Changes in ABET Criteria: A framework for transition with greater fidelity in artifacts supporting student performance

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Abstract

The Naval Architecture and Marine Engineering Program at the U.S. Coast Guard Academy is accredited by the Engineering Accreditation Commission (EAC) of ABET. The accreditation process requires programs to meet criteria and outcomes indicative of a robust and supportive academic environment where graduates are adequately prepared to meet employer needs post-graduation. Changes to the long-standing ABET Criteria were approved in 2018, and all general reviews conducted in the 2019 – 2020 accreditation cycle, and beyond, will be evaluated against these new criteria.

In anticipation of a 2019 ABET general review, the program's transition to the new ABET Criteria is described. This includes program interpretation of the updated ABET Criteria, with a specific focus on Criterion 3, Student Outcomes, and newly revised ABET language and definitions. Additional impacts to the assessment framework as a result of a new (institutional) core curriculum are also discussed.

Concurrently, evidence-based changes were applied to the assessment framework to achieve greater fidelity in the artifacts provided as evidence of student performance. A student performance vector was implemented to categorize the quality of student work as Excellent, Adequate, Marginal or Unsatisfactory (EAMU Vector). The implementation and application of the EAMU vector is described and data collected from the 2018-2019 academic year is presented to show both an increase in the fidelity of the assessment data and the creation of meaningful student performance data trends over time.

The ABET accreditation visit found no shortcomings in Criterion 3 – Student Outcomes. For this reason, this paper is apropos, as it may reduce challenges for any other mechanics-based programs seeking initial accreditation or those programs seeking to revise their assessment framework in preparation for ABET accreditation.

Introduction and Background

Quality assurance in engineering education is paramount [1], [2]. Programmatic and peer review contribute to both the quality and relevancy of engineering programs by encouraging curricular development and pedagogical innovation. Engineering accreditation, most often achieved through the Engineering Accreditation Commission (EAC) of ABET, formerly the Accreditation Board for Engineering and Technology, provides this opportunity for programmatic as well as peer review.

The EAC recently approved changes to its General Criteria for Baccalaureate Programs for implementation in the 2019 – 2020 Review Cycle. The changes include the following components:

- The Introduction and Definitions that apply to all parts of the criteria
- Criterion 3 – Student Outcomes (SOs)
- Criterion 5 – Curriculum

All general reviews conducted in the 2019 – 2020 accreditation cycle, and beyond, will be evaluated against these new criteria.

Changes to Criterion 3, with revised accreditation definitions, will likely impact each programs' assessment architecture the most. In Criterion 3, seven new student outcomes, enumerated (1) – (7), have replaced the previous eleven student outcomes, identified as (a) – (k). The specific mapping between the new outcomes (1) – (7) and legacy outcomes (a) – (k), as well as updated language and definitions, are provided in [3]. Since current ABET-accredited

engineering programs will have some component of the legacy Student Outcomes (SOs), most programs will require changes in assessment processes. The majority of changes will occur at or below the SO level where programs must:

1. Revise student performance criteria to explicitly support the new SOs.

2. Verify that evaluative student artifacts can provide appropriate evidence of student performance.

The magnitude of change will vary from program to program depending upon on the scope of the legacy outcomes and the specific assessment structure [4].

Changes to the assessment process described above, and experiences with a 2019-2020 general review, may provide guidance and assessment process considerations for other engineering programs transitioning to the new ABET Criteria. Academic programs seeking initial accreditation from ABET may also benefit from the process, approach and techniques described in this paper.

Program Assessment Architecture

The Naval Architecture and Marine Engineering Program assessment architecture consists of Program Educational Objectives (PEOs), Student Outcomes (SOs), Performance Indicators (PIs) and Barometric Assessments (BAs). Although this argot may be unique to the Naval Architecture and Marine Engineering Program at the U.S. Coast Guard Academy, most engineering programs will have a similar hierarchy of levels in their assessment framework. Student Outcomes are the cornerstone of an ABET accredited program, as programs must provide evidence that students achieve each SO. Student outcomes are defined by statements that describe what students are expected to know and be able to do by the time of graduation. Student outcomes are closely linked to Program Educational Objectives (PEOs). Achievement of SOs should indicate that students are prepared to achieve the PEOs.

The program subdivided each Student Outcome into one or more Performance Indicators (PIs). PIs are measurable interpretations of each SO that describe a competency or skill that each student is expected to attain. The Performance Indicators are influenced by faculty interpretation of the PI as it applies to the specific program, in this case, Naval Architecture and Marine Engineering.

Student achievement of a Performance Indicator is evaluated using a combination of specific assignments, projects and/or examination problems, rubric score or a survey response called Barometric Assessments (BA's). BA's serve as "barometers" of student performance in achieving the specific Performance Indicators. For each Performance Indicator, the Program has identified two or more BAs that were judged to be key measures of student achievement of that Performance Indicator. The demonstration of student achievement of a particular Performance Indicator is examined in one or more Program-required courses using sets of one or more BAs. The Program declares that a Student Outcome has been achieved when all Performance Indicators tied to that outcome have been achieved in at least one course.

