Board #445: Work in Progress: Structuring Engineering Internships to Support Community Benefits Plans

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Introduction

In 2022, the Infrastructure Investment & Jobs Act (IIJA) and the Inflation Reduction Act (IRA) were signed into law. These Acts are intended to promote investments in domestic energy industries. The US Executive branch established multiple grant funding mechanisms to distribute investments. Recognizing that IIJA and IRA investments will require significant workforce development and that investments must benefit disadvantaged communities, the funding opportunity announcements for these grants include requirements to achieve these ends.

U.S. Department of Energy (DoE) specifies that applicants must include Community Benefits Plans (CBPs) within their proposals. CBPs require applicants to invest in domestic workforce development, advance diversity, equity, inclusion, and accessibility in the nation's workforce, and meet the objectives of the Justice40 Initiative. Justice40 mandates that at least 40% of the benefits of certain federal investments must flow to disadvantaged communities, which DoE defines as "*being marginalized, underserved, [or] overburdened by pollution*" [1].

These requirements present opportunities for universities to provide undergraduate engineering students with career development pathways within the industries targeted by the IIJA and IRA. The opportunities are particularly well-suited for Minority Serving Institutions (MSIs), such as Asian American, Native American, Pacific Islander Serving Institutions (AANAPISIs) and Hispanic Serving Institution (HSIs). Our university, Portland State University (PSU), is an eligible AANAPISI and an emerging HSI [2].

Students face myriad challenges on their academic pathway, with increased barriers to retention and success for those from historically excluded and first-generation backgrounds [3, 4]. Past research considering the experiences of these students has identified several critical barriers that may impact students' ability to persist to degree completion including financial challenges, struggles with mental health and well-being, and feeling a sense of isolation. Importantly, students from minority backgrounds often struggle to remain in school and meet their basic needs due to financial challenges [5]. Internship opportunities can provide financial and social support, and bolster students on their pathway to degree completion. Additionally, co-curricular learning opportunities are particularly important for students from underrepresented groups as they provide opportunities for students to build their sense of scientific identity and grow their network [6].

PSU is partnering with Portland General Electric (PGE), the Bonneville Power Administration, several electrical equipment manufacturers, and the Confederated Tribes of the Warm Springs (CTWS) on two IRA-funded DoE projects to create our Power Engineering Internship (PEI) program. The PEI will provide engineering career development pathways within the regional electric utility industry and help ensure that federal investments in the electric utility industry advance the priorities of supporting quality jobs and ensuring that the future workforce represents our diverse regional population from diverse backgrounds.

The PEI contributes to the CBPs of these two DoE projects through multiple actions: by increasing the representation of MSIs as project partners, collaborating with faculty in an MSI, and identifying workforce training partners to foster improved access to careers for members of the community, including underrepresented individuals. The intern program also supports the goals of the Justice40 Initiative, specifically by increasing job creation, addressing the clean energy job pipeline, and providing job training for individuals.

Within this Work-In-Progress manuscript, we describe the internship structure and responsibilities, present our assessment methods, relate survey questions to federal workforce development goals, and map survey questions to ABET Criteria 3 Student Objectives. Relevant academic literature is reviewed within the various sections of the paper. The survey questions are included in the Appendices.

PEI Program Description

The PEI will provide engineering students with internships, covering the full academic year as well as the summer. Several of the project partners are located in the Portland metropolitan area, so interns will be able to participate in internships throughout the academic year. Interns will work full-time during summers, 40 hours per week, and part-time during the academic year, averaging 15 hours per week. Each intern will earn approximately $20k per year, which will provide significant financial support during their engineering schooling. Such funding is particularly important to disadvantaged students who typically attend MSIs [5,7].

The interns will join a team that is either demonstrating the feasibility of grid-forming inverters at PGE's Wheatridge Wind Farm or that is building transmission capacity across the Cascade Range in collaboration with the CTWS. Wheatridge is North America's first energy center in the United States to combine wind, solar, and energy storage systems into a grid-forming hybrid power plant. The transmission corridor will create opportunities for the CTWS to develop clean energy resources that will provide sustained, long-term revenues. The interns will learn about the design, planning, and operation of these facilities and contribute to industry-leading projects aimed at enhancing grid reliability, renewable energy integration, and energy efficiency.

As is often the case with many MSIs, PSU hosts multiple programs that serve historically excluded students, including career services, mentoring, and internship preparation. The PEI program will leverage the offerings provided by two such programs, the Center for Internship, Mentoring and Research (CIMR) and the Engineering Work Experience (EWX). CIMR[1] provides multiple career-related resources to students, including mentoring, advising, and career development. CIMR programs support diversification of the regional workforce. EWX[2] provides a structured process for placing students within engineering internships. The PEI has adopted the EWX processes for placing interns with regional companies.

