Designing a Sustainability Engineering Program at the University of Puerto Rico, Mayagüez

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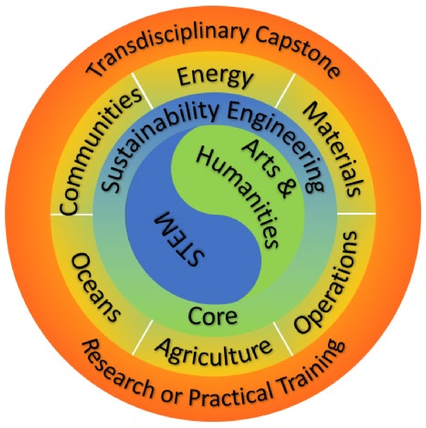
Introduction. In the United States, undergraduate bachelor's degree programs in "Sustainability" appear to be of two types [1]:

- Environmental Engineering, usually affiliated with Civil and Environmental Engineering Departments
- Interdisciplinary Sustainability Studies programs that are not engineering degree granting

In Engineering, there are several examples of minor programs and master' programs as well. **Nevertheless, there appear to be no engineering degree programs that comprehensively address the three pillars of sustainability**, variously articulated as the 3P's (People, Planet, and Prosperity) or the 3E's (Equity, Environment, and Economics). This initiative seeks to develop a new bachelor's program called Sustainability Engineering at the University of Puerto Rico, Mayagüez Campus, to open as soon as August 2025, with a plan to first develop a Minor as a formative precursor, to begin in August 2023. The curricular philosophy is to blend STEM with the Arts & Humanities, followed by a Sustainability Engineering Core, thematic specialization, opportunities for research or practical training, and a transdisciplinary Capstone. The strategy will include developing Sustainability Mindset in a social-technical sense, establishing a Community of Practice, increasing participation of women, providing opportunities for career planning and workforce development, and working with stakeholders across many sectors. Backward design is used to map program outcomes to student centered learning activities [2].

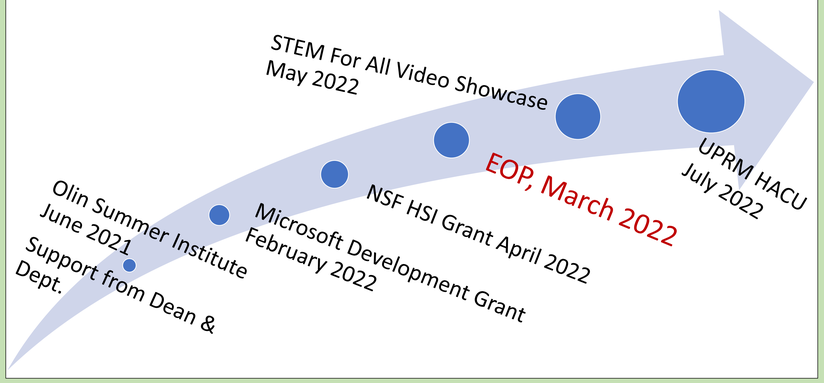
The Minor is designed to attract freshmen (while allowing later entry as well), starting with a summer camp immediately prior to the first semester, and including a foundational pair of courses in the first year, *Creating a Sustainable World* and *This is Engineering*. The fundamental reason for this is to orient students with key frameworks, mindsets, and a supportive community of practice that will guide their entire curricular trajectory.



Sustainability Mindset
Community of Practice
Workforce Development
JEDI Participation of Women
Stakeholder Engagement

The Modular approach is key not only for the development of the new Bachelor's program, but also for the enhancement of the existing majors. Each area of specialty represents a collaboration with disciplinary departments to create more minor sequences that will be open to all engineering students.

Procedures/Methods. As the initiative is young (2 years), the main developmental approach has been to seek grants and establish alliances with stakeholders:



Progress. The key progress to date are the development and delivery of three new courses:

- **Energy and Sustainability (Summer 2022, I. Baigés).** Introduction to the Anthropocene and a historical overview of human uses of energy; understanding energy at human, animal, and machine scale; Work, Energy, and Power; the First and Second Laws of Thermodynamics; overview of industrial and commercial energy production; decision making factors. Indirect alignment with the EOP framework given that its emphasis is on basics of energy and the energy required for materials and products.

- **Creating a Sustainable World (Fall 2022, Spring 2023, C. Papadopoulos).** A general education level course to (1) engage students with other disciplines as they relate to sustainability, (2) foster interdisciplinary teams, and (3) anticipate other sustainability initiatives in other Colleges. Introduces sustainability frameworks; earth systems science; planetary boundaries; a survey of energy, water, materials, agriculture, and other sectors, as they relate to sustainability; economic and political issues; arts and literature; career planning. Essential part of the EOP framework that applies is Systems Thinking and is introduced via Earth Systems Science.

- **Products, Services, and Sustainability (Spring 2023, I. Baigés).** Designed to connect products and services to sustainability, both in terms of existing impacts and possible measures to redesign products and services to better align with principles of sustainability. Basic notions of life cycle analysis and circular economy are presented. The EOP elements of materials and design most apply to this course.

- **Program Creation and Approval.** Draft proposals for the Minor and Bachelor's program are well underway and are being reviewed by internal and external stakeholders. Both of these proposals are expected to be submitted to the requisite faculty committee during the Spring 2023 semester.

