The Changing Role of Assessment in Engineering Education: A Review of the Literature

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Abstract

This review shows that engineering educators are putting a lot of effort into preparing for accreditation visits based on EC 2000 criteria. Many schools have developed their assessment plans; they have articulated objectives and outcomes. Although most of the published plans place a heavy emphasis on traditional assessment methods, non-traditional techniques such as journals and portfolios are gaining acceptance among some leaders in the engineering education community. Concerns about the increased workload for faculty resound through the assessment literature. In addition, authors acknowledge a need to generate more ideas on how to efficiently document the feedback loop. Thus, EC 2000 is significantly influencing engineering education.

Introduction

It is now generally accepted that undergraduate education in the United States is experiencing a paradigm shift. Educational leaders in both K-12 and college environments have been calling for a major change in the way we teach; leaders are imploring us to switch from an emphasis on what teachers teach to an emphasis on what students learn. Thus, in a system that values student learning, assessment becomes increasingly important.

In recent years there have been significant changes in the way in which many engineering educators think about assessment. Assessment of student learning is becoming an integral part of the undergraduate engineering curriculum. There are several reasons for this change. First, new accreditation criteria are changing the way engineering educators think about assessment. Second, many colleges are responding to externally imposed mandates of state legislatures. Third, many educators have been receptive to the trend from teacher-centered instruction to student-centered learning. Finally, colleges need to demonstrate to stakeholders (potential students, parents, and employers) what their graduates know. The purpose of this literature review is to answer the question, “How have undergraduate engineering educators changed the way they do assessment in the past four years?”

Search Methods

In order to conduct this literature review, the writer used the GALILEO database as a preliminary source. Through GALILEO, the author was able to access electronic versions of ERIC, Education Abstracts and Psychological Abstracts. Primary sources included the Journal of Engineering Education, ASEE Prism, American Society for Engineering Education conference proceedings, and Frontiers in Education conference proceedings. Literature reviews and reference lists that appeared in the Journal of Engineering Education were the only secondary sources used for this paper.

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Since there have been so many recent changes in engineering education, the search was limited to articles written in the past four years. When an author published preliminary work as part of a conference proceedings and more detailed, comprehensive work on the same subject in the Journal of Engineering Education, the journal article was chosen for this review.

The Assessment Reform Movement

In a frequently referenced article, Barr & Tagg (1995) called for a paradigm shift for undergraduate education. According to the authors, educators need to switch from the belief that a college is an institution that exists to provide instruction to the realization that a college is an institution that exists to produce learning. In this article, the authors compare the difference between the instruction paradigm and the learning paradigm and note that the learning paradigm is consistent with the assessment reform movement. Furthermore, they assert that, “Information from a sophisticated assessment system will gradually lead to the transformation of the college’s learning environment and support structures.” (p. 21).

If assessment is to lead to the transformation of the college learning environment, then it follows that the way we view assessment should change. In the past, many have associated assessment with testing, especially standardized testing. However, Dick and Carey (1996) advocate a wider view. They define assessment as a “term that includes all types of activities that can be used to have learners demonstrate their ability to perform” (p. 142). Wiggins (1998) offers a slightly different view. He believes that the purpose of assessment is “primarily to educate and improve student performance, not merely to audit it” (p. 7). Ewell (1998) observes that, ideally, assessment is less of a set of procedures, and more of a mindset. Shaeiwitz (1996) asserts, “The goal is to make assessment an integral part of the curriculum” (p. 245). Thus, new ways of looking at assessment involve a large-scale attitude change. There is evidence that, through the assessment reform movement, undergraduate engineering education is undergoing such a shift.

Assessment in Engineering Education

Ten years ago, only a small minority of engineering educators published papers on assessment. Since that time, professional engineering journals have been devoting more and more of their space to assessment issues. Assessment experts from other fields are being included as authors in engineering journals and presenters at engineering conferences. Engineering educators are debating the difference between goals and objectives; they are expressing interest in learning outcomes and common threads in the curriculum (American Society for Engineering Education, 1998).