[1] PSU Center for Internship, Mentoring, and Research (CIMR)
[2] PSU Engineering Work Experience (EWX) Internship

Assessment Methods

The two DoE programs will support these internships for multiple years, three years for the Wheatridge wind project and seven for the CTWS transmission corridor project. As such, our team has developed assessment tools that will allow us to measure the PEI program over several iterations using a consistent set of tools. These assessment tools will inform project operation, provide our project partners with metrics pertaining to their CBPs and Justice40 objectives, and also serve as an indirect ABET assessment tool for engineering departments at PSU.

Assessments provide means for evaluating progress towards achieving program goals, which for our DoE-funded projects are to:

> *Build an equitable and inclusive clean energy workforce pipeline.*
> *Invest in a diverse and talented workforce.*

Further, the program also addresses an aspect of the Justice40 Initiative, specifically item 2.a.(4):

> *Increase in job creation, the clean energy job pipeline, and job training for individuals.*

Although achievement of these goals is difficult to measure directly, we can infer progress towards the goals using assessment tools that measure students' *sense of belonging* within the engineering profession and their perception of their *career preparation*. Sense of belonging and career preparation are indicators of the likelihood that students will complete their engineering education (program retention) and stay in the profession over the long run (career persistence). By focusing on a sense of belonging and career preparation, we can infer whether the intern program is contributing toward the building of an equitable and inclusive clean energy workforce pipeline, and if the intern program is a successful job-creating investment in a diverse and talented workforce.

Academic literature supports the relationships between sense of belonging and career preparation with program retention and career persistence. The literature also suggests that students who engage in internships and have supportive mentors report higher levels of belongingness and feel more prepared to enter the workforce. Additionally, Patrick *et al.* report that identity may be an underlying explanation for persistence in engineering, which may partially explain why underrepresented individuals leave engineering fields at greater numbers than their peers [8]. The authors categorize identity as personal identity: characteristics of the individual; social identity: characteristics as a member of a group; and engineering identity: characteristics as an engineering student.

Factors contributing to the underrepresentation of minoritized groups in engineering include students' experiences with discrimination, hostility in the classroom and in their disciplines, and lack of support from faculty and peers. Schauer et al. suggest methods for retaining these students, including promotion of internships, and that mentoring has multiple positive impacts on students' professional development [9]. Yang *et al.* report that internships contribute to the professional identity of engineering students, particularly for first-generation and low-income engineering students [10]. Internship participants reported feeling professionally recognized by colleagues and managers if they engaged in technical work and were provided support for that technical work. Likewise, Meador reported that internships are a positive contributing factor to

increased retention among underrepresented engineering students [11]. Strayhorn et al. provide evidence that underrepresented student engagement in engineering internships improved their communication and problem-solving skills; both of which are aspects of career preparation [12]. The authors also attempted to investigate the impact that internships have on the development of underrepresented students' professional identity. One-on-one interviews with participants showed that they gained valuable knowledge about the professional environment, which reflects on their career preparation, though few of the students could provide clear examples of how internships impacted their professional identity. However, Ozis *et al.* found a significant positive correlation between the number of professional experiences a student has and the student's professional identity [13]. The authors found that students with any professional experience, which they define broadly beyond just internships, report significantly higher professional identity than students who did not engage in professional experiences. And, they found that having more than one experience further improved professional identity. Underrepresented students reported very similar career readiness to non-underrepresented students, which the authors attribute to effective outreach programs at their university.

To this end, our assessment tools focus on better understanding students' sense of belonging and their career preparation. Considering that these DOE grants span multiple years, our team has developed assessment tools that will allow us to measure the program over several iterations of internships using a consistent set of tools.

Administration of Surveys

We will administer student surveys three times during the internship periods: at the beginning, midway through, and after completion. The multi-point approach allows us to observe how students' perceptions evolve during the course of the internships [14]. Mentors will be surveyed twice during the internship period: midway through and after completion.

Student survey questions are grouped into four categories. The first two pertain directly to *sense of belonging* and *career preparation*, Tables A1 and A2. The third, *professional confidence*, informs both sense of belonging and career preparation, Table A3. The fourth category of questions helps gauge program administration, Table A4. Answers to survey questions are either qualitative open-ended or ranked on the five-point Likert scale (strongly agree, agree somewhat, neutral, disagree somewhat, or strongly disagree).

Most of the *sense of belonging*, *career preparation* and *professional confidence* questions are posed at the beginning and end of the internship period, though some *career preparation* questions are posed only at the end. Programmatic survey questions are posed at the midpoint and end of the internship period.

Mentor survey questions are grouped into three categories. The first category pertains to *career preparation*, Table B1. These questions are answered using the Likert scale, and are posed only at the end of the internship period. The second and third sets of questions help assess program administration, Tables B2 and B3. These questions are posed at the midpoint and end of the internship period. Answers to these questions are qualitative open-ended.

