

BOARD #122: Using Internships as Means for Indirect Assessment of ABET Criteria 3 "1-7" Student Outcomes

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Work In Progress: Using Internships as Means for Indirect Assessment of ABET Criteria 3 “1-7” Student Outcomes

Motivation

The Electrical & Computer Engineering (ECE) Department at Portland State University (PSU) has developed a Power Engineering Internship (PEI) program that provides engineering career development pathways within the electric utility industry. The PEI is supported by several U.S. Department of Energy grants that aim to develop quality career opportunities and develop a future electric utility workforce that represents the nation’s diverse populations.

The PSU ECE Department intends to use surveys of internship participants as assessment tools for its ABET accreditation process, in particular, the ABET Criteria 3 Student Outcomes (SOs). SOs relate to the knowledge, skills, and behaviors that students acquire as they progress through an engineering program [1]. They describe what engineering students are expected to know and should be able to do by the time they graduate.

Engineering education literature presents multiple methods for using internships as means for assessing SOs. Methods include using self-assessments that derive from internship experiences as well as mapping survey responses from employers and interns to SOs. Such methods gain value as they are assessed over multiple years. However, the majority of this literature discusses assessment tools that were developed for the ABET 2000 Criteria 3 “a through k” SOs. One of our motivations is to provide assessment tools that can be used to assess modern Criteria 3 SOs based on students’ internship experiences.

PEI Program Description

PSU operates the Power Engineering Internship program with funding from two U.S. Department of Energy grants. The program is operated in partnership with the lead organizations of these grants, an investor-owned utility, Portland General Electric (PGE), and the Confederated Tribes of the Warm Springs (CTWS). One of the programmatic goals of the PEI is to create and sustain a clean energy engineering workforce pipeline on behalf of these lead organizations. Both grants support internships at PGE, which is also a partner on the CTWS grant.

The PEI provides engineering students with year-long internships, spanning both the academic year and the summer. The interns work at PGE facilities located throughout the Portland metropolitan area. Interns are employed full-time during summers and part-time during the academic year. Proximity of the worksites to the PSU campus enables the interns to participate in the program while attending school full-time. During the academic year, students average fifteen hours per week, adjusting their work schedule according to their academic workload. The interns are allocated 930 hours per year, 480 in the summer and 450 during the academic year, which they can plan as they see fit. The internships provide meaningful financial support for the students, who can earn up to \$21k if they use all of their allocated hours. Such funding is particularly important for the typical student who attends a minority serving institutions, such as PSU [2, 3].

The PEI is open to engineering students in their junior year or above and is unrestricted in terms of engineering major. Selected applicants have come from electrical engineering, computer engineering, and mechanical engineering. All but one of the interns (a computer engineering major) in the 2024-25 cohort had taken at least one power engineering course prior to their start date. The 2025-26 cohort includes mechanical and computer engineering majors who will not have taken a power course prior to the start of their internship. This may or may not be a challenge, and is something we are monitoring as the programs proceed.

Each intern is assigned to an engineering team and an engineering mentor from that team. The interns also have an academic mentor, a faculty member from PSU. To date, interns have been assigned to teams focused on battery energy storage systems, operations, transmission planning, asset management, and risk management groups. Each of the interns has been involved with multiple engineering projects, including distribution and transmission systems modeling, system planning impact studies, transient analysis, commissioning and testing, load hosting studies, and developing risk models for photovoltaic and wind power assets. The interns are also learning to use utility software packages and data management systems, including CYME, PowerWorld Simulator, and Pi System.

Assessment Methods

The former “a through k” SOs have been supplanted by new “1-7” SOs. Our team has developed an assessment method using these new SOs that enables measurement of the PEI program over several internship iterations using a consistent set of tools [4]. These tools inform program operation and provide metrics for tracking the progress of the program. We administer surveys to both the interns and their engineering mentors at multiple points during the internship period. This approach provides insights into how the perceptions of the interns and mentors evolve over the internship period [5].

