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Faculty Development to Facilitate Institutionalization of the Engineers for One Planet Framework

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Work In Progress: Faculty Development to Facilitate Institutionalization of the Engineers for One Planet Framework

Introduction

As we continue to train engineering students to become professional engineers, sustainability must be viewed as a foundational principle and priority in engineering education and design. The Lemelson Foundation (TLF) developed the Engineering for One Planet (EOP) Framework as a guide to integrate sustainability into engineering courses and curriculums. This work in progress describes an on-going study developing and delivering faculty development workshops to create advocates for the Engineering for One Planet (EOP) Framework within their institution.

Villanova University College of Engineering (CoE), in partnership with TLF, developed a project with two nesting goals to provide: 1) knowledge and facilitate development of learning tools for faculty in their individual classes, and 2) a framework for institutionalization of sustainability principles in engineering schools. While individual courses build students' sustainability knowledge and design application, fully adopting EOP in a curriculum will help students to approach engineering design with systems thinking. A key to widely bringing sustainability into a curriculum is for an institution's stakeholders to be comfortable in their competency of sustainability topics [1]. Explicit formation and training of educators and staff may instill comfort and confidence in integrating sustainability topics into curricula and in institutional shifts [2], [3], [4]. Sammalisto et al. (2015) illustrate that knowledge plays a foundational role in an educator's perception of sustainability as it relates to their work and life.

The faculty development workshop content was designed for faculty from various disciplines and focuses on building a faculty's confidence and competency in sustainable engineering concepts, and builds their peer network to learn from. This work-in-progress reviews the workshop content, faculty outcomes observations from two modalities (in-person, week-long and on-line synchronous, semester) on, and leads towards a larger institutionalization framework.

Project Approach

The EOP Framework is comprised of nine topics, and each topic has several learning outcomes. The EOP faculty development workshop materials were divided into modules that could be taken individually or together (Fig. 1). Throughout the workshop, critical thinking and communication and teamwork topics were integrated into the modules as these outcomes were best exampled versus discussed. In each module, examples of learning tools (e.g., assignments, activities) were highlighted to connect how a sustainability concept could be implemented in class.

The workshop order began with contextual information on the need for sustainability by introducing faculty to deeper knowledge on the climate crisis, defining planetary boundaries and the role of humans, and having faculty calculate their environmental footprints (Module 1 in Fig. 2). The EOP Framework was introduced, which deepened faculty understanding on learning outcomes for systems thinking, knowledge and understanding, and skills, experiences, and behaviors. Other aspects of the workshop development were:

- Ten integrated active learning examples of critical thinking exercises.
- Example learning tool modules from previous workshop faculty.

- A guided workbook to aid a faculty to evolve their course with included EOP learning outcomes, along with an updated syllabus and new learning tool.
- Built upon a tool developed by colleagues at Arizona State University [5] as a pre-workshop, end-of-workshop, and post-course implementation assessment tool to understand the extent that EOP learning outcomes are included in different courses.

Module 1	Module 2	Module 3	Module 4	Module 5
• Welcome to the Anthropocene • Introduction to EOP Framework: Knowledge and Understanding	• EOP Framework: Technical & Leadership Skills • Workbook: Initial Selections	• Systems Thinking Mindset • Individual Systems Tools	• Workbook: Systems Thinking • Environmental Literacy	• Responsible Business & Economy • Social Responsibility
Module 6	**Module 7**	**Module 8**	**Module 9**	**Module 10**
• Workbook: Knowledge & Understanding • Materials Selection	• Environmental Impact Assessment • Materials Design	• Workbook: Technical & Leadership Skills • Learning Tool Examples & Development	• Individual Learning Tool Presentations & Feedback	• Finalize Your Learning Tool & Individual Syllabus Development

Fig. 1. Workshop Module Content.