Students participating in the PEI program will have both a faculty mentor and an industry mentor, a model shown to be effective by Dallas *et al.* in their industry internship program [15]. The authors report that both students and mentors find this dual-mentorship approach to be very beneficial. These benefits include improved expectations for working in engineering, improved feelings of belonging within an engineering community, and access to support pathways into knowledge and skills. Literature cited by Dallas *et al.* note students benefit through improved retention for women and minority students [16-18], and increases in mentees' sense of self-efficacy [19]. PEI mentors will provide guidance to interns during their internship periods, both professional and academic. Mentors will be involved from the beginning of the process, conducting interviews with internship candidates and making higher recommendations, and through to the end, concluding with the post-internship survey.

Assessment Alignment with DOE Goals, Community Benefits Plan and the Justice40 Objective

The student and mentor surveys will inform progress towards achieving the two DOE project goals, specifically by collecting data pertaining to *sense of belonging* and *career preparation*. The surveys will also inform project operation and provide our project partners with metrics pertaining to the Community Benefits Plan. The surveys provide means for measuring the four SMART (Specific, Measurable, Assignable, Realistic and Time-Related) milestones for the CBP.

CBP1 Identification of at least two qualified applicants each year of the project
CBP2 Recruitment of two mentors from project partner companies for each year of the project
CBP3 Hiring of two interns each year of the project
CBP4 Full-time hiring, post internship and graduation, of the interns

The CBP SMART milestones are straightforward to measure, as they are simply counts of applicants, placements, mentors and new hires, respectively, of which we will take note of during the interview processes and through participant response to the surveys. However, the Justice40 objective cannot be measured directly. As will be done for the DOE goals, we can infer progress by considering student and mentor survey questions that pertain to sense of belonging and career preparation, specifically the survey questions noted in Table 8.

Table 8. ***Mapping between the Justice40 objective and the internship survey questions.***

	Justice 40 Objective 2.a.(4)	**Survey Questions**
(1)	*Increase in job creation, the clean energy job pipeline, and job training for individuals*	SSP4, 5 SCP1-3, 5-9 MCP1, 2

Alignment of Assessments with ABET Student Outcomes

The engineering education literature contains multiple examples of engineering faculty using internship experiences as a means for assessing ABET Criteria 3 Student Outcomes (SOs), dating back several decades [20-22]. Biasca and Hill developed a method for assessing multiple SOs based on students' internship experiences, specifically using reflection papers and electronic portfolios [23]. Sirinterlikci also leveraged internship experiences to inform Criteria 3, which he

did by mapping student and employer survey data to SOs [24]. Laingen *et al.* describe the value of internship competency assessments as a means for achieving continuous student learning improvements, which were articulated through multi-year assessment of program SOs [25]. However, for all of the papers cited above, the assessment tools were developed for the now-outmoded ABET 2000 "a through k" SOs.

More recently, Ozis *et al.* developed SO assessment methods based on internship experiences that map to the modern "1-7" Criteria 3 SOs [13]. Moreover, the authors discuss the impacts that internships have on the perspectives and experiences of underrepresented engineering students. The authors identify mapping to six of the seven SOs. The Criteria 3 SOs are, in brief : (1) *problem solving*; (2) *engineering design*, (3) *effective communication*, (4) *ethical responsibilities*, (5) *teamwork*, (6) *experimentation, data interpretation and engineering judgment*, and (7) *the ability to acquire and apply new knowledge*. Oziz et al. map their assessments to all of the SOs except (6). We have mapped many of our survey questions to SOs as well, specifically (1), (3), (5), (6) and (7), as summarized in Table 9.

Table 9. ***Mapping between ABET SOs and the internship survey questions.***

	ABET SO	**Survey Questions**
(1)	*an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.*	SCP8 SPC1, 8, 9 MPC2 MCP3
(3)	*an ability to communicate effectively with a range of audiences.*	SCP4
(5)	*an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.*	SSP1, 2 SCP3
(6)	*an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.*	SPC2, 3
(7)	*an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.*	SPC4-7

Conclusion and Future Work

This Work-In-Progress reports on the development of both the Power Engineering Internship program and our assessment methods. The PEI program will provide engineering career development pathways within the regional electric utility industry, thereby addressing the goals of DoE-funded infrastructure investments in the electric utility industry to *build an equitable and inclusive clean energy workforce pipeline*, and to *invest in a diverse and talented workforce*. The program also supports the Justice40 Initiative by *increasing job creation, addressing the clean energy job pipeline, and providing job training for individuals*.

