AC 2011-1903: ASSESSING FIRST-YEAR PROGRAMS: OUTCOMES, METHODS, AND FINDINGS

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Abstract

First-year programs reflect a wide array of approaches, from general engineering programs to discipline-specific introductions to the major spanning one or two semesters; many of these programs have published descriptions of their approaches to assessment and the effects of various intervention strategies on student retention or specialized outcomes. Yet much of this work remains localized; little research to date has examined assessment across multiple programs to identify large-scale trends, locate similarities and differences in targeted learning outcomes, analyze methods of assessment, and identify best practices. As engineering education focuses on continuous curricular enhancement to best address the needs of 21st-century engineers, however, the community has a strong need to develop and share robust methods of assessing a variety of outcomes at the first-year level. This paper begins to address this need by providing a preliminary review of existing approaches discussed in the literature in recent years.

Introduction

In recent years, the terms "cornerstone" and "capstone" have emerged as markers to describe the first and last years of the engineering curriculum. Capstone courses emerged from industry concerns about deficits in graduating engineers and are now embedded in accreditation requirements[1, 2]. As a result, although diversity in capstone experiences persists across majors, institutions, and even individual faculty [3, 4], these external pressures have yielded a relatively high degree of consensus around the learning outcomes, teaching approaches, and assessment [3-7]. For example, in McKenzie et al.' 2004 survey[7] of capstone faculty, over half of all capstone instructors considered all eleven of the ABET-identified student learning outcomes appropriate for assessment in the capstone course, and more than three-quarters actually assess at least five of the eleven outcomes. Communication, problem-solving, use of engineering tools, designing to meet a need, and the application of mathematics, science, and engineering dominate the list of assessed outcomes, while lifelong learning, understanding contemporary issues, and identifying impacts of engineering solutions, though identified as important outcomes, were assessed by less than half of the respondents. Even more notably, capstone faculty appear to have consensus around how to conduct assessment, with over 90% using final written and oral reports as the means to evaluate student learning, though as McKenzie noted, there was significant variation in how these assessments were applied and used, and few if any standard evaluation rubrics are used across programs (though several have been developed).

While capstone courses are driven largely by a sense of industry and accreditation expectations for graduates, cornerstone courses, as first-year engineering programs have come to be called, span a much greater spectrum in terms of learning outcomes and assessment approaches. Although first-year engineering programs have existed for decades and the first-year programs division of ASEE has a long history, the term cornerstone has risen primarily in the 21st century as a potential locus for defining the goals and outcomes appropriate to this level [8, 9] Sheppard, in her 1997 call for a renewed focus on design in the first-year, notes the way in which first-year design courses began to emerge in the late 1960s out of concern for gaps in students' design abilities, growing throughout the '70s and '80s only to wane again in the '90s as the pressure to increase the "technical" content of the curriculum grew.[9] Beginning in the late '90s with the work of Sheppard and others[8, 9], and continuing through the 2008 Carnegie Foundation report on engineering education[10], the past decade has seen a renewed call for design-focused first-year programs (and, more recently, design across the curriculum[1, 10]).

Despite these calls, however, and a general concern for helping students develop both professional skills and a professional identity, first-year programs remain exceptionally diverse in their approaches, learning outcomes, and modes of assessment. Approaches range from general engineering programs with a focus on design in a broad sense to discipline-specific introductions to the major with projects localized to a specific field; from a single course spanning one quarter or semester to full-year sequences; from a general set of science and mathematics courses to cornerstone engineering courses that emphasize design and professional development. This diversity can make it challenging to provide analysis across programs, reach consensus about appropriate learning goals for first-year students, or develop systematic approaches to assessment.