Surveys are an indirect ABET assessment method. Indirect assessment methods use data that pertain to students' experiences to infer progress towards achieving SOs. These data may be gathered from student self-assessments, graduation rate statistics, or employer feedback, among others. In contrast, direct assessment involves evaluation of students' performances that relate to specific SOs. Evaluations of exams, laboratory reports, or project deliverables that are designed to address specific SOs link directly to numerical evaluation of those SOs.

Indirect assessments provide insights into perceptions of learning and program effectiveness, which may be particularly valuable if gathered from third parties, such as internship mentors. However, the sources of indirect assessments are not usually designed for SO assessment. For these resources to be effective assessment tools, their composition must be evaluated and, where possible, their content must be mapped to specific SOs. Using both direct and indirect assessments as part of an ABET evaluation process improves program assessment by diversifying the sources of metrics. This diversity includes tools that are specifically designed to assess SO achievement and others that infer SO achievement.

Engineering education literature contains many examples of using internship experiences as an indirect means for assessing SOs. However, nearly all of these assessment tools were developed for the ABET 2000 “a through k” SOs, which have since been replaced by the new “1-7” SOs. Examples include linking products from students’ internship experiences (reflection papers and portfolios) to SOs [6], mapping student and employer survey data to SOs [7-9], and evaluating internship competency assessments to infer achievement of continuous student [10].

Student and Mentor Surveys

The student and mentor surveys provide metrics that would indicate if the PEI is a successful job-creating investment, which is a programmatic goal for creating a clean energy engineering workforce pipeline. Given that it is not possible to assess whether or not a program has successfully created persistent careers for students prior to those students graduating from university, the surveys focus on measuring students’ *sense of belonging* within the engineering profession as well as their perception of their own *career preparation*. These are linked to program retention and career persistence, respectively, which in turn relate to the likelihood of degree completion and professional career longevity [11-13]. So, by measuring *sense of belonging* and *career preparation*, we can infer whether the PEI program is helping to create a clean energy engineering workforce pipeline. However, while assessing *sense of belonging* and *career preparation* are the principal purposes of the surveys, the surveys provide additional value in that they can be used as an indirect method for ABET Criteria 3 assessment. This latter value is the focus of this paper.

The internship surveys are administered to both the interns and their mentors, and they are organized into categories of questions. The categories include *Sense of Belonging* (-SB) and *Career Preparation* (-CP), which directly address the measurement points discussed above; *Professional Confidence* (-PC), which further informs sense of belonging and career preparation; and *Program Evaluation* (-PE), which informs program administration. The student survey (S-) consists of four categories of questions, detailed in Appendix A: SSB, SCP, SPC and SPE. The mentor survey (M-) consists of three categories, Appendix B: MCP, MPC and MPE.

Responses to questions use either a numerical five-point Likert scale or are open-ended response-based. The intern surveys are administered at the beginning, midpoint, and end of the internship period. Mentor surveys are administered at the midpoint and end. Midpoint surveys have fewer questions, and mainly serve as a check-in point. The majority of the *SB*, *CP* and *PC* questions are posed at the beginning and end points of the internship period. Some *CP* questions are posed only at the end point. PE questions are posed at the midpoint and end point. By administering a frequent cadence of surveys, we are developing a long-term, multi-point set of measurements that we can use to evaluate and adjust the PEI program throughout the project period.

Mapping Between Survey Questions and ABET Student Outcomes

Not all of the questions within the survey categories map to SOs, and none of the questions from the two *Program Evaluation* categories (SPE and MPE) map to SOs. This mapping was performed after these categories were designed, and they were not designed to address ABET SOs. However, all of the questions within the SPC category (Table A3) map to SOs. The

questions within this category were not specifically designed to map to SOs, but the questions were modified to align with engineering education and several ABET SOs, and hence the ABET-like terminology within the category questions.

Since the adoption of the modern “1-7” Criteria 3 SOs, some engineering educators have developed assessment methods based on internship experiences, mapping internship evaluations to specific 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*. An example is Ozis, *et al*, who mapped internship assessments to six of the seven new SOs: (1-5) and (7) [14]. Their results demonstrate the impact that internships have on the perspectives and experiences of engineering students, focusing specifically on underrepresented students. We have mapped our internship survey questions to SOs as well, specifically (1), (3), (5), (6) and (7), as summarized in Table 1.

