16]. These programs inspired the design of a new student changemaker program that values and supports students' lived experiences and innovative approaches. This bottom-up approach addresses the green skills gap and centers students in the curricular change-making process, which will help to educate and prepare the next generation of sustainability-conscious engineers.

Background

Over the past decade, engineering education programs around the United States have begun to integrate sustainability into their curricula, with initiatives such as Engineering for One Planet's Framework supporting these efforts. Unfortunately, as captured in the 2024 paper, *Empowering*

Change: The Role of Student Changemakers in Advancing Sustainability within Engineering Education [14], most of these integration efforts are extra-curricular, electives, or only available to environmental or civil engineering students. Traditionally, these efforts have been led by faculty and academic staff and have largely excluded students from the ideation, planning, and implementation processes. EOP is responding to these observed issues by launching a new student ambassador program. The goal of the ambassador program is to support students in identifying and advocating for the curricular changes they are seeking. As described in the aforementioned paper, this might include integrating sustainability into core or foundational classes, integrating sustainability across the entire curriculum, or integrating sustainability into specialized classes for different engineering majors.

Methods

To design a successful ambassador program, the **EOP Student Ambassador Program (EOP-SAP)** assembled a multifaceted team to join an advisory group. Ten participants were selected from the EOP Network: two students, five staff from nonprofits or academia, two faculty, and one staff at an academically affiliated society. Each participant was selected based on their experience integrating sustainability into the engineering curriculum, lived experiences, and belief in the value of engaging students in curricular change.

The EOP-SAP advisory group researched 17 changemaker programs across the globe; these programs are listed in **Appendix A**. These programs were identified based on the following attributes: programs that (1) were designed for college students to contribute to in a volunteer capacity; (2) focused on sustainability, climate change, environmental science/education, and/or related topics; and (3) sought to train students to achieve positive change related to sustainability at the university, community, or government level. The research benchmarked: (1) students' tasks and responsibilities; (2) student recruitment and retention; (3) training, tools, and support; and (4) the time commitment expected of students.

This research found that most programs recruited students via advertising on parts of campuses where sustainability activities happen, e.g. buildings where environmental courses are taught or that contain sustainability hubs. Recruitment also often occurred as a part of sustainability gatherings: club fairs, sustainability events, sustainability-related boothing as a part of larger events, etc. Programs utilized engaging and effective flyers with QR codes, which led to detailed information on their programs. Another important aspect of recruitment was allowing students to interface with existing ambassadors; if students are introduced to the work being done by students already engaged in the program, they are more likely to envision themselves engaging and can ask questions to ensure their participation is a good fit for them and the program alike.

Participation ranged from 6-24 months, with most programs lasting 6-12 months. Weekly time commitments ranged from 2-10 hours per week but usually fell in the 3-4 hour range. Programs

that involve in-person activities, such as scientific sampling or rallies, typically require more hours of students than those programs that allow for at-home or self-led work.

Ambassador Program Design

As captured in the EOP-SAP mission and vision (see **Appendix B**), the program is designed to provide students with the knowledge and tools needed to accelerate the integration of social and environmental engineering through collaboration with campus stakeholders. The overarching approach for ambassador training and support was inspired by both community of practice (CoP) and creativity and innovation literature. Etienne and Beverly Wenger-Trayner, preeminent CoP scholars, explain that a CoP-focused approach is particularly beneficial when the learning needed is context-specific and emergent and has not already been codified and disseminated [17]. This makes the CoP approach particularly useful in this context because students are generally excluded from curricular change processes. The approaches ambassadors might adopt or the challenges they might encounter have also yet to be identified. CoPs directly connect learning to practice, so by engaging in a CoP, ambassadors will benefit from insights that specifically pertain to the changemaker work they are undertaking. Finally, CoP practitioners have agency over their collective learning. Thus, EOP ambassadors will benefit from identifying and driving the focus of their learning and their projects based on their personal interests and contexts.

This CoP approach will show up in how ambassadors are convened biweekly, first as a cohort and then in smaller peer groups. Peer groups will be chosen after each campus team has identified their curricular project of choice, with a goal of matching teams with similar campus contexts and projects. Ambassadors will also automatically become members of the EOP Network. Being a part of and engaging in EOP Network activities will benefit students by enhancing their knowledge of EOP's mission and models for integrating sustainability. Once project work is underway, ambassadors will also be provided with knowledgeable mentors from the EOP Network to provide regular support and feedback. By meeting regularly with diverse peer groups and mentors from the EOP Network, ambassadors will engage in a supportive CoP-like model that will drive collective learning and support growth of their professional network.