There were 10 participants in the one week-long in-person workshop and 9 participants in the one semester-long synchronous on-line workshop, with 5 very active on-line participants. Participants were recruited with assistance from TLF as they had self-identified to TLF interest in learning more about EOP. Workshop feedback was gathered via written surveys and guided dialogue throughout the sessions to understand the most effective content topics and learning elements that contributed to building faculty's competency and confidence. Quantitative survey data on knowledge and confidence was gathered using a digital survey tool and a 7-point Likert scale was used. Some qualitative data, such as key takeaways and top-rated learning elements, we gathered via paper surveys for the in-person cohort and on-line forms for the on-line cohort as well as during guided dialgoue for both cohorts. Analysis of sentiments expressed in surveys as reviewed by the authors and guided dialogue are presented in the results.

Results and Discussion

Preliminary results indicate that the systems thinking content as well as environmental impacts and social responsibility content resonated with 100% of engineering faculty participants from all disciplines (Fig. 2). Based on frequency in survey data and in dialogue, the systems thinking principles that most resonated were: 1) the understanding of interconnections and interdependence of sustainability challenges and unintended consequences of proposed solutions, 2) the Stockholm Resilience Centre's Planetary Boundaries concept, 3) the application of STEEP (i.e., Social, Technological, Environmental, Economic and Political) framing to their course teachings and assignments, and 4) systems thinking mapping tools (e.g., Iceberg Model). 80% of faculty planned to add these concepts and exercises into their courses. Key concepts on environmental literacy and impacts as well as social responsibility were also among the list of major takeaways. Topics like life-cycle assessment and selection of materials with a cradle-to-cradle mindset also resonated with faculty, especially regarding these topics' importance and impact in creating a circular economy. Lastly, the social responsibility content related to stakeholder engagement and environmental justice were topics that some faculty found

challenging to confidently incorporate in their coursework, but all faculty found it important to include in upcoming semesters. Overall, faculty participants' sustainability knowledge and understanding of the EOP framework increased. Based on post-workshop survey responses, sustainability knowledge increased from an average 5.2/7 prior to workshop to an average 5.8/7 after the workshop and EOP framework knowledge increased from an average 4.4/7 prior to workshop to an average 6/7 after the workshop.