Table 1. Mapping between ABET SOs and the internship survey questions.

	ABET SO	Survey Questions
(1)	<i>an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.</i>	SCP8 SPC1, 8, 9 MCP3 MPC2
(2)	<i>an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.</i>	N/A
(3)	<i>an ability to communicate effectively with a range of audiences.</i>	SCP4
(4)	<i>an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.</i>	N/A
(5)	<i>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.</i>	SSB1, 2 SCP3
(6)	<i>an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.</i>	SPC2, 3
(7)	<i>an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.</i>	SPC4-7

To understand the mapping between the survey questions and the seven ABET SOs, we examine each of the categories and identify the subset of questions within these categories that are relatable to SOs. Only 16 of the 37 survey questions map to SOs. And as noted above, none of the questions within either of the *Program Evaluation* categories (SPE and MPE) map to any SOs. These PE questions pertain to the operation of the internship program rather than the engineering education topics addressed by the SOs. These questions inquire about how the

internship is going, if any support is needed, what could be improved, and impressions of the program. The intent is to identify shortcomings within the program and opportunities for improvement.

Very few of the questions within the mentor survey categories can be mapped to SOs. Just two of the nine questions within these categories relate to engineering education. Both map to SO (1). MCP3 and MPC2 query the mentors about their interns' development during the internship, specifying essential career skills and knowledge. These questions align with SO (1), assuming that essential career skills and knowledge are the tasks unique to engineering, specifically identifying and solving engineering problems by applying principals of engineering, science, and math.

The objective of the SSB category is to gain an understanding of the interns' *sense of belonging*. Two of the questions in this category map to the "teamwork" outcome, SO (5). The questions ask students about their sense of belonging in their community of engineers, and if they derive satisfaction with working within an engineering team. Answers should reflect their sense of being able to function within collaborative and inclusive teams that function effectively.

The SCP category addresses the interns' sense of *career preparation*. Three of the questions map to SOs. SCP3 asks the interns if they can clearly define their career goals, which maps to the goals, planning, and objectives setting aspects of SO (5). SPC4 pertains to students' sense of professional communication skills, in alignment with the effective communication aspects of SO (3). And, SCP8 asks the students about their professional preparation through acquisition of engineering skills, mapping to SO (1).

The SPC category queries the interns about their *professional confidence*. As noted above, we modified the questions within the SPC category to align with several ABET SOs. The questions originate from a survey that was developed by PSU's Center for Internship, Mentoring and Research to assess science-based internships. The modifications were minor; we modified the terminology to better align the questions with engineering while preserving the possibility of comparing similar assessments of engineering and science internships in future. Three of the questions (SPC1,8,9) map to SO (1), inquiring about the interns' confidence in being able to generate research questions, define constraints, and identify engineering solutions, as well as comprehend science, math, and engineering concepts, and see connections between these fields. Two questions (SPC2, 3) map to SO (6), asking about the interns' confidence in collecting, analyzing, and interpreting appropriate data, and applying engineering judgment to draw conclusions. And four of the questions (SPC4-7) map to SO (7), assessing the interns' confidence in acquiring and applying knowledge, using learning strategies, using engineering literature to guide problem formulation, integrating results from multiple studies, asking relevant questions, and identifying the knowns and unknowns about engineering problems.

Preliminary Assessment

To date, one intern has completed an internship and five are currently in progress. Four more are planned for 2025-26 AY. As such, insufficient data have been collected to show progression on our metrics from the beginning of the internships to the end. The survey results will only provide value after the post-internship survey data are collected and compared to the pre-internship

survey data. Table 2 shows preliminary data from the pre-internship survey, specifically survey questions that map to ABET SOs. These questions ask for responses along a Likert scale (1-*strongly agree*, 2-*agree somewhat*, 3-*neutral*, 4-*disagree somewhat*, or 5-*strongly disagree*). Likert scale data are ordinal; the intervals between points on the scale cannot be quantified, so consideration of the relationships of these data between one another, such as by using mean and standard deviation, warrants caution.