Accreditation’s Role in Shaping the Nature of Assessment

The Accreditation Board for Engineering and Technology (ABET) is the agency responsible for the accreditation of programs that lead to engineering degrees in the United States. On November 2, 1996 the ABET Board of Directors approved Engineering Criteria 2000 (EC 2000), which has been described as “a radically new set of criteria for accreditation of U.S engineering programs” (Peterson, 1998, p. 6).

An essential part of the EC 2000 is the requirement that engineering programs that seek accreditation must establish an internal assessment process. The outcomes assessment component of EC 2000 has three parts:

* Detailed, published educational objectives that are consistent with the institution’s mission and Engineering Criteria 2000;
A curriculum and process that ensures the achievement of these objectives; and

A system of ongoing evaluation that demonstrates achievement of these objectives and uses the results to improve the effectiveness of the program. (Peterson, 1998, p. 7)


**The Role of the NSF Coalitions**

The schools in the NSF Engineering Coalitions have been actively involved in developing materials for related to assessment in the undergraduate engineering curriculum. Dissemination activities include conference presentations, newsletters, and web pages. For example, the SUCCEED Coalition has published an Outcomes Assessment Planning Guide on the Web; it can be found at [http://www.succeed.vt.edu/products/outcomes/toc.html](http://www.succeed.vt.edu/products/outcomes/toc.html).

Many of the Coalition publications have been related to the process of assessment. For example, McGourty (1998) and his colleagues at the Gateway Coalition have delineated four strategies for dealing with the new assessment requirements. These are:

- Initiate a structured process.
- Provide assessment education.
- Create an assessment toolbox.
- Align key institution practices with assessment.

McMartin, Van Duzer, & Agogino (1998) give a detailed and candid description of the development of the Synthesis Coalition’s plan for assessment. The process, which began in January, 1995, included communication among faculty, administrators, students, and industry representatives from the seven different engineering schools that make up the Synthesis Coalition.

**Faculty Resistance/Faculty Workload**

In general, engineering educators have been slow to jump on the assessment movement bandwagon. Although the engineering education community has vocal leaders who support change, many professors have been resisting the movement to change their teaching style and the way they assess learning. Yokomoto, Goodwin & Williamson (1998) list four common beliefs that may explain faculty resistance:

- We already assess by using of grades
- Assessment is an unclear process
- It takes too much time
- It diverts attention from tenure, promotion, recruitment and retention

However, the authors observe that, after a period of resistance, most faculty reach the accommodation stage and finally the action stage. Judging from the number of articles being written about assessment in engineering education, it appears that many faculty leaders have reached the action stage.
Nevertheless, wanting to ‘do assessment’ and knowing how to ‘do assessment’ are two different issues. As Peterson (1998) observes, "Establishing measurable objectives and evaluating their outcomes are sophisticated activities with which most engineering educators have had little or no experience" (p. 7). The developers of EC 2000 have recognized this fact and have instituted a series of training workshops held at various locations throughout the country.

It is commonly accepted that the assessment reform movement will impact faculty workload. As one member of the Gateway Coalition states, “We have found that reward systems in most of our partner institutions are not designed to support the additional time that faculty need in order to incorporate assessment and continuous improvement into the classroom” (McGourty, 1998, p. 5). Members of the Synthesis Coalition observe, “Despite all of this effort to reduce the demands on faculty, assessment does take time, particularly if it is used effectively to improve courses” (McMartin, Van Duzer, & Agogino, 1998, p. 164). Even those who report on the positive value of a new approach to assessment (Deek, Fliltz, Kimmel, & Rotter, 1999), recognize that there will be an adverse effect on faculty workload. "It is important to note, however, that this assessment methodology (used in all freshman-level computing courses at NJIT and currently being adapted for other subjects) has led to a significant increase in effort on the part of instructors” (p. 324).

**Assessment as Continuous Improvement**

Several authors have noted the parallels between assessment reform and the Total Quality movement that emphasizes continuous quality improvement (CQI). Brawner, Anderson, Zorowski, Serow, & Demery (1999) describe ways in which qualitative assessment techniques can be used to achieve engineering curriculum renewal. They do this by applying the plan-do-check-act (PDCA) model that is an essential part of CQI. Benjamin, Thompkins, & Johnson (1998) give a detailed description of how quality function deployment (QFD) can be used to develop a business/engineering course. Educators in Europe (Karapetrovic, Rajamani, & Willborn, 1998) have compared ABET’s EC 2000 and ISO 9001 and found a number of similarities. Finally, Lohmann (1999) relates that efforts to implement a Total Quality program helped his school prepare for the ABET visit under EC 2000.

