A Novel Approach for Integrating the New ABET Student Outcomes (SOs) and Early Impacts on SOs during the COVID-19 Pandemic

Jai Kyoung Jung, Tanjina Afrin, and Thomas Timmes
Virginia Military Institute

Abstract

The Virginia Military Institute Civil & Environmental Engineering (CEE) Department's Civil Engineering Program is ABET (Accreditation Board for Engineering and Technology) accredited, most recently being reviewed in the fall of 2018. The accreditation process requires periodic assessment and evaluation of specific student outcomes (SOs). Beginning with the 2018-2019 accreditation cycle, ABET replaced the previously named SOs (commonly referred to as a listing of "a-k") with a new list referred to as "1-7". Concurrent with a change in our senior leadership, the CEE Department revisited their assessment and evaluation methodology to incorporate the changes in the listed ABET SOs. This effort included establishing accountable SO "Champions" from the faculty members and using a novel "Synchronization Matrix" to ensure reliable data could be collected across the CEE curriculum. Additionally, a Senior Exit Survey was created and distributed to the graduating class. This paper discusses how the new SO assessment methodology was developed and reports analysis of the survey results. Because this effort began during a pre-pandemic semester, this paper offers some early insight about the student perceptions of remote learning as well as direct and indirect assessments impacts on the SOs.

Keywords

Student Outcomes, Assessment, Evaluation, Survey, Pandemic

Introduction

B.M. Olds, et al.[1] demonstrated that continual assessment and evaluation of student performance is critical to maintaining excellence in an undergraduate educational program. Many accreditation agencies, such as ABET, well recognize this fact and emphasize the establishment of such a process as a requirement for accreditation[2]. The ABET accreditation process requires periodic assessment and evaluation of specific student outcomes (SOs). ABET defines an SO as what students are expected to know and be able to do by the time of graduation. Beginning with the 2018-2019 accreditation cycle, ABET replaced the previously named SOs (commonly referred to as a listing of "a-k") with a new list referred to as "1-7". Such changes necessitated revisiting of the assessment and evaluation methodology in the Civil & Environmental Engineering (CEE) Department at the Virginia Military Institute (VMI).

Effective assessment and evaluation processes use a combination of both direct (i.e., behavior observations, performance appraisal) and indirect methods (i.e., focus groups, surveys)[2,3]. Utilizing a direct method, the CEE department established SO "Champions" and designed a novel "Synchronization Matrix" to ensure reliable assessment data would be collected across the CEE curriculum by a variety of professors. As an indirect method, a senior exit survey for the graduating class was created, distributed, collected, and analyzed. This paper discusses how the new SO assessment methodology was developed and offers insights from the survey results. The paper also offers some early feedback from the students on their perceptions of remote learning and observed trends on the direct and indirect assessments of the SOs.

SO Champions

Key attributes of an engaged faculty are their knowledge, support, and dedication to the ABET assessment and evaluation process. These attributes must be manifested consistently throughout the years between official ABET visits. The CEE Department strategically employed a shared approach to address the recurring assessment and evaluation duties every semester. In accordance with ABET best practices and guidance, not every course needs to be included in the direct assessment process and not every SO needs to be evaluated every year. Our analysis led to the development of a novel ABET synchronization matrix to support the assessment and evaluation of SOs 1-7. The matrix uses 16 courses from our core (required) CE curriculum and five 400-level elective courses. Within the matrix, a single course may assess, using performance indicators, between one to three different SOs, and each SO is later evaluated using data from six to seven different assessed courses. Appropriately, an average of six different professors are included in the assessment and evaluation of a particular SO. This purposeful redundancy allows for a steady stream of assessment data despite natural variations of the academic/professional/personal cycles (bi-annual courses, sabbaticals, maternity leave, and retirements).

Every year following the spring graduation, the designated SO "Champion" facilitates the evaluation effort of the collective assessments for a particular SO. The evaluation not only allows for consideration of the data from 100 to 300-level courses, when the students are taking their initial CE courses, but also draws approximately half of the assessment data from 400-level courses typically taken in the students last two semesters prior to graduation. With this approach, the extent to which the SOs are being attained by the students can be evaluated longitudinally and specific to the ABET definition of a SO, "*…by the time of graduation*"[4].