Transition to New ABET Criterion 3 – Student Outcomes

To comply with this criterion, the mapping of Student Outcomes, Performance Indicators and Barometric Assessments to courses were completely overhauled in the 2017 – 2018 academic year. To do this, a faculty subcommittee met monthly to perform this mapping. The subcommittee included faculty with the greatest knowledge and breadth of the program, including the program assessment coordinator and a faculty member who serves as an ABET Program Evaluator. Faculty were guided by ABET documentation [3] that summarized the migration from the legacy Student Outcomes (a) – (k) to the new Student Outcomes (1) – (7).

The Naval Architecture and Marine Engineering Program has 10 Student Outcomes. The first seven outcomes are taken directly from the ABET Criterion 3, (1) – (7). It is expected that programs adopt these outcomes, in a wholesale fashion, to demonstrate compliance with Criterion 3. The remaining three Student Outcomes are developed from the ABET program-specific criteria for Naval Architecture and Marine Engineering programs listed in reference [5]. Although program-specific criteria are not explicitly required to appear as additional Student Outcomes, harmonizing these criteria as outcomes in the assessment architecture is both efficient and effective, as well as a best-practice in

assessment structure. The 10 Student Outcomes for the Naval Architecture and Marine Engineering Program and their amplifying Performance Indicators are shown in Table 1 (at end of paper).

The biggest challenge with this approach was that some legacy Student Outcomes are combined into a new (singular) outcome; some are natural, while others are more complicated. For example, legacy outcomes (a) "an ability to apply knowledge of mathematics, science and engineering" and (e) "…identify, formulate and solve engineering problems" are similar and combining them into a single Student Outcome (1) improves the efficiency of the assessment process. However, combining legacy outcomes (f), (h) and (j) into a single outcome (4) or that legacy outcome (k) is implied in Student Outcomes (1), (2) and (6) can be fraught with problems. The danger for a program is that they might assess one aspect of the outcome and miss the other which could result in a shortcoming that might otherwise be avoided by keeping these outcomes separate. *This requires that programs take great care in implementing changes, especially below the SO level, to ensure all elements of each outcome are achieved.*

Development of Assessment Framework below the Student Outcome level

Fundamental changes to the language and definitions pertaining to all Criteria heavily influenced the development of Performance Indicators and their subsequent Barometric Assessments. The most challenging aspects of this are described below.

The first is the definition, and rather inclusive aspects, of *Engineering Design*. The legacy student outcome (c) required that engineering design, "meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability". The use of the term "such as" as a determiner indicates that only a subset of need and constraints is required. The new Student Outcome states, "engineering design solutions must meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors." *Relative to the legacy student outcome, it would appear that all of these aspects should be included.* Therefore, EAC Criterion 3, Student Outcome 2 requires multiple Performance Indicators to encompass all these characteristics.

The second challenge is the *design of experiments*. The legacy student outcome (b) required that "students design and conduct experiments." This was a challenge because Naval Architecture and Marine Engineering students do not often design experiments. To achieve this outcome, experimentation was often artificially introduced in the curriculum. The new EAC Criterion 3, Student Outcome 6 more reasonably requires that "students develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions." This is more realistic and indicative of program specifics and may not require students to actually design experiments; only analyze and interpret the data. *This should result in programs having greater flexibility in demonstrating student achievement of this outcome.*

Next, oral communication skills have been expanded to include speaking to *a range of audiences*. The legacy student outcome (g) required students to communicate effectively while the new outcome (3) adds that students should effectively communicate across a range of audiences. As a result, students must now demonstrate the ability to a range of audiences, e.g., peers, faculty, industry representatives, people outside of their academic specialty, etc. *Programs must now ensure students speak to a range of audiences.*

Last, the role of the team has also changed significantly. Legacy student outcome (d) required that students "function on multidisciplinary teams." The new Student Outcome 5 also requires team members to "provide leadership and create a collaborative and inclusive environment." It is much more challenging to provide evidence of leadership *and* a collaborative and inclusive environment in a program than to merely function on a team.

As a process, the Program needed to be careful that PIs included all aspects of each student outcome and that each barometric assessment (or equivalent) was developed in a manner to meet the new language and definitions of the EAC Criteria. In September 2018, a final review of the Student Outcomes, Performance Indicators and associated Barometric Assessments was completed and presented to the entire Program faculty for approval and ratification.

At the same time as the new ABET Criterion 3 Student Outcomes were incorporated into the program, a new institutional core curriculum was being implemented. Therefore, this 2018-2018 overhaul allowed the faculty

subcommittee to also examine if any changes to the curriculum also affected the transition to the new assessment process. Had this not happened simultaneously, it would have been necessary to incorporate a separate review of the assessment process to ensure that all Student Outcomes were being assessed in the most appropriate courses, either due to old courses going away or new courses being brought in. Since the program largely relies on courses taught by faculty in the program, there was a minimal impact on the assessment process because of the new core curriculum.