Table 2. Preliminary results from survey questions. Data are from the survey conducted at the beginning of the internship in Summer 2025; data indicate the students' perspectives prior to starting their internships. Only survey questions that map to ABET SOs are shown.

Survey Question	ABET SO	Criteria Description (paraphrased)	Ave (stdev)
SPC1	1	<i>Generate a research question, ... identify engineering solutions</i>	1.8 (0.7)
SPC8	1	<i>Understand scientific, mathematic, and engineering concepts</i>	1.5 (0.5)
SPC9	1	<i>See connections between different areas of science, engineering, math</i>	1.7 (0.5)
SCP4	3	<i>Know how to communicate ... strengths, skills to a potential employee.</i>	2.2 (1.1)
SSB1	5	<i>Sense of belonging to a community of engineers.</i>	1.8 (0.4)
SSB2	5	<i>Derive personal satisfaction from working on an engineering team ...</i>	1.0 (0.0)
SPC2	6	<i>Determine how to collect, analyze, and interpret appropriate data</i>	1.7 (0.7)
SPC3	6	<i>Use engineering judgment to draw conclusions</i>	1.7 (0.5)
SPC4	7	<i>Use engineering literature to guide problem formulation</i>	2.0 (0.8)
SPC5	7	<i>Integrate results from multiple studies</i>	1.8 (0.4)
SPC6	7	<i>Ask relevant questions</i>	1.5 (0.5)
SPC7	7	<i>Identify what is known and not known about an engineering problem</i>	1.2 (0.4)

Assessing SOs involves examining criteria for each SO. Each survey question that maps to an SO addresses a criterium for that outcome. For instance, and referring to Table 2, there are three criteria for SO (1) and four for SO (7). Scores are averaged across the intern cohort and expressed as a percentage. A level score is then determined for each criterium, wherein levels indicate performance as *Exemplary*, *Accomplished*, and *Developing* as means for qualitatively expressing the value of the internship to the student. These levels consider the Likert scale scores for each student and whether the scores have improved from the beginning of the internship to the end. Each criterium is quantified using the percentage of students that fall within each level. Improvements will be gauged by noting an increase in score averages or narrowing of deviations. Results are expressed within a table, an example of which is shown in Table 3. These criteria scores will be accompanied by a narrative that provides context and conclusions of the assessment.

Table 3. An example criteria assessment table for an ABET SO.

SO (1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.			
Criteria	Exemplary	Accomplished	Developing
SPC1	% of students	...	...
SPC8	...	...	...
SPC9	...	...	...
Average	% of students	...	...

Conclusion and Future Work

This Work-In-Progress reports on an ABET Criteria 3 “1-7” Student Outcomes assessment method that we developed. SOs relate to the knowledge, skills, and behaviors that students acquire as they progress through an engineering program. They describe what engineering students are expected to know and should be able to do by the time they graduate. Using internships is a common means for assessing SOs. The diverse aspects of engineering internships provide opportunities to evaluate multiple SOs using the same source material. Assessments include evaluating internship deliverables, self-assessments, and survey responses from both employers and interns. Multiple engineering programs have used internships for indirect assessment over the years. However, many of these internship assessment procedures were developed for the old ABET 2000 Criteria 3 “a through k” SOs.

This paper presents a method for internship assessment that uses the modern Criteria 3 “1-7” SOs. The method uses data that we collect from surveys of the Power Engineering Internship program participants. The PEI program began in January 2024 will be funded through 2030. During this period, both interns and mentors will be regularly surveyed. Survey data will be used to improve the PEI program operation, improve survey administration, and contribute to Departmental ABET assessment. We anticipate improving the program and our assessment methods as the PIE participants are surveyed and the results are assessed over the coming years.