After the formal evaluation of the assessment data, the designated SO Champion documents the "State of the SO" for that academic year and joins with the other SO Champions to identify trends and solicit ideas for continuous improvement of the full CE Program (as required by Criterion 4, Continuous Improvement). The process concludes with conversion of the ABET synchronization matrix to a snapshot color-coded "scorecard" (Figure 1) to document the state of the SOs. Our methodology assigns the color green to an SO evaluated to be above 80% attained, amber to the 70-80% attainment level and red to an SO below the 70% attainment level. In the example "scorecard" seen in Figure 1, assessments were mostly "green" with a few courses assessed as "amber". Following discussion and evaluation of the assessments, only SO 6 was coded holistically as "amber" as seen in the topmost row. The faculty would then generate and document their ideas for continuous improvement of SOs throughout the CE program.

ABET Sync Matrix AY20xx		SO 1 Problem Solving	SO 2 Engineering Design	SO 3 Communi-cation	SO 4 Ethics	SO 5 Team Work	SO 6 Experiment	SO 7 Aquire & Apply	SOs per Course
Core Courses									
CE Fundamentals I	Semester 1				Fall				1
CE Fundamentals II							Spring		1
Surveying Lab						Fall	Fall		2
Engineering Geology						Fall/Spring			1
Structural Theory		Fall	Fall					Fall	3
Engineering Materials			Fall/Spring					Fall/Spring	2
Engineering Materials Lab				Fall/Spring		Fall/Spring	Fall/Spring		3
Soil Mechanics		Fall/Spring						Fall/Spring	2
Soil Mechanics Lab						Fall/Spring	Fall/Spring		2
Water Resources		Spring						Spring	2
Water Resources Lab				Spring		Spring	Spring		3
Environmental Engineering			Fall		Fall				2
Transportation Engineering		Spring			Spring				2
Civil Engineering Seminar				Fall	Fall				2
Reinforced Concrete Design		Spring	Spring						2
CE Design Capstone	Semester 8		Spring	Spring	Spring	Spring			4
	# of Core Courses	5	5	4	5	6	5	4	
400-level Elective Courses									SOs per Course
Hydrology		Fall	Fall					Fall	3
Environmental Engr Design				Spring		Spring	Spring		3
Structural Steel Design			Fall					Fall	2
Advanced Structural Theory		Spring					Spring		2
Haz Waste Treatment				Spring	Spring				2
	# of Electives	2	2	2	1	1	2	2	
	Total Courses	7	7	6	6	7	7	6	
	# of Profs Assessing	5	6	5	5	7	7	6	

Assessment & Evaluation Key	
Green	>80% Attained
Yellow	70-79.5% Attained
Red	<70% Attained

Figure 1. A notional ABET synchronization matrix "scorecard" showing the courses used to assess Student Outcomes (SOs) and the extent to which the SOs are attained (color-coded).

COVID-19 Pandemic Changes and Impacts

The above-described novel approach was implemented in the fall 2019 semester and used to generate subsequent continuous improvement efforts. During the fall 2019 semester, initially eight courses were used to assess SOs 1-7 and the professors all reported "green" assessments with just minor concerns noted for their courses. In the spring 2020 semester, all courses were offered via remote learning platforms after mid-March. By the spring 2020 semester, 11 courses were now being used for SO assessments. Three courses (e.g., soil mechanics, soil mechanics lab, and transportation engineering) were taught in both the fall and spring semesters. Therefore, these professors had the opportunity to uniquely compare their courses to identify the possible effects of the overall COVID-19 pandemic on student performance. Comparison of assessment data with these courses showed generally positive results. In the soil mechanics course, student performance improved, possibly due to the nature of the online education format. The students could access lecture videos and pause/restart them as desired. The students also provided insightful feedback on the length of video, preferring multiple shorter topical videos rather than one long recording of the full lecture. In addition, a number of topics were reviewed more in spring 2020 than in past semesters in preparation for the final exam.