Providing appropriate evidence of student performance

Once the student performance criteria was revised to explicitly support the new SOs, the program had to verify that the selected barometric assessments could provide appropriate evidence of performance, relative to each student outcome.

Prior to 2018, Student Outcomes were considered achieved if at least 75% of the program students (cohort) attained at least a 70% score on the Barometric Assessment associated with each Performance Indicator. This approach served the Program well for a number of years but limitations were reached with this method.

First, there was no good "dashboard" for rapidly assessing year-over-year trends for each Performance Indicator. Although the historical assessment data was available, it required substantial time (in an already time-intensive process) to collect, collate and analyze the information. After much discussion and a review of best practices, the faculty agreed that a three-year performance trend for each Performance Indicator would provide the most insightful and useful information.

Second, and perhaps more importantly, the approach used prior to 2018 lacked the fidelity to identify meaningful data trends; it only reported whether the Barometric Assessments demonstrated achievement of the Performance Indicator. Unfortunately, this information was reported as a single percentage, which masked both the distribution and variability of the underlying data. For example, an Outcome Score that is reported as 100% may have had all of the students achieving a 70% on the Barometric Assessment (prior threshold), and the following year, this could drop to 0% of the students achieving 70% only because every student scored a 69% on the Barometric Assessment. Therefore, the evaluation approach concealed the fact that these two sets of student performance data were, in fact, statistically the same.

Increasing the Fidelity in the Assessment of Student Artifacts

To remedy these limitations, and in keeping with assessment best practices, the Program modified the assessment framework to include an EAMU vector to increase the fidelity of the assessment process. The approach was first described in 1999 by Miller and Olds [6] as a rubric to assess student performance, using the headings of "Exemplary", "Proficient", "Apprentice", and "Novice". This concept has since evolved into a widely accepted rubric designation of (E)xcellent, (A)dequate, (M)arginal or (U)nsatisfactory, and the vector reporting out the number of students (or percentage of students) within each band.

The EAMU Vector is most visibly used as the assessment tool for EvalTools® [7]. The EAMU Vector measures the degree to which students achieve a Student Outcome Performance Indicator. The vector categorizes student work as (E)xcellent, (A)dequate, (M)arginal or (U)nsatisfactory. The Naval Architecture and Marine Engineering Program determined to band the scores for the pilot usage of EAMU as shown in Table 2.

Table 2. EAMU Vector Scoring Bands

(E)xcellent	90-100%
(A)dequate	80-89.99%
(M)arginal	70-79.99%
(U)nsatisfactory	<70%

The range of each scoring band follows best practices in higher education with the exception of the (U)nsatisfactory range. Program faculty elected to include a grade of "D" (60-70%) within the (U)nsatisfactory rather than in the

(M)arginal category because earning a "D" on an assignment negatively impacts the Naval Architecture and Marine Engineering graduation requirement of a 2.0 GPA.

Since most Naval Architecture and Marine Engineering student cohort sizes are not large enough to report overall percentages (no statistical significance), raw scores in each category are used to better reflect the underlying distribution of performance. Therefore, to calculate the EAMU Vector, the raw number of Naval Architecture and Marine Engineering students earning a grade in each scoring band are tallied, not the overall percentage of students earning a grade in each scoring band.

The Naval Architecture and Marine Engineering Program EAMU Average is computed on a 3.0 scale using the following equation:

$$EAMU\ Average = \frac{[3 * Count(E) + 2 * Count(A) + 1 * Count(M) + 0 * Count(U)]}{Count\ all}$$

This composite score provides an additional way to consider the data; student achievement can now be assessed on multiple parameters including the EAMU Vector, the EAMU Average, and the 3-year Average Trend, which shows a trend line (slope) for the data.

This process closely aligns with EvalTools® [7]; however, program data is captured on a 3.0 scale, rather than modulating it to a 5.0 scale, i.e., multiplying our average by 5/3 will result in values comparable to those used in EvalTools®. The vector, its average, and 3-year trend enables us to assess student performance in three distinct areas:

1. Percentage of students obtaining an "Unsatisfactory" score
2. Overall EAMU Average
3. 3-year trend

The 3-year trend is an assessment tool unique to the Naval Architecture and Marine Engineering Program. Since assessment data is collected for all Barometric Assessments each year, the 3-year trend to become a simple but useful metric to describe improvements (or declines) in student performance and/or changes in the grading fidelity of instructors.

After the EAMU vector is calculated for a particular Barometric Assessment, student performance is assessed using a collection of EAMU Matrix Flags shown in Table 3.