**The Development of Assessment Plans**

According to Aldridge and Benefield (1998), “One of the most obvious examples of the new focus on process is Engineering Criteria 2000’s requirement that every engineering program have an assessment system” (p. 23). Thus, much of the recent literature on engineering outcomes assessment revolves around ways to develop and document an assessment plan. As previously noted, the NSF Coalitions are actively involved in developing and disseminating assessment plans. In addition, a variety of other engineering educators have added to the literature on assessment plans (McGourty, 1998; McMartin, Van Duzer, & Agogino, 1998; Olds & Miller, 1998; Shaeiwitz, 1996; Yokomoto, Goodwin, & Williamson, 1998). Although the literature on specific assessment plans is abundant, many of these authors caution that each school should develop its own plan that reflects its own unique set of objectives.

**Involvement of Alumni and Employers**

The inclusion of employers and alumni on college advisory boards is not new. What is new, however, is the increased emphasis on including these groups as part of the assessment process. The most common ways to involve these groups is through the use of surveys. Additionally, some schools are reporting on the use of focus groups of graduating seniors or alumni as a way to inform curricular change. Although the use of alumni is highly recommended, one area of concern expressed by some authors is the significant time lag between the receipt of feedback and the delivery of instruction. Nevertheless, alumni are increasingly being used as part of the overall assessment process. For example, West
Virginia University’s assessment plan incorporates focus groups led by distinguished alumni and representatives from industry (Shaeiwitz, 1996). The author notes that the one drawback is the time-intensive nature of the focus group experience.

**The Use of Technology in Assessment**

In response to the outcomes assessment requirement of EC 2000, engineering educators are using technology to help plan and organize the various components of the assessment plan. Owen, Scales, & Leonard (1999) report on the creation of a database of outcomes and outcome indicators related to the specific accreditation outcomes listed in Criterion 3 of EC 2000. The database was developed with the Microsoft Access software program and is available for download at [http://ie.eng.clemson.edu/researchareas/ABET.htm](http://ie.eng.clemson.edu/researchareas/ABET.htm). By making the database file available on the Web, the authors hope to encourage program-to-program and school-to-school comparisons. Walcerz (1999) describes the use of Enable OA, an outcomes-assessment process incorporated into a commercially-available relational database. The author explains the capabilities of the software as they relate to the American Association for Higher Education (AAHE)’s Principles of Good Practice for Assessing Student Learning. The article also gives examples of how the software can be used in conjunction with ABET’s EC 2000.

Several educators have reported on the use of technology directly with the students. Hein and Irvine (1998) report on the use of on-line discussion groups to assess student understanding. They conclude that mentoring an on-line discussion group takes a lot of time, but is worth the effort. In the fall of 1998, Rose-Hulman adopted an electronic portfolio system (Rogers & Williams, 1999). The system is based on an Oracle database and can be accessed through the Web. See [http://www.rose-hulman.edu/ira/reps/](http://www.rose-hulman.edu/ira/reps/) for examples of these student portfolio projects.

Investigators at the Stanford Learning Laboratory suggest that new ways of using technology in the classroom will require new assessment methods. Sheppard, et al (1998) list six web sites that describe ways in which technology is used to support learning. The article also includes a good summary of emerging models for the assessment of technology-related projects.

**Classroom Assessment Techniques**

Although the majority of articles included in this review relate to program assessment, many recent articles in engineering journals and conference proceedings also focus on classroom assessment techniques. Many authors report that the classic text, Classroom Assessment Techniques: A Handbook for College Teachers (Angelo & Cross, 1993) has been the source of ideas. According to Angelo & Cross (1993), classroom assessment techniques are ongoing, context-specific activities that are an essential part of a formative assessment plan. Few of the examples listed in this text relate directly to the engineering curriculum; however, engineering educators are adapting these techniques for use in the engineering classroom. For example, Mehta & Schlecht (1998) have developed the Daily Homework and Quiz (DHQ) Method in which students can receive the frequent feedback that has been associated with increased learning. In the DHQ method, homework is graded in class and students record the results on optical scan sheets. Optical scan sheets are also used to process the quizzes. Each evening the scores are posted on the Web.