For the spring 2020 semester, as a whole, students performed comparable to historic norms. Where the student performance was markedly improved, as seen in the soil mechanics and reinforced concrete courses, possible reasons include the delivery of highly effective class materials from engaged professors using multiple technologies. Student feedback offered that having the ability to watch and re-watch a lecture helped them learn on their own time and pace. A number of faculty made a quiz for every video lecture, which also helped motivate and focus the students. Faculty efforts to set a hard (punitive) deadline for submissions seemed to improve student engagement with self-motivated work (e.g., watch the video, complete the practice problems, and take the quiz). There was also a possibility that 'lack of the challenges of student dormitory life' (a unique situation in VMI) allowed them to concentrate more on their coursework. For the CE capstone course, some student groups were able to produce CAD drawings and other visuals using programs other than AutoCAD that were as good or better than past years. The students that performed best saw and took the opportunity for an "out of the box" initiative to get the work done.

Senior Exit Survey

The senior exit survey was distributed to the 2020 May graduating class. Thirty of the 45 surveys administered were received for a response rate of 67% with margin of error of 10% at the confidence level of 95%. Fan and Yan[5] along with several other studies[6-11] reported their survey response rate as acceptable at approximately 25% and the response rate of this study exceeds the acceptable rate suggested by those researchers. The survey questions were developed to generate indirect data about the student perceptions of their aptitude in attaining the goals of each ABET SO. The students were asked to rate their response to essay statements or questions in a five-level Likert-type scale. For consistency, as of 2020 May, the CEE faculty all agreed to use the 5 point Likert-type scale for their assessments. As discussed in the "scorecard" description, a rating between 4 ~ 5 is color-coded green, 3.5 ~ 4 is amber, and less than 3.5 is red.

Table 1. Assessment of SO from Faculty and Student

	SO1 Problem Solving	SO2 Engineering Design	SO3 Communication	SO4 Ethics	SO5 Team Work	SO6 Experiment	SO7 Acquire & Apply
Faculty	4.06	4.12	4.31	3.82	4.26	4.15	3.90
Student	3.97	4.00	4.22	4.70	4.24	4.40	4.17

The assessment results from the CEE faculty and students are summarized in Table 1. Table 1 ties together the faculty's direct method of assessment and the student's indirect method drawing from their perception of their attainment of the particular SO. In other words, students assign their own Likert-type scale no matter what grade they received from the class. Overall, the assessment results from faculty members and students show strong agreement. This agreement strengthens the evaluation process and shows the value of including indirect assessment data. The largest gap between the two groups is SO 4. To address this gap, the options include revisiting the assessment method used by faculty members, modification of the question in the survey, or a continuous improvement initiative targeting SO 4.

Following the SO assessment questions, the students answered additional questions that utilized a hypothesis test and Pearson's r computation. The questions are summarized in Table 2. The intention of these questions was to identify the possible factors that affects the attainment of the SOs and then perform a hypothesis test. For example, does having an internship (Q26) improve the student outcomes (hypothesis)? The survey results, while an indirect measurement, contributed towards identifying opportunities for continuous improvement initiatives.

Table 2. Summary of Hypothesis and Correlation Questions

	Questions
Q26	Were you able to intern at a company specific to your major during your cadetship?
Q31	How do you rate your overall CEE experience?
Q35	Have you taken the Fundamentals of Engineering (FE) Exam?
Q36	Do you prefer attending an in-class course or a distance learning course?

An independent-samples t-test was performed to compare SOs and Q26, Q35, and Q36. There was a significant difference in the scores for internship experience ($M = 1.71$, $SD = 0.77$) and no internship experience ($M = 2.42$, $SD = 0.90$) for SO 5; $t(27) = 2.28$, $p = 0.03$. The results suggest that having the internship experience may have a positive effect on their perception of attaining SO 5. By contrast, additional analysis suggests that the survey sample did not provide sufficient evidence to conclude that taking the FE exam (Q35), nor online/face-to-face class preference (Q36) effected the SOs. However, at the same time, the lack of evidence does not prove that the effect does not exist. New and re-worded questions will be implemented in the future version of the survey as a result of this process.