Scaling Up. With this base of progress, the following further steps are planned:

- **New Courses.** The initiative is currently undertaking the development of several new courses, including This is Engineering (I. Baigés and C. Papadopoulos), Smart Cities (N. Santiago Santiago), Natural Capitalism (I. Díaz Rodríguez Rodríguez), a seminar on JEDI (N. Santiago Santiago), and Design Anthropology (R. Boglio). The team is also exploring collaborations with Olin College, Cornell University, and Oregon State University to exchange courses. Finally, in collaboration with some partners, short courses are being conceived that will serve to help industry establish and meet sustainability metrics.

- **Recruitment and Outreach.** The NSF HSI grant will support three cohorts of 10 students to progress through the Minor, with the first cohort beginning in Fall 2023. A series of outreach activities, website development, and other distribution of information are underway as of January 2023.

- **Development.** We seek to develop a comprehensive strategy for resource development through grants and philanthropic giving.

- **Stakeholder Engagement.** Key internal stakeholders include students, faculty, and administration, while external stakeholders include industry, government, and community organization/NGOs. Upcoming strategies include:

  - Presentations to engineering departments and Industrial Advisory Board
  - Development of an allied student association
  - Affiliation with American Association for Sustainability in Higher Education (AASHE)
  - Continued conversations with external partners to better understand needs.

Evaluation and Impact. There are several means of evaluation, ranging from basic program vitality to educational research.

- **Enrollment and Applications.** The basic metrics for program vitality are applications, enrollment, and retention. The first applications will be solicited in March 2023, but some enrollment data are available:

Energy & Sustainability Summer 2022	Creating a Sustainable World Fall 2022 + Spring 2023	Products, Services & Sustain. Spring 2023
22M/12F (35% F)	8M/8F (50% F) 8M/7F (47% F)	23M/7F (23% F)

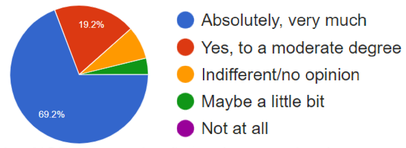
To develop professionals to work under the People, Prosperity, Planet paradigm that strives to foster human well-being in balance with the biosphere.

- **Program Development Research**. Based on conversations with colleagues, the following key questions need to be addressed through well designed survey instruments. Initial results based on 26 respondents from *Creating a Sustainable World* (Fall 2022 and Spring 2023).

  - What defines a Sustainability Engineer? How is such an engineer different from a traditional disciplinary engineer? What is the demand for "sustainability engineers" and who will hire them? While this line of inquiry is in progress, the potential is great to identify the need for professionals with cross-cutting engineering skills.

  - Is a greater emphasis on sustainability needed in the engineering curricula?

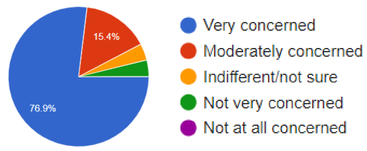
Curriculum needs to be updated to better address sustainability?



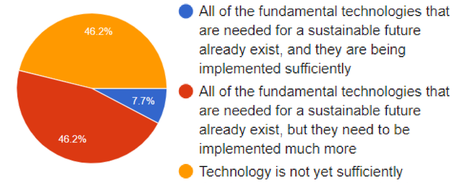
- **Educational Research.** As part of the NSF grant, the following two basic research questions will be investigated:

  - RQ 1. What are emerging competencies and mindsets established by other stakeholders?
  - RQ2. How do (pre)conceptions and mindsets for Sustainable Engineering evolve?

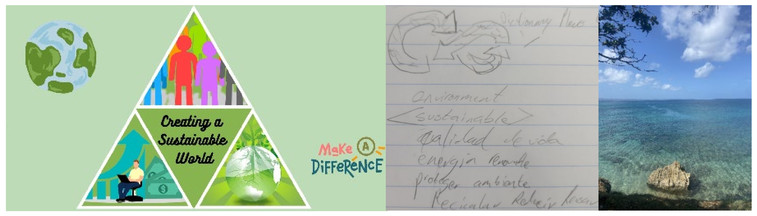
Concerned that future employer is not committed to sustainability?



Is technology sufficiently developed to address sustainability?



- Artistic and verbal expressions



References. [1] National Academies (2020), [2] Wiggins & McTighe (1998)

Acknowledgements. Special thanks to Andrea Welker and Abebayo Ogundipe, EOP mentors for valuable guidance. Also, this material is based upon work supported by the National Science Foundation under Grant No. 2150461. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. The team is grateful for this support as well as support from the Microsoft Corporation. The team also thanks the Stakeholder Advisory Board: Sandra Dika, University of North Carolina, Charlotte; Alejandra Castrodad Rodríguez and José Rabell, Resilient Power Puerto Rico; Owen Ingley, Plenitud Iniciativas; Matthew Fiedler and Samantha Snabes, re:3D, Inc.; Alba Colon, Hendrick Motorsports; Jaime Torres, AMGEN; Magaly Feliciano Lozada, Bacardi; Ingrid Vila, Cambio PR; Elaine Rivera, HP Inkjet Business; Brissa Quiroz, Microsoft; Nathaniel Buescher and Roy Torbert, Rocky Mountain Institute; Carl Soderberg, Former Director, EPA Puerto Rico; Praful Madhani, Texas Instruments.