It is through the issue of assessment that we approach this diversity; the emphasis on assessment nationally makes it a natural focal point, and any discussion of assessment inevitably raises issues associated with both learning outcomes and implementation structures. Our goal in conducting this review is to provide the first-year engineering community with a preliminary overview of areas of consensus and areas of difference in approaches to first-year programs. Such an overview, we believe, can be an effective starting point for more robust cross-institutional discussions of both what students need in the first year and how we as a community of practice can most effectively implement a cycle of assessment and improvement to help address those needs. This analysis, we hope, provides a first step towards such a discussion.

Method

The literature review was conducted by through a database search for articles pertaining to the assessment of first year or freshman engineering courses published in the last five years. Articles that focused on describing course implementations with little or no discussion of approaches to assessment were excluded from the review. Sources included the ASEE/IEEE Frontiers in Education Conference and the American Society for Engineering Education Annual Conference as well as the *Journal of Engineering Education*, and related engineering education journals and conferences. We note that the current such should not be considered exhaustive at this time because of the large number of papers associated with this area. To date, the review includes 50 articles, listed in Appendix A for reference. The articles were categorized based on the focus of the assessment and types of instruments used.

Findings

Focus: What outcomes are we assessing?

As noted above, an earlier review of approaches to design in the first-year engineering programs reflected a wide range of approaches and learning outcomes. In general, however, approaches to assessment identified through this literature fell into two broad categories, retention and design, with retention and related concerns as the clearly dominant issue. Of the 50 articles reviewed, almost half (23) addressed the impact of first-year programs on issues related to retention, motivation or attitudes towards engineering, and academic success. Design was the second most-dominant issue in discussions of assessment: approximately a third (16) focused on specific skills associated with design and problem solving, though often in conjunction with retention and motivation issues.

The prominence of retention and motivation issues in the assessment of first-year programs emerges in a variety of ways. In some instances, assessment focused on programs or pedagogies implemented specifically to improve retention and/or motivation. In such cases, factors related to retention and success (e.g. student satisfaction, grades, motivation constructs) were the sole focus of the assessment. In many cases, however, retention was included as a factor in conjunction with pedagogies designed to address other technical or professional learning outcomes. Assessment then included both specific learning gains (e.g. performance on design or problem-solving tasks) and retention measures. It is also important to note that this category includes assessment related to retention after the first year and to motivation (measured either through somewhat generic 'student satisfaction' surveys or through established motivation frameworks such as expectancy-value or self-efficacy).

Assessment related to design and problem-solving practices also took a variety of forms, and in many instances was linked to retention issues as well as to professional skills such as teamwork. Researchers included assessment related to design process knowledge, confidence in design-related tasks, and project outcomes.

Beyond these two core issue, researchers reported localized assessment efforts around a number of professional issues, including teamwork, ethics, communication, and leadership. Specific course-related topics, such as spatial analysis or localized topics within a field, also emerged in small numbers (though some of these issues were themselves tied to students' success in subsequent courses). A small number of studies focused on comparing teaching approaches to identify approaches that lead to higher learning gains.

Methods: How are we conducting assessments?

With respect to the methods used to conduct assessment, surveys dominated the literature reviewed, with more than half of the papers reporting survey data. Most surveys addressed issues related to student satisfaction and attitude, though many also included self-reported learning gains. In addition, several scholars report using faculty as well as student surveys to evaluate both satisfaction and perceptions of learning gains. In most cases, however, to conduct assessment related to satisfaction and motivation researchers developed individualized and localized instruments, often relying on five-point Likert-scale questions. Few studies published instruments, and few drew on instruments established by motivation theorists such as Deci and Ryan or Eccles to provide a framework for understanding satisfaction and motivation responses, though such instruments are becoming more common in newer work on assessment as these frameworks become more widely know.

Given the concerns for retention, it is not surprising that achievement scores also figured prominently in approximately a third of the articles reviewed, as measured by grades (on an assignment, within a first-year course, and in subsequent courses) as well as localized course-specific tests and standardized tests such as concept inventories. In the same way, retention rates were a dominant metric in a number of studies, though retention was equally often measured through students' self-reports regarding major and career plans rather than institution reports.

