Work in Progress:The Development of a First-Year Engineering Program Assessment Framework

Dr. Cory Brozina, Youngstown State University

Dr. Cory Brozina is an assistant professor and the Director of First Year Engineering at Youngstown State University. He completed his B.S. and M.S. in Industrial & Systems Engineering from Virginia Tech, and his PhD is in Engineering Education, also from Virginia Tech. His research interests include: Learning Analytics, First-Year Engineering, and Assessment.

Work in Progress: The Development of a First-Year Engineering Program Assessment Framework

Abstract: This WIP paper will describe the initial development of a framework to help first-year engineering programs in their assessment and evaluation activities. There continue to be calls to increase the rate at which engineers graduate with a degree while retaining the students who enter into an engineering program. Consequently, first-year engineering programs are on the rise nationally as engineering colleges continue to see the increased value that first-year programs provide to students motivation, identity development, and overall success in engineering. Additionally, as students transition from high school to the first year of engineering, it is imperative programs develop a comprehensive assessment framework to ensure students are not only meeting learning objectives in courses but integrate into the university environment on multiple measures.

Therefore, this paper brings together student-learning objectives along with student-growth objectives to produce a detailed framework to understand the development of first-year engineering students holistically. By combining ABET outcomes one through seven, with theoretically-grounded assessment measures of motivation and identity, along with student support and success measures, we propose a comprehensive way to assess a first-year engineering program. This framework will allow first-year engineering administrators to detail the growth and development of their program in an easily relatable manner to engineering department chairs and college deans by providing a high-level view of first-year engineering.

Introduction

The call for an increase in the number of technical-minded graduates will not dissipate anytime soon in this current world of technological advancement. Engineering colleges are under pressure to not only graduate students but to graduate more well-rounded engineers who can tackle the many challenges we face. To meet the call, colleges are putting more efforts to create robust first-year experiences for engineering students through the development of formal first-year engineering programs (Bates, 2014; Rabb, Howison, & Skenes, 2015).

As first-year engineering gains traction with nearly 60% of engineering programs having a first-year engineering course (Chen, Brawner, Ohland, & Orr, 2013), there are needs to conduct more formal research within the first-year engineering space. One specific need is for a program-wide assessment and evaluation plan that goes beyond student-learning objectives and incorporates programmatic initiatives such as increased retention and student motivation. These student-growth objectives are often missing in an assessment plan for first-year engineering.

Literature Review

First-Year Engineering Programs

First-year engineering (FYE) programs have a wide variety of goals and outcomes for their students. There is no one model that fits all programs' approach, and the structure and content of each program depend upon the needs of the students and institution. Recently, Reid, Reeping, and Spingola (2018) introduced a taxonomy, or classification list, for an introduction to engineering

courses. The FYE classification list details the content areas in which first-year course elements may include: (1) Design, (2) Professional Skills, (3) Engineering Profession, (4) Academic Advising, (5) Math Skills, (6) Engineering Tools, (7) Global Interests, and (8) Communication. First-year courses do not necessarily include all of those elements, but typically most course elements can be mapped to the classification list.

For example, one element of a first-year program is that of engineering design, which is introduced in the first-year to students to get a better understanding of what engineers do (Dym, 1999). This element maps to the design element of the classification list.

While the varying elements of first-year engineering courses help students understand engineering and the various disciplines better (Meyers, Bucks, Harper & Goodrich, 2015; Meyers & Brozina, 2016) there are additional benefits to a common first-year engineering program which includes increased student retention (Brawner, et al., 2009; Ohland, Brawner, Chen, & Orr, 2014), increased motivation, and higher identity with the field of engineering.

With the multitude of objectives that can be included within a first-year engineering program, there is the need to properly assess and evaluate the program outcomes.