Curriculum change is challenging, so ambassadors must be motivated to be effective. In Seelig's book *Insight Out*, she explains the three keys to motivation: autonomy, mastery, and purpose [18]. To that end, ambassadors will be encouraged to independently identify the curricular changes they are most passionate about making, thus providing a sense of autonomy and purpose. Ambassadors will then identify projects that will enable them to develop an understanding of mastery, i.e. a project that is challenging but important and achievable.

Every university's campus, academic departments, faculty, governing bodies, and students are different. As such, the methods used to achieve effective curricular change will be context specific and bespoke. As captured in **Figure 1** below, students will engage in workshops and have access to resources that will help them to:

- Establish a baseline for sustainability curriculum in one or more engineering department curriculums or across campus (e.g. general education curriculum)
- Complete a comprehensive stakeholder mapping of relevant faculty, staff, academic committees, and student groups on campus
- Perform outreach to and collaborate with stakeholders on campus to advance sustainability topics in the curriculum
- Understand proven approaches for integrating sustainability in different parts of engineering curriculum
- Spread the word about the importance of sustainability in engineering curriculum on campus via department presentations, club events, and more
- Create and execute a campus-specific plan for at least one sustainability curricular development project over the course of the academic year

To support the development of innovative approaches, an iterative approach that emphasizes learning from their experiments and peers will be noted and celebrated at the end of the year with a Learning Journey Festival. **Figure 1** captures the initial semester-long training process and the end-of-year festival.

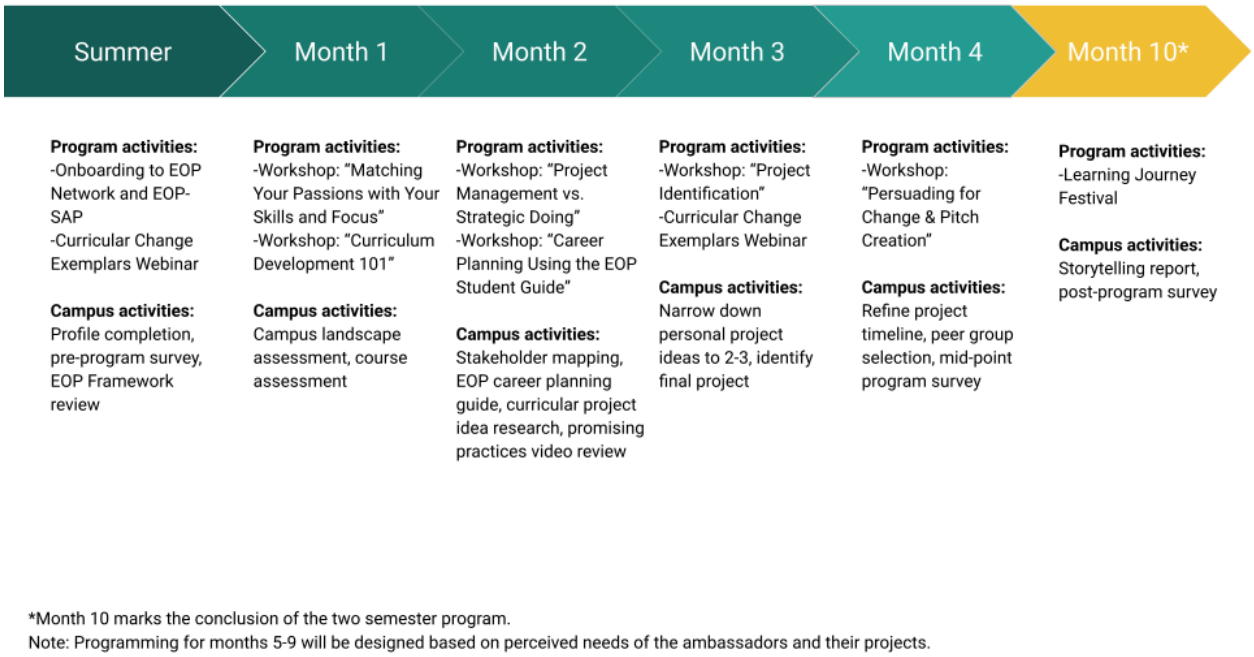

Figure 1. Training program for new EOP Student Ambassadors, and timeline for the first semester and final month of the program.