To measure learning gains, researchers used a variety of instruments, include pre- and post tests and evaluation rubrics. Scoring rubrics were applied in several instances, particularly as related to design and problem-solving performance, though few if any rubrics appeared in common use across programs.

Other approaches to assessment included resource-intensive activities such interviews, focus groups, and analysis of student texts, though these methods were employed most often when assessment was conducted in the course of a broader research project (e.g. comparison of teach methods, exploration of research questions about retention and persistence) rather than as a regular mechanism for course or student evaluation. Finally, a small number of articles included measures such as peer evaluations and attendance as measurement tools.

Importantly, especially in more recent years, a number of articles represented multiple methods of assessment to triangulate data around a critical construction – for example, student satisfaction reports coupled with final course grades or retention rates or student-reported learning gains coupled with faculty perceptions.

Implications and Conclusions

The preceding review of approaches to assessment point to two significant issues facing engineering educators concerned with first year programs.

1. Outcomes surrounding retention and support for success currently dominate the literature.

The dominance of these issues suggests that they represent one clear point of consensus among first year educators with respect to course goals and desired outcomes. Retention itself is one clearly identifiable metric, though approaches to measurement (self-reports versus institutional data) vary slightly. Approaches to satisfaction and motivation, however, are more varied, and only in the most recent work do we begin to see use validated instruments across programs or the emergence of a common vocabulary around critical terms.

At the same time, the lack of dominant trends around specific learning outcomes suggests a potential lack of consensus around other goals for first year programs, with the exception of design and problem-solving broadly conceived. "Design," often blurred with problem-solving or with experimental demonstrations of engineering principles, is one obvious second area for consensus, but the diversity of approaches identified through the review suggests that our community lacks a clear sense of what design outcomes, at what level, are appropriate at the first-year. Unlike capstone courses, where both accreditation and industry expectations provide at least a starting point for defining expected levels of success, cornerstone design programs lack a robust framework for determining appropriate outcomes within and across majors and institutions.

Beyond retention and design-related outcomes, however, the research shows little overlap in learning outcomes that merit assessment. While diversity in outcomes is expected both by discipline and by institution, the results of this review suggest a significant opportunity for the engineering educators to engage together in a robust discussion about how to identify and measure a core set of learning outcomes that might be applicable either within or across certain disciplinary or institutional contexts.

2. Survey methods appear to dominate assessment approaches, though rubrics, grades, and tests play a notable role. However, instruments are rarely shared across studies.

Despite the prominence of surveys as an assessment tool, and the development of a number of useful survey instruments by researchers in engineering education and related fields, few instruments are used across contexts. While assessment is, and in many respects should be, a localized effort that takes into account the specific context in which a course or program operates, the availability of validated instruments to measure student motivation, persistence, and attitudes, and the relative absence of these instruments from the articles reviewed, suggests a significant area for discussion among first-year educators. We may, perhaps, be spending a great deal of time "re-inventing the wheel," by developing unique instruments for each course, when both the course administrators and the community at large would be well served to identify instruments that could be effective across institutions.

Similarly, although rubrics, too, often need to be customized to local outcomes and contexts, this review points to the possibility of educators working together to develop a core or base set of rubrics for key outcomes such as design that could provide a basis for more localized approaches. That is, while one rubric certainly would not fit all institutions, a set of rubrics that identify both areas to measure and ways of articulating performance levels could provide a useful starting point for developing a community of practice and a shared discussion around these issues.

These two issues – the relative lack of consensus on learning outcomes beyond retention (and potentially design) and the lack of instruments that can be used across contexts – point to key areas for further research and discussion among first-year educators. The sheer number of articles written about first-year programs indicates both the importance of these course and the passion that faculty have for effectively engaging and supporting students at this critical junctions. Building a strong community of practice in dialogue with one another around these core issues can be a key step in achieving those goals.

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Appendix A: Articles Reviewed

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