Assessment and Evaluation of First-Year Engineering

It is critical that first-year engineering programs have a plan to assess the objectives and outcomes. Continuous improvement will allow a program to make adjustments along the way to meet their objectives and outcomes for students. Recently, Spurzer, Douglas, Folkerts, and Williams (2017) developed an assessment framework for the first-year introduction to engineering courses which focuses on student-learning objectives. While this is much needed, there is an opportunity to expand beyond assessing only student-learning objectives to include student-growth objectives (e.g., motivation, identity, self-efficacy, integration). The term student-growth objective is coined from the ever-expanding research and instruments used to measure student development. Therefore, this work in progress paper proposes an initial framework which includes both student-learning and student-growth objectives to help administrators assess first-year engineering program-wide.

Proposed Framework

In any assessment plan, it is important to break down the list of objectives and outcomes so that valid and reliable assessment measures can be utilized to evaluate a program. In Figure 1, we display our framework to include both student-learning and student-growth areas. Each area includes objectives (1a/2a), outcomes (1b/2b), assessment measures (1c/2c), and evaluation (1d/2d).

(1a) Student-Learning Objectives and (2a) Student-Growth Objectives

It is important to determine what the objectives of the program will contain, both student-learning and student-growth. Listed in Figure 1 part (1a) and (2a) are examples of objectives for a first-year engineering program. It is not necessary to include all the listed objectives, but those listed serve as a model for what a first-year program's mission can include.

First-Year Engineering Program					
(1a) Student-Learning Objectives			**(2a) Student-Growth Objectives**		
Multiple elements of the FYE Classification scheme can be used to define your overall learning objectives for your program.			In addition to learning objectives it is important to define growth objectives to ensure students develop and mature into successful engineering students who receive proper support.		
FYE Classification List			**FYE Growth List**		
(1) Design	(2) Professional Skills	(3) Engineering Profession	(1) Retention	(2) Persistence	(3) Motivation
(4) Academic Advising	(5) Math Skills	(6) Engineering Tools	(4) Identity	(5) Belonging	(6) Integration
(7) Global Interests	(8) Communication				
(1b) Student-Learning Outcomes			**(2b) Student-Growth Outcomes**		
You will use your student-learning objectives defined in (1a) to create more in-depth details of the outcomes for your program.			You will use your student-growth objectives defined in (2a) to create more in-depth details of the outcomes for your program.		
Example 1: ABET 1-7 criteria (note: typically not all 1-7 outcomes will be assessed in a FYEP)			Example 1: Increase motivation in Course X and Course Y.	Example 2: Ensure students integrate academically to the program.	Example 3: Develop a sense of engineering identity among students in the program.
(1c) Assessment Measures			**(2c) Assessment Measures**		
There are numerous ways in which to assess student-learning outcomes both quantitatively and qualitatively. But you must determine what works best for your program (e.g. test questions, questionnaire, focus group, design presentations, lab reports, etc.)			Example 1: Use the MUSIC Model of Academic Motivation instrument.	Example 2: Use the Academic Integration construct within the ESII.	Example 3: Use the "Identity" instrument.
(1d) Evaluation			**(2d) Evaluation**		
For each assessment measure it is important, a priori, to determine your goal/standard for each measure.			For each assessment measure it is important, a priori, to determine your goal/standard for each measure.		

Figure 1: A proposed framework for assessing a first-year engineering program

(1b) Student-Learning Outcomes and (2b) Student-Growth Outcomes

Once the objectives are determined, a set of outcomes can be developed for each objective listed in parts (1a) and (2a). For example, ABET criteria 3, an ability to communicate effectively with a range of audiences would be an outcome if an objective of the program is to develop the professional skills of students. Beginning in the 2019-2020 review cycle ABET has changed Criterion 3: Student Outcomes from (a)-(k) to 1-7. If motivation is a student-growth objective, then to increase motivation in course X and Y could be used as an outcome.

(1c & 2c) Assessment Measures

Once outcomes are determined, valid and reliable assessment measures should be used to determine the quality of each outcome. There are multiple ways to assess both student-learning and student-growth outcomes, but it is imperative that they be both valid and reliable measures. For instance, if an outcome is to increase the academic integration of the first-year program, the academic integration construct within the engineering student integration instrument (Lee, Godwin, Nave, 2018) which consists of five Likert-scale questions ranging from strongly disagree to strongly agree. Recently, the student integration instrument has been used to measure first-year commuter student support and success (Brozina, 2018).