Additionally, the program is designed to provide students with workshops, tools, processes, and a network in service of the dual goal of supporting their (1) curricular change efforts, and (2) development of professional skills to benefit their future careers. In addition to understanding curriculum development and how to make curricular changes, they will engage in training that covers key concepts like persuasive communications, project management, and agile strategic planning. They will begin to develop an entrepreneurial mindset, as well as advocacy and leadership skills. They will conclude the program by receiving a badge that they can use to showcase their many experiences and skills.

The initial cohort is planned to run from September 2025 to June 2026 to provide sufficient time for students to engage in trainings and support that will scaffold the identification and execution of their change efforts.

In addition to this formalized series of trainings, ambassadors will have the option to pursue two highly recommended collaborations. During the application phase, ambassadors will be encouraged to recruit a team of colleagues from their institution. However, if ambassadors cannot recruit a team, they will still be welcomed into the cohort and will still receive exemplary peer support from their peer groups. As the program proceeds, ambassadors will be tasked with recruiting a faculty sponsor in order to collaborate on curricular change efforts. Again, while there are perceived benefits of having a faculty sponsor, if the ambassador cannot recruit a sponsor, they will continue to be involved in the program and receive similar support from EOP Network mentors.

In addition to formalized trainings and on-campus collaboration, ambassadors will also be supported by self-serve resources, including the EOP Framework and teaching guides. The EOP Framework, which comprises 93 core and advanced sustainability learning outcomes in nine topic areas, and the companion teaching guides, will provide ambassadors and faculty on their campus with approaches that they can adopt and adapt in classes across the curriculum. In addition to the framework, ambassadors will have access to a video library of promising curricular change practices contributed by EOP Network members, and guides developed to lead ambassadors through the curricular research and project implementation stages of the program. Finally, at the close of the two-semester program, ambassadors will be invited to re-engage with the program to continue their curricular change work and/or support new ambassadors as near peer mentors. See **Appendix C** for a complete list of program features and benefits.

Implementation and Evaluation

EOP-SAP recruitment began at the annual Engineers for a Sustainable World (ESW) conference (ESWCon) in March 2025 at the University of Akron. ESW is an international nonprofit network of over 1850 students and 50 collegiate chapters united by their shared passion for technical

sustainability. The annual ESWCon brings 150-200 students together for an energetic conference that engages students with sustainability content via workshops, talks, a two-day design challenge, and more.

At ESWCon25, the authors recruited students at a career fair booth and at a session titled "Engineering for One Planet Student Ambassador Program: Empowering Undergraduate Students to Advocate for Curricular Change" that introduced students to the program, collected feedback on the model for the program, and recruited potential students. The authors engaged in additional recruitment efforts, including an ESW webinar, social media promotion, email blasts on over 25 campuses, and personal recruitment and nominations from members of the EOP Network. At the time of writing this paper, the program has received more than 60 applications. The recruitment process will conclude in May of 2025 and be followed by interviews to support the selection of final candidates.

Two qualifications are sought in ambassadors: (1) they must be currently enrolled as a student at a higher education institution, and (2) they must have a passion for sustainability, climate change, and climate action. Ideally, ambassadors will, but are not required to, pursue a degree in engineering. Students will be accepted into the program based on their demonstrated passion for and/or experience with sustainability efforts and their enthusiasm for bettering engineering education on their campus. Ideally, the majority of ambassadors will be at a sophomore or junior standing in college to increase the likelihood they will remain involved in the program for multiple years, thus maximizing the likelihood of project completion.

The logic model (**Figure 2**) captures aspects of the program that were discussed previously, as well as anticipated outcomes for the EOP-SAP pilot cohort. In addition to the program features described above, as captured in the inputs column, the EOP Network Manager and EOP Network Engagement Coordinator will onboard and facilitate the engagement of ambassadors. The advisory group will also be involved, supporting the facilitators, and once data is available, engage in sensemaking to understand what worked well and provide suggested modifications to the program structure. Also, financial support from the Lemelson Foundation permitted travel to ESWCon25 for ambassador recruitment and ongoing program management.