**The Role of Assessment in Course Development**

There is some evidence that engineering educators are putting greater effort into incorporating assessment techniques into their courses as they are developed. Wankat (1999) describes the changes that occurred in a sophomore level chemical engineering class as a result of the on-going assessment
techniques that were built into the course. The author writes, “The course was structured with a large number of opportunities for student practice and a large number evaluations of the student” (p. 195). As a result of this continuous improvement model, the instructor modified his teaching style midcourse in response to information included in a structured midcourse evaluation.

**Non-traditional assessment**

The traditional model of education in engineering has been lectures, homework problems, and tests. More recently, labs and design projects have become common parts of the curriculum. Traditionally, short-answer or multiple-choice tests have been the most commonly-used methods for assessing student performance in the engineering undergraduate curriculum. For curricula that include extensive lab courses or design projects, performance assessment is more common. Performance-based or authentic assessment uses techniques such as oral presentations, debates, written portfolios, exhibitions, and videotapes. Some engineering educators are experimenting with these alternative approaches to traditional assessment methods.

Senior design courses are a common feature of current engineering curricula. Napper & Hale (1999) are using external reviewers to evaluate senior design project reports. In their program, three different people review a videotape of the presentation. According to the authors, one drawback to this method is the lack of inter-rater reliability.

In the engineering undergraduate curriculum, portfolios are widely discussed, but seldom used. Faculty resistance centers around the extraordinary time commitment required for evaluating portfolios. Nevertheless, some educators are including a portfolio requirement in their assessment plan. Members of the Synthesis Coalition determined that student portfolios, focus groups, and interviews were too time intensive to be used as core assessment tools. However, the Synthesis assessment plan calls for each member institution to recruit a small sample of students to participate in the labor intensive assessment efforts (McMartin, Van Duzer, & Agogino, 1998).

In a recent article, Christy & Lima (1999) describe their success with two approaches to portfolio development. They suggest a senior level course portfolio should be selective (final, evaluative) and a freshman level course portfolio should be non-selective (working, descriptive).

It should be noted that Darling-Hammond (1994) has expressed some concerns about the adoption of performance-based assessment. She states, “the equitable use of performance assessments depends not only on the design of the assessments themselves, but also on how well the assessment practices are interwoven with the goals of authentic school reform and effective teaching” (p.5).

**Documenting the feedback loop**

Engineering educators are being told to use assessment results as a part of the curriculum revision process. This is not a new idea; traditionally faculty members have revised courses and curricula on the basis of a variety of factors. However, often there is little documentation of the use of assessment results to inform the change. EC 2000 will likely change that practice. As Aldridge and Benefield advise, “The need to show results will be particularly important in relation to demonstrating that educators and administrators are using information generated by the internal assessment system to help further develop and improve the program” (1999, p.28). This literature review revealed no articles that effectively dealt with the issue of how to efficiently document the feedback loop.
Conclusion

This review shows that engineering educators are putting a lot of effort into preparing for accreditation visits based on EC 2000 criteria. Many schools have developed their assessment plans; they have articulated objectives and outcomes. Non-traditional techniques such as journals and portfolios are gaining acceptance among some leaders in the engineering education community. However, concerns about the increased workload for faculty resound through the literature. Other issues also remain unanswered. How do we measure students’ attitudes? How do we assess “soft subjects” such as teamwork and lifelong learning? Although several investigators (Besterfield-Sacre, Atman, & Shuman, 1997; Lewis, Aldridge, & Swamidass, 1998) are addressing these concerns, much work needs to be done. Finally, we need to generate ideas on how to efficiently document the feedback loop.

These are exciting, but difficult, times for engineering educators. As the engineering curriculum changes, so must assessment. The theme of continuous improvement that appears throughout the literature implies that the result will be a better environment for learning.

References


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