(1d & 2d) Evaluation

Often missed in an assessment plan is an evaluation aspect containing the goals for the program for each measure assessed. The goals of each assessment metric will be different and depending on the state of the program. For instance, if academic integration is a major concern of the program

and is either initially low or perceived to be low, then a goal may be to average a 5.0 on a 7-point scale. It is dependent on the needs to the program where each goal will be set.

Future Directions

The future directions of the assessment framework will be to theoretically ground the student-growth objectives list from the broader first-year experience literature. The initial creation of the FYE growth list was put together from general knowledge from the field of engineering education assessment. However, it must be grounded within literature to have a fundamental impact moving forward. Additionally, it will be essential to develop further and expand the FYE growth list and to develop a comprehensive list of valid and reliable assessment measures for each element on the FYE growth list. Having a full list of instruments in which administrators can assess a first-year program will help garner support for moving beyond measuring only student-learning outcomes. This detailed list will ensure the development of a better-rounded first-year program.

Conclusion

The development of a comprehensive assessment framework for first-year engineering programs that goes beyond student-learning objectives and includes student-growth objectives is much needed. This need is brought about by an understanding that the experience students have in their first-year is critical to their development and growth. By developing an assessment framework that helps administrators clearly understand and develop a path to assess both student-learning and student-growth objectives greater benefits will come from first-year engineering programs.

References

Bates, J. S. (2014, June), *A First-Year Course Based on Conceptual Design* Paper presented at 2014 ASEE Annual Conference, Indianapolis, Indiana.

Brawner, C., Camacho, M., Long, R., Lord, S., Ohland, M., and Wasburn, M. (2009) Work in Progress – The Effect of Engineering Matriculation Status on Major Selection. ASEE / IEEE Frontiers in Education Conference, San Antonio, TX.

Brozina, C. (2018). Measuring commuter student support and success through academic integration. In 2018 IEEE Frontiers in Education (FIE) (pp. 1-4). San, Jose, CA. IEEE.

Chen, X., Brawner, C. E., Ohland, M. W., & Orr, M. K. (2013). A taxonomy of engineering matriculation practices. *American Society for Engineering Education Annual Conference,* Atlanta GA.

Dym, C. (1999) Learning Engineering: Design, Languages, and Experiences. Journal of Engineering Education, Volume 88, Issue 2, pg. 145-148.

Lee, W. C., Godwin, A. and Nave, A. L. (2018), Development of the Engineering Student Integration Instrument: Rethinking Measures of Integration. J. Eng. Educ., 107: 30-55. doi:10.1002/jee.20184

Meyers, K., & Brozina, C. (2017). *Supporting an Informed Selection of an Engineering Major.* Paper presented at the American Society for Engineering Education Annual Conference, Columbus, OH.

Meyers, K., Bucks, G., Harper, K., & Goodrich, V. (2015, June), *Multi-Institutional Evaluation of Engineering Discipline Selection.* Paper presented at the ASEE Annual Conference and Exposition, Seattle, Washington. 10.18260/p.24512

Ohland, M., Brawner, C., Chen, X., and Orr, M. (2014) A Comparative Study of Engineering Matriculation Practices. American Society for Engineering Education National Conference, Indianapolis, IN.

Purzer, S., Douglas, K. A., Folkerts, J. A., & Williams, T. V. (2017). An assessment framework for first-year introduction to engineering courses. Paper presented at the ASEE Annual Conference and Exposition, Columbus, OH.

Rabb, R. J., & Howison, J., & Skenes, K. (2015, June), *Assessing and Developing a First-year Introduction to Mechanical Engineering Course* Paper presented at 2015 ASEE Annual Conference and Exposition, Seattle, Washington.

Reid, K., Reeping, D., & Spingola, E. (2018). A Taxonomy for Introduction to Engineering Courses. *International Journal of Engineering Education*.