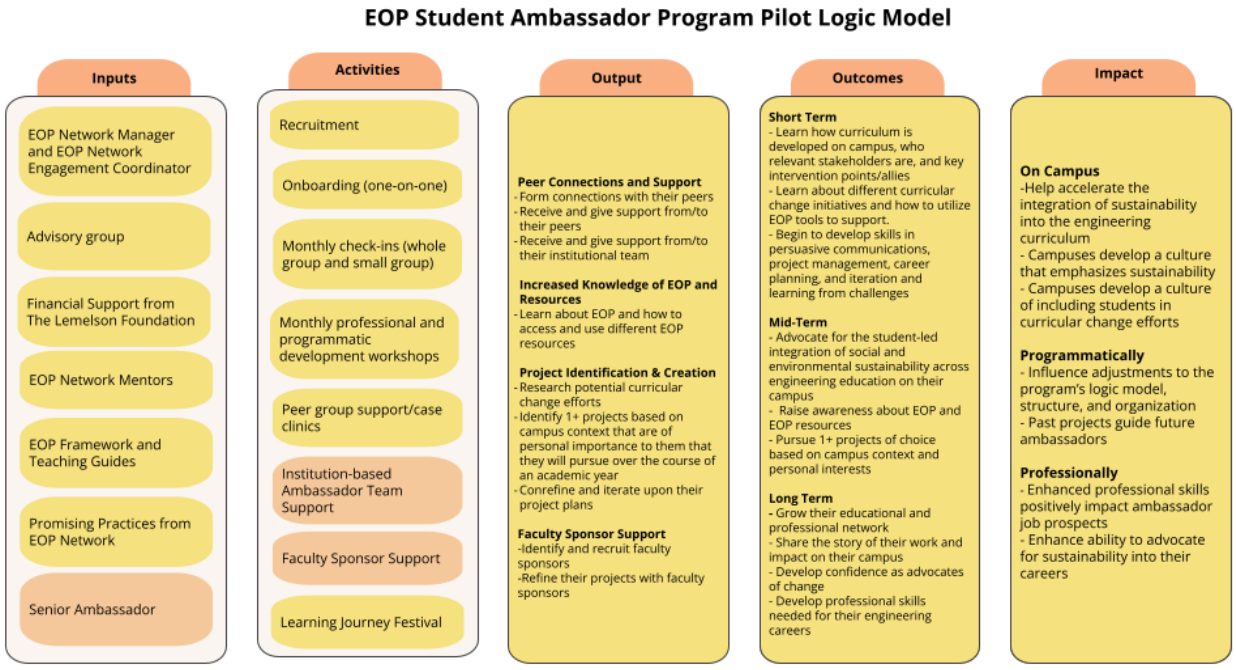

Figure 2. Logic model for the EOP-SAP evaluation.

Evaluation metrics for this ten-month pilot are captured in the logic model's output, outcomes, and impacts columns. The program aims to capture which of these outputs and outcomes ambassadors were able to achieve during that ten-month period and early stage indicators that ambassadors are moving towards the longer term impacts. Modeled after the evaluative process outlined by Matthew et al (2022) [19], a participatory evaluation approach [20] will be adopted to engage stakeholders in the evaluation process. This will help ensure the findings result in a deeper understanding of the program and more actionable findings. The participatory approach will combine Emergent Learning [21] with Wenger-Trayner's Cycles of Value framework [22].

Emergent Learning is, "...a set of principles and practices that help people across a system think, learn and adapt together in order to overcome complex challenges and achieve important social change goals." This approach is thus well suited to the kind of complex change we are trying to effect in a new way by working with students. Wenger-Trayner's Cycles of Value, as seen below, categorizes the different types of value that participants might derive from participating in the program over time, including: immediate value, which is the sense of validation and support experienced by meeting with peers; applied value, where ambassadors take learnings from their peers and the program and apply them to their own campus context; and realized value, where the outcomes of ambassadors' chosen projects are realized (see **Figure 3** below).

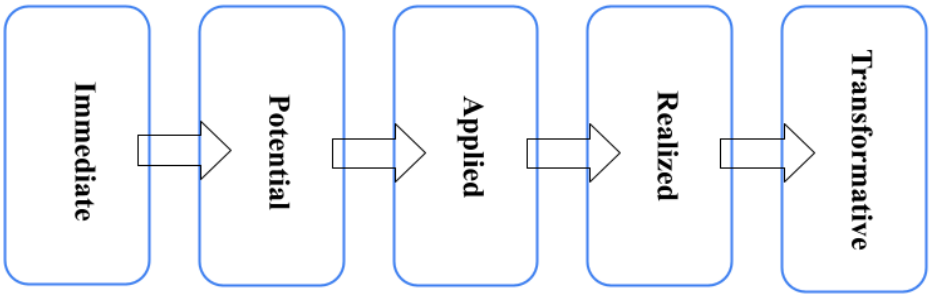

Figure 3. Cycles of Value, adapted from Wenger-Trayner [22].