Table 3. Assessment Matrix Flags

EAMU		**3-year Trend**	
Category	Criteria Description	Category	Criteria Description
Red Flag	Any average below 2.0 AND 10% EAMU vector in U	Red Flag	Less than -0.2 (Trending downward rapidly)
Yellow Flag	Any average below 2.0 OR 10% EAMU vector in U	Yellow Flag	Between -0.1 to -0.2 (Trending downward gradually)
Green Flag	Any average above 2.75 AND 0 EAMU vector in U	Green Flag	Above 0.2 (Trending upward rapidly)
No flag	Any vector that does not fall into one of the above categories	No flag	Trend does not fall into one of the above categories

The flags described above serve as a catalyst or trigger for continuous improvement discussions during the end-of-course review process. Any flag in assessment must have a documented discussion about it, whether it includes any recommended course improvements or not. It was decided to have two levels of flags for low performance, and only

one for high performance in order to not oversaturate the process. The green flags are good for indicating what may be excessively high grades and their implications, but between a 2.0 and 2.75 EAMU Average computes to an average grade in the 80's, and this is not considered excessively high, particularly since the institution is considered "highly selective." The flags being triggers for discussion ensures that ABET assessment is directly tied to curricular continuous improvement. Flags are also addressed in the biennial Program Reviews that reviews all Student Outcomes collectively rather than individually.

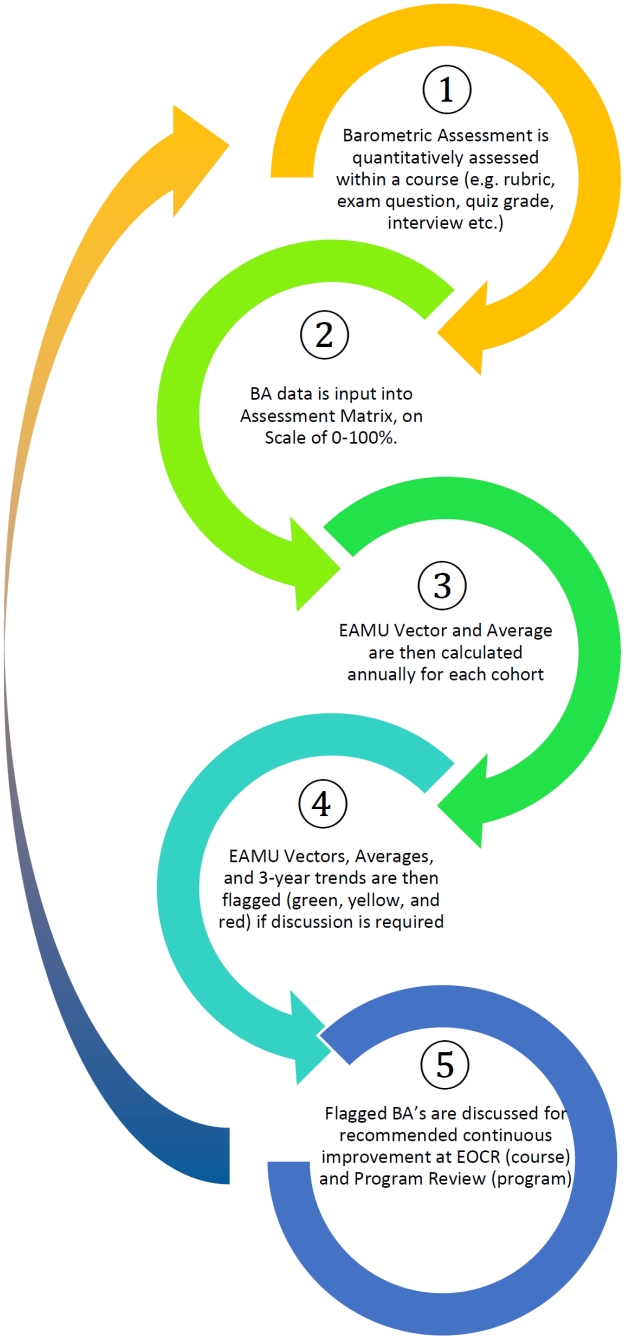

Figure 1. ABET Criterion 2 Student Outcome Assessment Process within Program Review Process

Description of Assessment Process

Outcome assessment occurs on an annual basis. Most courses used in assessment are taught only one semester each year. For those courses taught in both the fall and spring semesters, the semester with the largest Naval Architecture and Marine Engineering cohort is selected, e.g., 6201 Ships and Maritime Systems is assessed in the Fall. Figure 1 describes the assessment process using the EAMU vector and is described below.