The authors believe this assessment method can be adapted for use by other engineering programs for their own ABET reviews. The survey questions address engineering internships in general, not specifically electric power engineering, and therefore are applicable to a wide range of engineering disciplines. However, in adopting this assessment method, educators should consider applying the assessment to a representative fraction of the program’s students, if possible. Currently, one of the shortcomings of our use of this assessment method is the small number of students who are participating in this engineering internship program; we have not applied this assessment method to all of our students who participate in internships. As such, the method provides an indirect assessment of just a sample of our student body.

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References

- [1] Anon., “2024-2025 Criteria for accrediting engineering programs,” ABET, 2021
- [2] L. Falcon, “Breaking down barriers: first-generation college students and college success.” Innovation Showcase, 10(6), 2015.
- [3] Kuh, G., Kinzie, J., Buckley, J., Bridges, B., & Hayek, J., “What Matters to Student Success: A Review of the Literature,” National Postsecondary Education Cooperative, July 2006

- [4] J. Lindwall and R. B. Bass, "WIP: Structuring engineering internships to support community benefits plans," in 2024 ASEE Annual Conference & Exposition, June 2024.
- [5] M. Minnes, S. G. Serslev, and M. Edwards, "Attitude shifts and transformation during computer science and engineering student internships," in 2020 ASEE Virtual Annual Conference, June 2020.
- [6] K. L. Biasca and S. Hill, "Assessment of ABET student outcomes during industrial internships," in 2011 ASEE Annual Conference & Exposition. Vancouver, British Columbia, June 2011.
- [7] A. Sirinterlikci, "Mapping professional performance metrics into ABET outcomes assessment process," in 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana, June 2016.
- [8] L. Hubbard, P. Mente, and S. Blanchard, "Student internships: A rich source of data for assessment of program outcomes," in 2004 ASEE Annual Conference. Salt Lake City, Utah, June 2004.
- [9] R. Guardiola, L. Hanneman, S. Mickelson, and T. Brumm, "Development of workplace competencies sufficient to measure ABET outcomes," in 2001 ASEE Annual Conference. Albuquerque, New Mexico, June 2001.
- [10] M. A. Laingen, S. A. Freeman, T. J. Brumm, and M. Shelley, "Examining the use of engineering internship workplace competency assessments for continuous improvement," in 2015 ASEE Annual Conference & Exposition. Seattle, Washington, June 2015.
- [11] A. D. Patrick, A. N. Prybutok, and M. Borrego, "Predicting persistence in engineering through an engineering identity scale," *International Journal of Engineering Education*, vol. 34, no. 2(A), 2018.
- [12] A. M. K. Schauer, A. Kohls, and K. Fu, "Push and pull: Exploring the engineering retention problem for underrepresented groups and gauging interest in interdisciplinary integration into undergraduate curriculum," in 2023 ASEE Annual Conference & Exposition. Baltimore, Maryland, June 2023.
- [13] J. Yang, J. D. Towles, S. Sheppard, and S. Atwood, "Internships' impact on recognition for first-generation and/or low-income students," in 2022 ASEE Annual Conference & Exposition. Minneapolis, Minnesota, August 2022.
- [14] F. Ozis, K. N. Winfree, and E. Glass, "To infinity and beyond: Boosting URM students' career trajectories through professional experiences," in 2021 ASEE Virtual Annual Conference, July 2021.

Appendix A - Student Survey Questions

Student survey questions are posed at the beginning, midpoint, and end of the internship, except those marked with an (*), which are posed only at the end of the internship. Questions that map to ABET Criteria 3 SOs are highlighted in bold font. Likert scale questions are denoted with a (%). Open-ended questions are denoted with a (#).