Beginning with the primary learning question we are seeking to answer, "What will it take for student ambassadors to benefit from their engagement with the program and affect change on their campuses?", the facilitators will identify action hypotheses related to the learning question. For example, "If ambassadors identify projects that are of personal importance to them, they are more likely to follow through on and complete their projects." Facilitators will then use learning logs to capture data to prove or disprove said hypotheses. Additionally, students will evaluate their own journey through the program and the program by completing pre-, mid-, and post-program surveys. At the end of each semester, the advisory group will convene for a learning meeting where the learnings are discussed, further interpreted, and captured as notes in an Emergent Learning Table, a four-quadrant table with the categories: (1) Stories and Data, (2) Insights and Patterns, (3) Hypotheses, and (4) Opportunities/Commitments to Action. Through this sensemaking, the advisory committee will identify (1) program refinements, and (2) revisions to action hypotheses and the logic model. Thus, as captured in **Figure 4** below, this cyclic approach will continually improve our understanding and support of the EOP Student Ambassador Program.

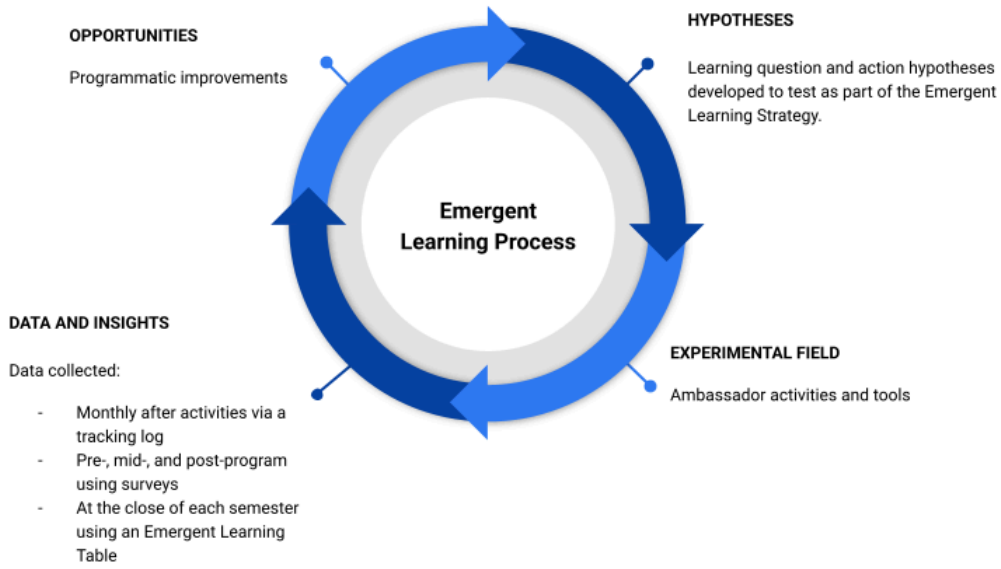

Figure 4. The Emergent Learning Process, adapted from Matthew et al [19].

Conclusion

In this paper, we explored the green skills gap and the lack of student representation in the development of sustainability-focused curriculum for engineering education. Analysis of these two issues led to the call for the EOP Student Ambassador Program, the design of which has been guided by research on CoP literature, Emergent Learning practices, and other sustainability volunteer programs for students. Through this ambassador program, we aim to train students to advocate for sustainability-focused curricular change that will positively impact thousands of students and prioritize the teaching of fundamental green skills. We hope that by providing the foundational framework to create, evaluate, and grow a student ambassador program, faculty, staff, and administrators will be encouraged to support and engage student changemakers and students will be emboldened to bring their lived experiences and passions to this important changemaking process.