At the end of each semester, the assessment coordinator requests the grades or rubric scores for each barometric assessment (Figure 1, Step 1). With few exceptions, e.g., student interviews, the data is readily available in each course gradebook and is simply transferred to our Excel-based Assessment Matrix. Using the ranges presented in Table 2, all grades are assigned as (E), (A), (M) or (U). This process is highlighted as Figure 1, Step 2. Once student performance data is collected, the EAMU vector raw score and average is computed (Figure 1, Step 3). The EAMU vector raw score and average are then flagged based on the criteria defined in Table 3 (Figure 1, Step 4). The resulting flags then trigger continuous improvement discussions during the End-of-Course Review (EOCR) process (Figure 1, Step 5). Another time for continuous improvement discussion, particularly when flags are observed repeatedly for one Student Outcome and/or over multiple years, occurs at the biannual Program Review (Figure 1, Step 5).

Expected Level of Attainment of Each Student Outcome

A cohort is an entire class of Naval Architecture and Marine Engineering students; i.e., all Program students in a particular course are used in assessment. If the course has students from other majors in it, only the Program student grades are considered for assessment purposes. The process described below is used to check whether each Student Outcome is attained.

Performance Indicator(s) are assessed in one or more courses. The Performance Indicator is declared to have been attained if the Program students in at least one of the

Barometric Assessments have successfully demonstrated that Performance Indicator. A Student Outcome is considered to be attained when all of the Performance Indicators for that Outcome have been successfully demonstrated by the Program students (see Table 1 at end of paper). If Performance Indicator achievement is not attained, then proposed remedial action for future offerings of the course is identified and documented in the End-of-Course Review document. Course and Program improvements from this process also flow from the Course Review to the biannual Program and Departmental Reviews.

In order to visually ascertain if a BA, PI or SO have been attained, the flags presented in Table 3 above are used. Green flags for the BA EAMU vector indicate that grades are very high, and a discussion is triggered in order to ensure grading fidelity and assessment level of rigor. This trigger does not indicate a lack of attainment of the BA, while discussion is documented in the Course Review if continuous improvement efforts have been identified.

A yellow flag for the BA EAMU vector indicates that more students in the cohort are falling below marginal than are above. This is a trigger for discussion, but largely represents a useful indicator of the distribution of the grade. Any continuous improvement efforts identified are documented in the course review. For purposes of assessment, the BA is still considered attained.

A red flag for the BA EAMU vector is both a trigger for discussion of continuous improvement, and a failure to attain that BA. If all BAs fail in the same PI, the PI fails and the SO fails as well, e.g. Table 1 at end of paper, SO9. Red flags are taken very seriously, and the course review discussions are valued as the first line of continuous improvement efforts.

Flags for the trends are just visual indicators of the 3-year trend, and can be used as a warning of a possible red flag in the future, or that the rigor of the BA may need to be adjusted (for a green trend). 3-year trend flags do not factor into BA attainment. Figure 2 illustrates this process.

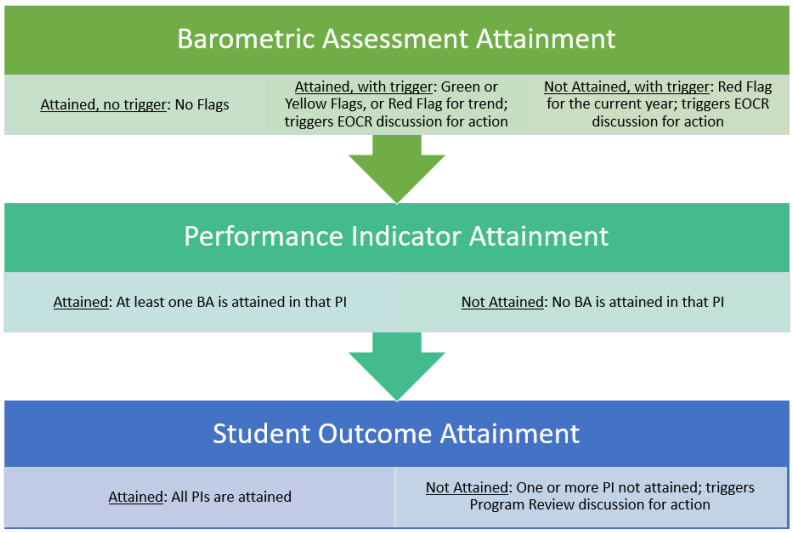

Figure 2. Attainment of Student Outcomes

Results and Recommendations

Flagged assessments during the Course Review process leads to a more productive conversation than a pass/fail criteria. Referencing an assessment as flagged allows faculty to be more equity-minded in the discussion, e.g.,"The final exam didn't align well with the course material and should be revisited" versus pass/fail leading to a more deficit-minded conversation, e.g., "Students these days are not ready for college."

Often, ABET Assessment can easily be disassociated with the accredited program of study. To counter this, adopting a mindset that flags are an automatic trigger for discussion allows for ABET Assessment to permeate all continuous improvement efforts, rather than be viewed as a separate and extra effort.