A Pearson product-moment correlation coefficient (Pearson's r) was computed to assess the relationship between the CEE experience (Q31) and each SO. There was a positive correlation between the CEE experience and SO 5 ($r = 0.485$, $n = 30$, $p = 0.007$), and SO 6 ($r = 0.410$, $n = 30$, $p = 0.024$). In addition, a positive correlation was found between the CEE experience and students' GPA ($r = 0.451$, $n = 30$, $p = 0.012$). Overall, it can be concluded that increases in the CEE experience were correlated with increases in rating of SO 5, SO 6, as well as high GPA.

The survey results revealed that 57% of students rated their CEE experience as 92 or better and 70% rated it as 85 or better. This is an encouraging result and as a follow-up, an open-ended essay question asked why the students rated their CEE experience as they did. The responses were all categorized by content to determine patterns in the responses. The results revealed that professor/teacher plays an important role imparting a good CEE experience. Having a fun learning environment is also seen as an important and notable factor.

Because of COVID-19 pandemic, VMI turned all classes into an online format after the spring break, similar to many other colleges nationwide. Therefore, in the same semester, the students had a chance to experience in both face-to-face and online remote learning. Seventy percent (70%) of students preferred the traditional face-to-face classes, even though 64% of students felt their workload decreased or stayed the same after transitioning to online classes. Then the students were asked to choose three greatest distractions during the face-to-face and online learning formats. The results are summarized in Figure 2. During the face-to-face class, the students indicated free time, personal entertainment, and friends as the greatest distraction. However, 'friends' became the least distractive factor when transition to online and remote learning. Instead, helping with family obligations, lack of peer/instructor support, and lack of physical resources emerged as key distractors. The department may not be able to control the family obligations or lack of physical resource, but the perceived lack of peer/instructor support is definitely an area for a continuous improvement initiative.

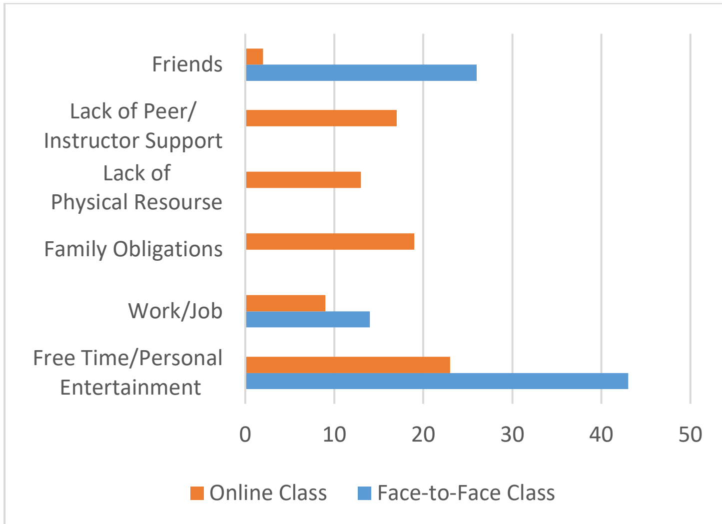

Figure 2. Factors Distracting Students

Conclusions

This paper has discussed a novel approach of integrating and implementing ABET's newly listed SOs in a CE curriculum, some early insights while assessing the SOs during the COVID-19 pandemic, and the trends when comparing direct and indirect assessment data from a new senior (graduate) exit survey.

- The novel strategy included establishing SO "Champions" who used a synchronization matrix to collect performance data across the CE curriculum from a variety of courses and professors.
- At the end of each spring semester, the designated SO champions evaluated the assessment data from these courses, documented the "State of the SO" for that year, identified trends, and solicited ideas for continuous improvement.
- Early data showed the abrupt transition to remote learning did not significantly affect the overall student attainment of the SOs. While this finding is promising and speaks well to the adaptive nature of faculty and students alike, continued analysis of the trends is essential to better guide the continuous improvement of the CE curriculum.
- Analysis of a new senior (graduate) exit survey revealed good correlation between the faculty (direct) assessments and the student (indirect) assessments of the SOs.
- Student feedback following the switch to remote learning coupled with answers from the exit survey suggested that professor effort to integrate new techniques and technologies

and a fun learning environment are notable factors for a perceived good college experience.