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Appendix

Appendix A

Changemaker Programs Benchmarked by the EOP-SAP Advisory Group

Organization	Program	Program Website
Clinton Foundation	Clinton Global Initiative University (CGI U) Commitment-Makers	https://www.clintonfoundation.org/programs/leadership-public-service/clinton-global-initiative-university/
EarthEcho International	Ocean Protection Ambassadors	https://www.earthecho.org/ocean-protection-ambassadors
EarthEcho International	Water Challenge Ambassadors	https://www.monitorwater.org/ambassadors
EarthEcho International	Youth Leadership Council	https://www.earthecho.org/youth-leadership-council
Engineers for a Sustainable World (ESW)	Student Chapter Program	https://www.eswglobal.org/
Engineers Without Borders (EWB)	Student Chapter Program	https://www.ewb-usa.org
Global Climate Pledge	University Climate Ambassadors	https://www.globalclimatepledge.com/university-climate-ambassadors/
Green Schools Alliance	Student Ambassadors Program	https://www.greenschoolsalliance.org
Microsoft	Microsoft Learn Student Ambassadors	https://studentambassadors.microsoft.com
Net Impact	Campus Ambassadors Program	https://www.netimpact.org
Stanford University's Hasso Plattner Institute of Design	University Innovation Fellows Program	https://universityinnovationfellows.org/
Sunrise Movement	Sunrise Hubs Program	https://www.sunrisemovement.org/hubs/
Surfrider Foundation	Blue Water Task Force	https://www.surfrider.org/programs/blue-water-task-force

SustainUS	Agents of Change Program	https://www.sustainus.org
United Nations	Sustainable Development Solutions Network (SDSN) Youth	https://www.sdsnyouth.org/
UNICEF	Campus Initiative Ambassadors	https://www.unicefusa.org
World Economic Forum	Global Shapers Community	https://www.globalshapers.org

Appendix B

The EOP-SAP Mission and Vision

Mission: "The Engineering for One Planet (EOP) Student Ambassador Program enables undergraduate students to advocate for integrating social and environmental sustainability across engineering education. By equipping students with the knowledge and tools to engage faculty and campus leaders, the program aims to amplify their voices in curricular transformation efforts. Through meaningful dialogue and action, EOP Student Ambassadors will foster a culture of sustainability on campuses and accelerate curricular change, supporting future engineers to design and innovate with the planet and its people in mind."

Vision: "The Engineering for One Planet (EOP) Student Ambassador Program envisions a world in which every college graduate has gained sustainability literacy and green skills from their college experience in order to support a sustainable future."

Appendix C

Benefits Ambassadors Derive from EOP-SAP Program Features

EOP Student Ambassador Program Features	Benefits for EOP Student Ambassador Program Advocacy	Benefits for Professional Development
Peer support network	Learn from what other ambassadors are doing at other colleges, whether projects chosen are similar or dissimilar	Establish lasting connections with like-minded individuals that will support the development of a meaningful professional network

Support to develop an approach customized for a specific campus context and personal interests	Learn how to prioritize work that matches one's passions and skills	Understand how to apply learning from program to develop a project from start to finish in a professional setting Learn how to prioritize work that matches one's passions and skills
Training in persuasive communications	Learn how to effectively communicate the value of their curricular ventures, bring in supporters, and bridge the gap between interested and disinterested stakeholders	Ability to better communicate person-to-person and in presentations Learn about effective and proven communication strategies
Faculty sponsor recruitment	Receive regular support from someone with extensive experience developing curriculum at one or more universities	Ability to confidently find mentors in and outside of the workplace and pitch ideas effectively to more senior people
Promising curricular practices video library	Support ideation and implementation of curricular projects by learning about proven approaches for curricular change	
EOP Teaching Tools	Learn more about existing EOP resources in order to supplement ambassador projects and avoid reinventing the wheel	Understand how to find and the importance of finding similar resources for different ventures in the future
EOP Network membership	Join a dynamic network of passionate individuals from different industries and types of organizations Bring their student voice to an important, multidisciplinary, national cause	Learn about the importance of joining themed network-style groups and organizations to supplement (potentially) more focused career work, e.g. the value of joining a sustainability-themed network as a mechanical engineer
Learning Journey Festival	Connect with EOP Student Ambassadors and the EOP Network to recap a year of hard work, identify strategies for future ambassadors, and celebrate their	Understand the importance of effectively reporting on one's work, celebrating both successes and setbacks, sharing the impact of extensive work, and connecting with

	individual and group accomplishments	others
Project Management Workshop	Learn and begin to use approaches to increase the likelihood of project success, enhance team performance and communication, and effectively manage risk and project efficiency	Learn and begin to use approaches to increase the likelihood of project success, enhance team performance and communication, and effectively manage risk and project efficiency Benefit from increased job opportunities and higher earning potential
Strategic Doing Workshop	Learn how to use an agile, iterative approach to strategic planning. This enables the individual to address the complex, wicked challenges of today in both open networks and in situations where the individual does not have positional authority.	
Career Planning Workshop	Advocate for the integration of content in the curriculum that will help support a sustainability-centered career	Learn how to prepare for a sustainability-focused career while still in college