The three year trend is still in development after only one year with some retro-active grades available, but has already helped to lead to discussions about potential grade inflation or re-racking of course material. 1442 Principles of Ship Design saw in the fall of 2019 that the EAMU Vector was flagged green for one assessment, and there was a follow-on discussion to revisit the rigor of this assignment and grading in order to check for potential grade inflation. Also, the course 1204 Engineering Material Science used several factors including a past red flag for the EAMU Vector using the final exam grade to revisit the exam and ensure that the depth and breadth of the final exam was appropriate. After modifications to the final exam, the Barometric Assessment went from a red flagged EAMU Vector to a yellow flagged EAMU vector. These examples shows that the ABET Assessment of Student outcomes is closely tied to the continuous improvement of the course.

- ABET Assessment should not be an extra lift, but fully incorporated into other continuous improvement efforts of the curriculum. Annual assessment doesn't need to be a burden if it's organically rooted in a course.
- EAMU provides a more robust system that is more than just a pass/fail criteria, leading to better assessment.
- Currently, the Naval Architecture and Marine Engineering Program is relying largely on analytic, in-class data for assessment. An additional layer that will be conducted through a capstone audience survey is planned to be implemented this year as a more holistic, qualitative approach, but the survey will be in the form of a rubric to overlay on the EAMU vector.

Conclusion

When programs adopt the new ABET Criterion 3 Student Outcomes, it is important to recognize that a robust assessment framework requires more than a direct mapping from the legacy SOs (a) – (k) to the SOs 1 – 7. Changes to the language, definition and certain verbiage of the Criteria necessitates a comprehensive review of the mapping between SOs and to subsequent levels of an assessment architecture. Additionally, programs must recognize the need to assess attainment of all elements of a Student Outcome, demonstrated in this paper by subdividing Student Outcomes into Performance Indicators that both break apart the Student Outcome and interpret for measurement the Student Outcome.

The Naval Architecture and Marine Engineering Program implemented an EAMU Vector to achieve a higher fidelity in the measurements that support attainment of Student Outcomes. Rather than using a singular data point for analysis, five data points are used to assess and evaluate student performance, namely each value of the EAMU Vector along with the average. This formulation of student performance provides an effective year-on-year trend of the average student performance that can further discussion about continuous program improvement.

A byproduct of the EAMU Vector, average, and trend are the implementation of flags, including high, moderately low, and low, that have aided discussions of continuous improvement in a very positive way both during Course Reviews and Program Reviews. These discussions, along with the use of Barometric Assessments taken directly from courses in the curriculum have allowed for the ABET continuous improvement process to be more entrenched in the Program continuous improvement process, which is the original desire of ABET for accreditation.

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Table 1. Student Outcomes, Performance Indicators and Assessment Results.