- Successful adoption of such techniques and technologies seem to strengthen the peer/instructor support and may ultimately benefit the departmental goal of maintaining a fun learning environment.

In the future, with a larger set of longitudinal data, the faculty can better identify trends and opportunities for continuous improvement and further optimize student attainment of the SOs. The authors hope that the novel and strategic effort described in the paper will benefit engineering programs at many other colleges.

References

1 Olds, Barbara M., Barbara M. Moskal, and Ronald L. Miller. "Assessment in engineering education: Evolution, approaches and future collaborations." Journal of Engineering Education 94.1, 2005, 13-25.

2 Sundararajan, Sriram. "A strategy for sustainable student outcomes assessment for a Mechanical Engineering program that maximizes faculty engagement." 121st ASEE Annual Conference and Exposition, Indianapolis, IN, 2014.

3 Rogers, G. "Assessment for continuous improvement: What have we learned?" International Journal of Engineering Education, v18, 2002, 108-109.

4 ABET, www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2020-2021/.

5 Fan, Weimiao, and Zheng Yan. "Factors affecting response rates of the web survey: A systematic review." Computers in human behavior 26.2, 2010, 132-139.

6 Visser, Penny, Jon Krosnick, Jesse Marquette, and Michael Curtin. "Mail surveys for election forecasting? An evaluation of the Columbus Dispatch poll." Public Opinion Quarterly 60, no. 2, 1996, 181-227.

7 Curtin, Richard, Stanley Presser, and Eleanor Singer. "The effects of response rate changes on the index of consumer sentiment." Public opinion quarterly 64.4, 2000, 413-428.

8 Keeter, Scott, Courtney Kennedy, Michael Dimock, Jonathan Best, and Peyton Craighill. "Gauging the impact of growing nonresponse on estimates from a national RDD telephone survey." International Journal of Public Opinion Quarterly 70, no. 5, 2006, 759-779.

9 Holbrook, Allyson L., Jon A. Krosnick, and Alison Pfent. "The causes and consequences of response rates in surveys by the news media and government contractor survey research firms." Advances in telephone survey methodology 1, 2008, 499-528.

10 Locke, Richard, Cathy Schleck, Jeanette Ziegenfuss, Timothy Beebe, Alan Zinsmeister, and Nicholas Talley. "A low response rate does not necessarily indicate non-response bias in gastroenterology survey research: a population-based study." Journal of Public Health 21, no. 1, 2013, 87-95.

11 Afrin, Tanjina, Jai Kyoung Jung, Matthew Swenty, Paul Ackerman, Thomas Timmes, and Charles Newhouse. "Predicting and Preventing Perception Problems in Freshmen Engineers." ASEE SE Annual Conference, Raleigh, NC, 2019.

Jai Kyoung Jung

Jai Kyoung earned his Ph.D. in Civil and Environmental Engineering at Cornell University. His research topics include computational and experimental approaches to infrastructure sustainability. As an Assistant Professor, he teaches geotechnical engineering and foundation design at VMI. At the same time, he is expanding his research topics in multidisciplinary areas including big data analysis for condition assessment of underground infrastructure system.

Tanjina Afrin

Tanjina earned her Ph.D. in Civil Engineering from Clemson University. She is currently an Assistant Professor at VMI. She teaches basic fluid mechanics, water resources engineering, and hydrology. She enjoys helping students with their class/research projects.

Thomas Timmes

Thomas is a 1992 graduate of VMI who spent over 25 years working as an environmental engineer in the U.S. Army Medical Service Corps. He earned his M.S.E. from Johns Hopkins University and his Ph.D. at Penn State University. As a Professor at the VMI, he teaches the environmental engineering courses and enjoys working with students on research projects in the environmental engineering laboratory.