Table A1. Students: Sense of Belonging survey questions

	Questions	C3 SO
<i>To what extent are the following statements true of you?</i>		
SSB1%	I have a strong sense of belonging to a community of engineers.	(5)
SSB2%	I derive personal satisfaction from working on a team that is doing important engineering.	(5)
SSB3%	I think of myself as an engineer.	N/A
SSB4%	I feel like I belong in the field of engineering.	N/A

Table A2. Students: Career Preparation survey questions

	Questions	C3 SO
SCP1%	I know what I am going to do after graduation.	N/A
SCP2%	I have chosen a career to pursue after graduation.	N/A
SCP3%	I can clearly define my career goals.*	(5)
SCP4%	I know how to communicate my strengths and skills to a potential employee.	(3)
SCP5%	I feel prepared to enter the workforce.	N/A
SCP6%	I know and understand the types of jobs for which my skills and abilities are relevant.	N/A
SCP7%	My internship prepared me to enter the workforce.*	N/A
SCP8%	I gained valuable skills through my internship.*	(1)
SCP9#	What are your next steps in your career and education and how has this internship experience supported you on your pathway?*	N/A

Table A3. Students: Professional Confidence survey questions

	Questions	C3 SO
<i>How confident are you that you can:</i>		
<i>SPC1</i> [%]	Generate a research question, define constraints, and identify engineering solutions	(1)
<i>SPC2</i> [%]	Determine how to collect, analyze, and interpret appropriate data	(6)
<i>SPC3</i> [%]	Use engineering judgment to draw conclusions	(6)
<i>SPC4</i> [%]	Use engineering literature to guide problem formulation	(7)
<i>SPC5</i> [%]	Integrate results from multiple studies	(7)
<i>SPC6</i> [%]	Ask relevant questions	(7)
<i>SPC7</i> [%]	Identify what is known and not known about an engineering problem	(7)
<i>SPC8</i> [%]	Understand scientific, mathematic, and engineering concepts	(1)
<i>SPC9</i> [%]	See connections between different areas of science, engineering and mathematics	(1)

Table A4. Students: Program Evaluation survey questions. SPE questions are posed at the midpoint and end of the internship.

	Questions	C3 SO
<i>SPE1</i> [%]	How would you rate the quality of your internship placement?	N/A
<i>SPE2</i> [#]	What have you been working on in your placement?	N/A
<i>SPE3</i> [#]	What has been the most important part of the program?	N/A
<i>SPE4</i> [#]	What could be improved?	N/A
<i>SPE5</i> [#]	Please describe your overall impression of the internship program.	N/A
<i>SPE6</i> [#]	Do you have more to share about any of the specific program components you didn't mention above?	N/A

Appendix B - Mentor Survey Questions

Mentor survey questions are posed at the midpoint and end of the internship. Questions that map to ABET Criteria 3 SOs are highlighted in bold font. Likert scale questions are denoted with a (%). The Likert scale is 1-*strongly agree*, 2-*agree somewhat*, 3-*neutral*, 4-*disagree somewhat*, or 5-*strongly disagree*. Open-ended questions are denoted with a (#).

Table B1. Mentors: Career Preparation survey questions for the internship mentors.

	Questions	C3 SO
	<i>To what extent are the following statements true of you?</i>	
<i>MCP1%</i>	If I had the resources, I would offer a job to my intern after their graduation.	<i>N/A</i>
<i>MCP2%</i>	My intern is prepared to enter the workforce.	<i>N/A</i>
<i>MCP3%</i>	My intern demonstrated growth in essential career skills over the course of the year.	<i>(1)</i>

Table B2. Mentors: Placement Check-in survey questions

	Questions	C3 SO
<i>MPC1#</i>	What has the intern been working on?	<i>N/A</i>
<i>MPC2#</i>	What do you think the intern has gained and/or learned this term? (knowledge? skills? professional network?, etc.)	<i>(1)</i>
<i>MPC3#</i>	How have the learning agreement and work plan been working for you and the intern?	<i>N/A</i>

Table B3. Mentors: Program Evaluation survey questions

	Questions	C3 SO
<i>MPE1#</i>	From your perspective, how is the internship going? What have been the successes and where have there been challenges?	<i>N/A</i>
<i>MPE2#</i>	Is there any support from the internship team that would make the experience better for you or the intern?	<i>N/A</i>
<i>MPE3#</i>	Do you have any ideas for topics you'd like to see addressed in supervisor training?	<i>N/A</i>