ATTAIN	*SO1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics*				2018-19					2017-18					2016-17					3-yr.
	Performance Indicators		Barometric Assessment Courses	Barometric Assessment	E	A	M	U	Avg	E	A	M	U	Avg	E	A	M	U	Avg	Trend
Attain	SO1-1	Identify, formulate and solve complex engineering problems.	1355 Marine Engineering	Heat Exchanger Homework Assignment	14	4	0	2	2.50	16	3	0	0	2.84	20	1	0	2	2.70	-0.1
			1356 Ship Structures	Final Exam Grade	3	8	5	4	1.50	3	13	1	1	2.00	7	5	6	5	1.61	-0.05
			1242 Applied Naval Arch & Marine Engr	Great Boat Race	21	4	2	0	2.70	8	4	4	0	2.25	23	0	0	0	3.00	-0.15
ATTAIN	*SO2: 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,*				2018-19					2017-18					2016-17					3-yr.
	Performance Indicators		Barometric Assessment Courses	Barometric Assessment	E	A	M	U	Avg	E	A	M	U	Avg	E	A	M	U	Avg	Trend
Attain	SO2-1	Apply engineering design to produce solutions that consider the environment, and vessel and crew/passenger safety.	1442 Principles of Ship Design	Intact Stability Submittal	9	8	0	0	2.53											
			1453 Ship Propulsion Design	Propulson Plant Trade-off Submittal	7	3	7	0	2.00	13	10	0	0	2.57	4	2	10	0	1.63	0.188
			1444 Ship Design/System Integration	Crewing Submittal	10	7	0	0	2.59	4	19	0	0	2.17	0	0	16	0	1.00	0.794
Attain	SO2-2	Apply engineering design to produce solutions that consider economic, global, and cultural and social (national) factors.	1444 Ship Design/System Integration	Final Project Report (Executive Summary)	9	8	0	0	2.53	11	12	0	0	2.48	16	0	0	0	3.00	-0.24
			1444 Ship Design/System Integration	Cost Submittal	0	0	0	17	0.00	15	8	0	0	2.65	16	0	0	0	3.00	-1.5
ATTAIN	*SO3: an ability to communicate effectively with a range of audiences*				2018-19					2017-18					2016-17					3-yr.
	Performance Indicators		Barometric Assessment Courses	Barometric Assessment	E	A	M	U	Avg	E	A	M	U	Avg	E	A	M	U	Avg	Trend
Attain	SO3-1	Demonstrate effective writing of technical material (clarity, references, graphics, etc.).	1355 Marine Engineering	Major-specific Position Paper	11	7	1	0	2.53	3	9	7	0	1.79	13	2	10	0	1.63	0.451
			1453 Ship Propulsion Design	Individual Propeller Submittal	16	0	0	0	3.00	17	6	0	0	2.74	4	2	10	0	1.63	0.688
Attain	SO3-2	Demonstrate effective oral presentation of technical material.	1444 Ship Design/System Integration	Final Presentation	12	5	0	0	2.71	12	9	2	0	2.43	15	1	0	0	2.94	-0.12
ATTAIN	*SO4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions*				2018-19					2017-18					2016-17					3-yr.
	Performance Indicators		Barometric Assessment Courses	Barometric Assessment	E	A	M	U	Avg	E	A	M	U	Avg	E	A	M	U	Avg	Trend
Attain	SO4-1	Demonstrate an understanding of professional and ethical responsibility that conforms to industry and professional engineering standards.	FE Exam	Ethics & Professional Practice Q's	0	17	0	0	2.00	0	17	0	0	2.00	0	14	0	0	2.00	0
			1493 Engineering Ethics	TBD - Course in Development																
Attain	SO4-2	Make informed judgements considering the environmental impact of shipping.	1242 Applied Naval Arch & Marine Engr	Propulsion Plant Homework																
			1453 Ship Propulsion Design	Propulson Plant Trade-off	7	3	7	0	2.00	13	10	0	0	2.57	4	2	10	0	1.63	0.19
Attain	SO4-3	Make informed judgements to minimize the production and lifecycle cost of ships.	FE Exam	Engineering Economics Practice Q's	0	0	17	0	1.00	0	17	0	0	2.00	0	14	0	0	2.00	-0.5
			1442 Principles of Ship Design	Hull Geometry Submittal	10	7	0	0	2.59	11	12	0	0	2.48	16	0	0	0	3.00	-0.21
Attain	SO4-4	Recognize the global nature of the marine industry.	1442 Principles of Ship Design	Student interview rubric	13	0	4	0	2.53	16	0	6	1	2.35	14	0	2	0	2.75	-0.11
			6201 Ships and Maritime Systems	Group project presentation grade	22	7	0	0	2.76	18	3	0	0	2.86	15	5	0	0	2.75	0.00
ATTAIN	*SO5: 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*				2018-19					2017-18					2016-17					3-yr.
	Performance Indicators		Barometric Assessment Courses	Barometric Assessment	E	A	M	U	Avg	E	A	M	U	Avg	E	A	M	U	Avg	Trend
Attain	SO5-1	Demonstrate teamwork with shared leadership and inclusive collaboration.	1442 Principles of Ship Design	Teammate Contribution Rubric/CATME/Faculty Rubric	16	0	0	1	2.82	14	7	0	2	2.43	6	6	1	3	1.94	0.443
			1444 Ship Design/System Integration	Peer Rankings/Faculty Rubric	2	11	2	2	1.76	9	6	4	4	1.87	12	0	0	4	2.25	-0.24
Attain	SO5-2	Demonstrate the ability to establish realistic goals, plan tasks, and meet objectives.	1437 Engineering Experimentation	Design Project	5	8	5	0	2.00	5	11	6	0	1.95	2	11	6	0	1.95	0.023
			1442 Principles of Ship Design	Mission Analysis Submittal	8	9	0	0	2.47	4	15	4	0	2.00	8	4	4	0	2.25	0.11
			1444 Ship Design/System Integration	Final Project Report (Executive Summary)	9	8	0	0	2.53	11	12	0	0	2.48	16	0	0	0	3.00	-0.24
ATTAIN	*SO6: an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions*				2018-19					2017-18					2016-17					3-yr.
	Performance Indicators		Barometric Assessment Courses	Barometric Assessment	E	A	M	U	Avg	E	A	M	U	Avg	E	A	M	U	Avg	Trend
Attain	SO6-1	Develop and conduct an experimental procedure to collect data (or test a hypothesis or characterize a system).	1437 Engineering Experimentation	Design Project	5	8	5	0	2.00	5	11	6	0	1.95	2	9	4	1	1.75	0.125
			1444 Ship Design/System Integration	Tow Tank Submittal	3	10	4	0	1.94	4	11	8	0	1.83	12	4	0	0	2.75	-0.4
Attain	SO6-2	Analyze experimental results to draw supported conclusions.	1355 Marine Engineering	Engine Test Bed Lab	15	3	1	0	2.74	5	8	6	0	1.95	23	0	0	0	3.00	-0.13
			1444 Ship Design/System Integration	Tow Tank Submittal	3	10	4	0	1.94	0	16	7	0	1.70	12	4	0	0	2.75	-0.4