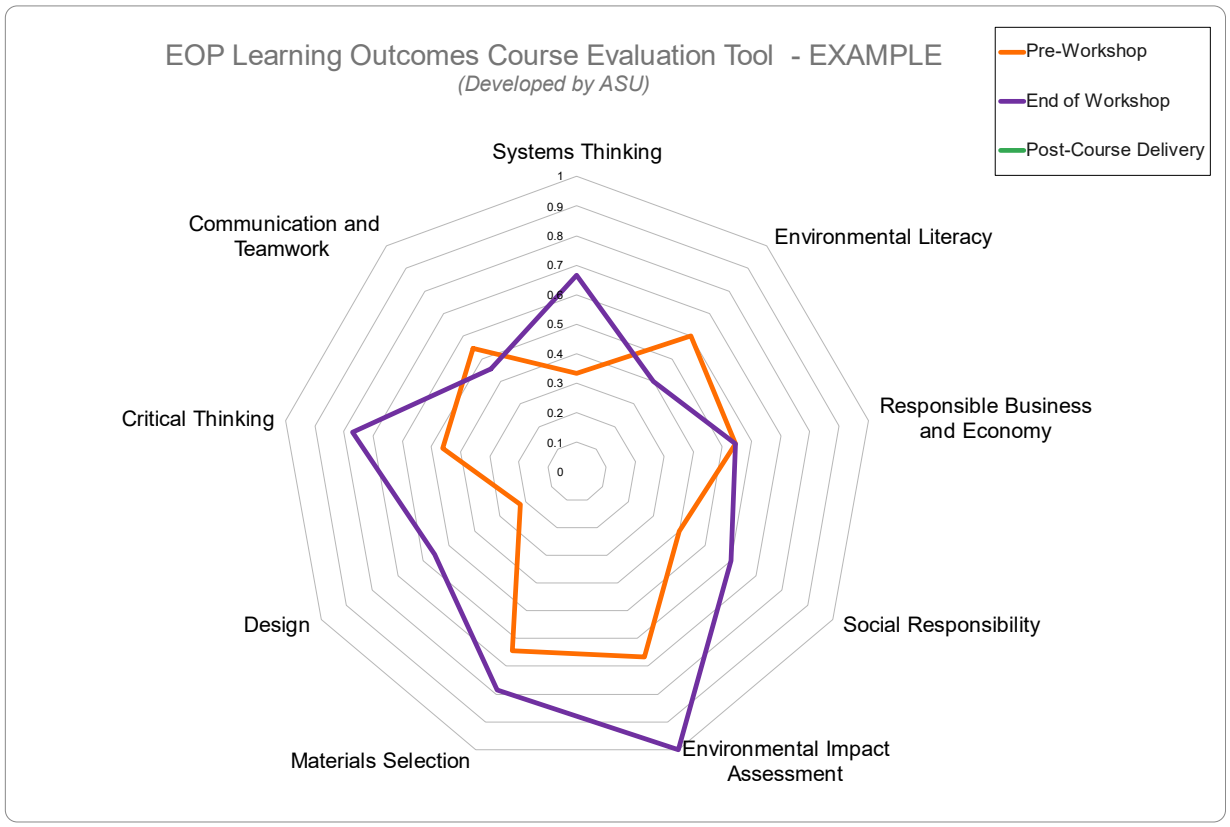

Fig. 2. Example of EOP Learning Outcomes Course Evaluation

Regarding workshop format and delivery, using different types of exercises and engagement techniques maintained participation and contributed to learning. Workshop participants shared that they benefitted from additional resources and real-world examples as this reinforced pathways for workshop content implementation and desired impacts. The in-person cohort expressed that the immersive, residency workshop experience allows participants to focus on their development and disconnect from their regular responsibilities more easily. On-line participants found it challenging to balance work responsibilities with workshop program expectations during the semester. Subsequently, these faculty required more frequent reminders on timed program content and tasking submissions, e.g., for every one reminder to in-person participants, there were three to four reminders for on-line participants. Interpersonal connections and spontaneous interactions were more limited with the on-line cohort than the in-person cohort. On-line participants benefitted from working through exercises and applying learning tools and activities in an online environment.

To evaluate institutionalization of the EOP Framework into coursework and core learning outcomes, faculty completed an assessment of the EOP learning outcomes being implemented in

an upcoming course. The example above in Fig. 2 shows the results of the assessment which was given to all faculty prior to the workshop beginning and at the end of the workshop. A rating of 1.0 represents more alignment of learning outcomes for that topic area in their course.

Throughout the faculty workshops, there was discussion around opportunities and constraints faculty experienced trying to implement the EOP Framework in their courses and beyond. Common opportunities were institutions that had full administrative support and educational initiative support were able to redesign courses and restructure the curriculum. Frequently, restructuring focused on the first-year. A potential drawback to this is if the EOP Framework was not referenced in subsequent years. There was consensus that the ideal would be vertical and horizontal integration of EOP topics included in a few courses in each academic year.

Other common challenges were faculty who co-taught that were not EOP trained or with institutions that require higher-level approval for curricular change. It was identified that demonstrating how integrating EOP topics could be another method to meet ABET requirements could ease EOP adoption and institutionalization. Moving forward, there is a plan to collate and make available learning tools, such as assignments and exam questions, that faculty can use to demonstrate and assess sustainable engineering elements. Another challenge was the lack of resources, which could be mitigated by leveraging industry partners to provide stated need, and potentially collaborate on in-class projects/capstone projects.

Overall, there is an appetite for institutionalization of sustainability into engineering curriculums. A foundational element of institutionalization is faculty understanding and confidence in 1) teaching the material, and 2) becoming a change leader within an institution. It was recognized that having a community of practice could help to continue to evolve courses and also to provide insights and ideas for ways to advocate for increased curriculum integration.

Acknowledgment

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