These goals cannot be measured directly. Using the surveys presented in this WIP, we will measure students' *sense of belonging* within the engineering profession and perception of their *career preparation*, which are both indicators of the likelihood that students will complete their engineering education and stay in the engineering profession over the long run. We can then infer whether the intern program is contributing toward the two DoE goals and the Justice40 objective. The survey results will also provide an indirect ABET assessment of our engineering programs.

Over the coming years, our team will establish a cadence of candidate recruitment, program operation, survey administration, and analysis of survey results. Survey results will be used to improve program operations, improve data collection, and inform our evaluation of the DoE and Justice40 goals. Our team will follow up on this WIP with subsequent ASEE publications that report on the assessment findings.

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Appendix A Student Survey Questions

Table A1. *Students, Sense of Belonging* survey questions. These questions are posed at the beginning and end of the internship.

	Questions	**Type**
To what extent are the following statements true of you?		
SSB1	I have a strong sense of belonging to a community of engineers.	Likert Scale
SSB2	I derive personal satisfaction from working on a team that is doing important engineering.	Likert Scale
SSB3	I think of myself as an engineer.	Likert Scale
SSB4	I feel like I belong in the field of engineering.	Likert Scale
SSB5	I have a strong sense of belonging to a community of engineers.	Likert Scale

Table A2. *Students, Career Preparation* survey questions for the interns. Most of these questions are posed at the beginning and end of the internship, except those marked with an (*), which are posed only at the end of the internship.

	Questions	**Type**
SCP1	I know what I am going to do after graduation.	Likert Scale
SCP2	I have chosen a career to pursue after graduation.	Likert Scale
SCP3	I can clearly define my career goals.	Likert Scale
SCP4	I know how to communicate my strengths and skills to a potential employee.	Likert Scale
SCP5	I feel prepared to enter the workforce.	Likert Scale
SCP6	I know and understand the types of jobs for which my skills and abilities are relevant.	Likert Scale
SCP7	My internship prepared me to enter the workforce. (*)	Likert Scale
SCP8	I gained valuable skills through my internship. (*)	Likert Scale
SCP9	What are your next steps in your career and education and how has this internship experience supported you on your pathway? (*)	Open-ended

Table A3. *Students, Professional Confidence* survey questions for the interns. These questions are posed at the beginning and end of the internship.

	Questions	**Type**
How confident are you that you can:		
SPC1	Generate a research question, define constraints, and identify engineering solutions	Likert Scale
SPC2	Determine how to collect, analyze, and interpret appropriate data	Likert Scale
SPC3	Use engineering judgment to draw conclusions	Likert Scale
SPC4	Use engineering literature to guide problem formulation	Likert Scale
SPC5	Integrate results from multiple studies	Likert Scale
SPC6	Ask relevant questions	Likert Scale
SPC7	Identify what is known and not known about an engineering problem	Likert Scale
SPC8	Understand scientific, mathematic, and engineering concepts	Likert Scale
SPC9	See connections between different areas of science, engineering and mathematics	Likert Scale

Table A4. *Students, Programmatic* survey questions for the interns. These questions are posed at the midpoint and end of the internship.

	Questions	**Type**
Placement Questions		
SP1	How would you rate the quality of your internship placement?	Likert Scale
SP2	What have you been working on in your placement?	Open-ended
Program Evaluation Questions		
SP3	What has been the most important part of the program?	Open-ended
SP4	What could be improved?	Open-ended
SP5	Please describe your overall impression of the internship program.	Open-ended
SP6	Do you have more to share about any of the specific program components you didn't mention above?	Open-ended

Appendix B Mentor Survey Questions

Table B1. *Mentors, Career Preparation* survey questions for the internship mentors. These questions are posed at the end of the internship.

	Questions	**Type**
	To what extent are the following statements true of you?	
MCP1	If I had the resources, I would offer a job to my intern after their graduation.	Likert Scale
MCP2	My intern is prepared to enter the workforce.	Likert Scale
MCP3	My intern demonstrated growth in essential career skills over the course of the year.	Likert Scale

Table B2. *Mentors, Placement Check-in* survey questions for the internship mentors. These questions are posed at the midpoint and the end of the internship.

	Questions	**Type**
MPC1	What has the intern been working on?	Open-ended
MPC2	What do you think the intern has gained and/or learned this term? (knowledge? skills? professional network?, etc.)	Open-ended
MPC3	How have the learning agreement and work plan been working for you and the intern?	Open-ended

Table B3. *Mentors, Program Evaluation* survey questions for the internship mentors. These questions are posed at the midpoint and the end of the internship.

	Questions	**Type**
MPE1	From your perspective, how is the internship going? What have been the successes and where have there been challenges?	Open-ended
MPE2	Is there any support from the internship team that would make the experience better for you or the intern?	Open-ended
MPE3	Do you have any ideas for topics you'd like to see addressed in supervisor training?	Open-ended