Table 1. Student Outcomes, Performance Indicators and Assessment Results (con't)

ATTAIN	*SO7: an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.*				2018-19					2017-18					2016-17					3-yr.
	Performance Indicators		Barometric Assessment Courses	Barometric Assessment	E	A	M	U	Avg	E	A	M	U	Avg	E	A	M	U	Avg	Trend
Attain	SO7-1	Demonstrate ability to teach/improve oneself beyond classroom, e.g., identify knowledge gaps and seek out resources to perform research.	1355 Marine Engineering	Major-specific Position Paper	11	7	1	0	2.53	3	9	7	0	1.79	13	5	2	3	2.22	0.154
			1356 Ship Structures	Aluminum Barge Project	12	5	3	0	2.45	6	9	3	0	2.17	12	11	0	0	2.52	-0.04
Attain	SO7-2	Engage in professional development (professional society, internships, seminars and/or speakers).	1444 Ship Design/System Integration	Student interview rubric	12	5	0	0	2.71	3	4	7	9	1.04	9	3	2	2	2.19	0.259
Attain	SO7-3	Demonstrate an ability to become proficient in new engineering software or tools.	1444 Ship Design/System Integration	Seakeeping Submittal	3	10	4	0	1.94	12	11	0	0	2.52	12	4	0	0	2.75	-0.4
ATTAIN	*SO8 – Demonstrate the ability to apply probability and statistical methods to naval architecture and marine engineering problems.*				2018-19					2017-18					2016-17					3-yr.
	Performance Indicators		Barometric Assessment Courses	Barometric Assessment	E	A	M	U	Avg	E	A	M	U	Avg	E	A	M	U	Avg	Trend
Attain	SO8-1	Apply probability and statistics to NA&ME problems.	1437 Engineering Experimentation	Data Uncertainty Lab	8	10	0	0	2.44	14	5	1	1	2.52	6	1	6	3	1.63	0.41
			1444 Ship Design/System Integration	Tow Tank Submittal	3	10	4	0	1.94	0	8	15	0	1.35	12	4	0	0	2.75	-0.4
NO ATTAIN	*SO9 – Possess a basic knowledge of fluid mechanics, dynamics, structural mechanics, material properties, hydrostatics, and energy/propulsion systems in the context of marine*				2018-19					2017-18					2016-17					3-yr.
	Performance Indicators		Barometric Assessment Courses	Barometric Assessment	E	A	M	U	Avg	E	A	M	U	Avg	E	A	M	U	Avg	Trend
Attain	SO9-1	Demonstrate basic knowledge of fluid mechanics and hydrostatics.	1340 Fluid Mechanics	Modelling and Similitude Exam Question or quiz	19	0	1	0	2.90											
			1242 Applied Naval Architecture & Marine Engineering	Final Exam Excerpt	4	4	6	14	0.93											
Attain	SO9-2	Demonstrate basic knowledge of dynamics.	1211 Dynamics	Vibrations Exam Grade	9	9	4	6	1.75	7	7	0	8	1.59	8	10	2	1	2.19	-0.22
			FE Exam	Dynamics - Student Performance Data	0	17	0	0	2.00	0	17	0	0	2.00	0	0	14	0	1.00	0.5
No Attain	SO9-3	Demonstrate basic knowledge of ship structure and materials.	1356 Ship Structures	Final Exam Grade	3	8	5	4	1.50	3	13	1	1	2.00	7	5	6	5	1.61	-0.05
			1204 Engineering Material Science	Final Exam Grade						3	9	3	7	1.36	7	6	6	4	1.70	-0.85
Attain	SO9-4	Demonstrate basic knowledge of energy/propulsion systems	1453 Ship Propulsion Design	Final Course Grade	5	11	1	0	2.24	16	3	4	0	2.52	3	12	1	0	2.13	0.055
			1355 Marine Engineering	Course Exam Average	6	10	3	0	2.16	2	14	3	0	1.95	8	10	5	0	2.13	0.014
ATTAIN	*SO10 – Exhibit familiarity with instrumentation appropriate to Naval Architecture and/or Marine Engineering including experiment design, data collection, analysis, and formal report*				2018-19					2017-18					2016-17					3-yr.
	Performance Indicators		Barometric Assessment Courses	Barometric Assessment	E	A	M	U	Avg	E	A	M	U	Avg	E	A	M	U	Avg	Trend
Attain	SO10-1	Demonstrate familiarity with instrumentation appropriate to Naval Architecture and/or Marine Engineering including experiment design, data collection, analysis, and formal report writing.	1437 Engineering Experimentation	Design Project	5	8	5	0	2.00	5	11	6	0	1.95	2	9	4	1	1.75	0.125
			1444 Ship Design/System Integration	Tow Tank Submittal	3	10	4	0	1.94	0	0	15	0	1.35	12	4	0	0	2.75	-0.4