

# Strategies for Developing, Implementing, and Institutionalizing a Comprehensive Assessment Process for Engineering Education

Jack McGourty

Fu Foundation School of Engineering and Applied Science  
Columbia University

**Abstract** - This paper draws upon experiences in facilitating the development and implementation of comprehensive educational assessment and continuous improvement programs in several universities associated with the National Science Foundation's Gateway Coalition for Undergraduate Engineering Education. Four integrated strategies, required to imbed assessment and continuous improvement in the educational environment, are fully described.

## Introduction

The push is on for an outcome-driven assessment process that will indicate quality, success or failure in undergraduate engineering. Prospective students want to know if their investment of four years and perhaps \$80,000 is going to be worth the effort. Faculty want to know if they are teaching the right mix of skills and knowledge for the information age. Administrators are reinventing the curriculum, reengineering the requirements for graduation and seeking or renewing outside accreditation. The Accreditation Board of Engineering and Technology (ABET) is pushing college engineering administrators to incorporate sound assessment techniques into their majors and programs. Even industry is getting into the act with hiring practices geared toward those who measurably demonstrate the specific technical and managerial competencies they seek.

At present there is no single, widely accepted, outcome-driven assessment process to measure the quality of an undergraduate education in engineering. Given the fierce independence of American engineers, academics and industry leaders, it is doubtful whether any single measurement system could ever win universal acceptance for long. However, this fact does not mitigate the pressure to develop some kind of structure to support performance measurement and continuous improvement.

This paper describes four strategies that have been implemented in several engineering programs to address the need to embed assessment and continuous improvement as a fundamental ingredient of the educational process. These strategies were identified based upon experiences in facilitating the development and implementation of comprehensive assessment programs in several universities including Columbia University, Cooper Union, Drexel University, New Jersey Institute of Technology, Ohio State

University, Polytechnic University, University of Pittsburgh, and University of South Carolina.

## The Four Strategies

Implementing a comprehensive assessment process in an educational institution presents several challenges to administrators, faculty, and students. Administrators must provide a great deal of support and resources if the process of assessment and continuous improvement is to become an integral part of the institution's educational fabric. Faculty must take ownership of the design and implementation of assessment initiatives. Students need to take a more proactive role in their own education and the evaluation of knowledge and skill acquired throughout their program. There is simply no one action that an institution can take in order to implement an effective assessment process.

Through our work with several engineering institutions, including many National Science Foundation-sponsored coalition participants, we have identified an integrated set of strategies to support assessment initiatives. The four strategies are: 1) initiate a structured process to involve faculty and staff in the ongoing planning, development, and monitoring of the program; 2) offer "just-in-time" educational sessions to develop faculty and student knowledge and skills in assessment; 3) create an assessment toolbox providing administrators and faculty with templates that can be used in and outside the classroom; and 4) identify, review, and modify as required, key institutional practices to ensure that they are aligned with educational objectives and outcomes.

These strategies work together as a system to support the development and implementation of assessment into the university environment. Each strategy supports and complements the other actions. Focus on one strategy, without the others, and you lessen the impact that your actions will have on the institution and its assessment-related initiatives.

While these strategies must be viewed as a system, let's take each one in turn and describe each strategy's objectives, key work activities, and common pitfalls. A logical starting point is a structured process that provides all involved with a clear direction and set of common expectations.

**Strategy 1. Initiating a structured process.** Our experience demonstrates that the only way to build a strong assessment

and continuous improvement foundation is to provide all participants with a roadmap to follow. There are two important reasons for this requirement. First, the design and implementation of assessment processes require a large degree of participation across the institution. Members from both academic and non-academic units become involved at some point during the process. This is especially true when accreditation issues are being addressed. For example, Drexel University found it necessary to integrate such non-academic units as CO-OP, career services, and the alumni office into their assessment program. Without a clear structure to follow, the diversity of institutional needs cannot be adequately identified and subsequently met.

The second reason for needing a structured process is that assessment programs require specific activities in order to be effective. Effective assessment programs must measure what they are supposed to measure and accomplish this in a consistent and useful manner. If the design and development of assessment methods are done haphazardly, they will not be effective and may become an unnecessary drain on institutional resources.

The structured process must provide a clear direction to all involved, help to establish expectations, and create a common language to support cross-institutional communication. First, the process must provide all participants with a clear direction and understanding of the appropriate steps required to develop and implement an effective assessment program. Participants should be exposed to what actions are required and what their role is during each step. All our institutions follow a five-step process that will be described later in this paper and is illustrated in Figure 1.

A second, and most critical objective of a formal process, is that it helps establish expectations of all involved. When one begins to facilitate the development of an assessment program, there are many and varied expectations on the part of administrators, faculty, and students. For example, some participants will become involved because they see assessment as a way to drive curriculum reform and innovation, while others view it as a necessary evil thrust upon them by an accrediting body. Participant expectations must be brought out into the open, discussed, and converged when possible. This needs to be done very early in the process and should not be left unresolved.

Finally, the structured process must create a common language for all involved to use. Developing and implementing a comprehensive assessment program requires a great deal of cross-institutional communication. In fact, this may be one of the greatest challenges. As we began our process, it became evident that communication among the various departments and programs was almost non-existent. Once you open these lines of communication, a common language must be established. When starting, everyone has their own definition of what assessment is and what it is not.

Early assessment advocates will confuse objectives and outcomes, typically using one for the other. Your process must help to define what assessment is and all of the key constructs associated. Most important, the process must allow participants time to calibrate with each other, to ensure that they are speaking the same language and sending the same messages across the institution.

A Five Step Process. In order to design and implement a comprehensive assessment plan for educational institutions, we identified a five-step process to follow [1], as illustrated in Figure 1. These five steps serve as a framework by which all of our institutions' assessment committees follow to support their efforts. Again, as with the four strategies, these steps can not be viewed as a linear process or one where you can select certain elements and not others. We have found that many of the activities associated with these steps can be done in parallel. However, there are specific actions that are prerequisite. Here is a brief description of each.



**Figure 1.**  
**Five Step Assessment Process**

Step 1. Identification and definition of educational objectives, strategies, and outcomes. This first step comprises some of the most important and challenging activities in the overall process. Unfortunately, these activities are often not given the proper attention they deserve. Faculty and staff typically want to jump right in to the selection of assessment methods or analysis of existing data. While these activities are important and to some extent can be done in parallel, the definition of objectives, strategies, and measurable outcomes is of primary importance.

In our institutions, assessment committees were formed to work with administrators, faculty, students, and external constituents to define institutional, departmental, and course-level objectives, strategies and measurable outcomes. You will note that there are three levels of objectives, strategies and outcomes.

Institutional level objectives, strategies and outcomes are defined as those that cut across all departments and

programs. Typically, these institutional objectives are communicated through a mission or vision statement. Institutional objectives are associated with all that is going on within the university including academic and non-academic activities. Department level objectives, strategies, and outcomes focus on academic programs and the effect these have on graduates as a result of the curriculum offered. Course-level objectives, strategies, and outcomes help to define what learning outcomes are expected as a result of a specific course. All three levels must be addressed and there must be a clear, seamless linkage from the institution's mission to program and course-specific objectives.

Each of our institutions was provided with a series of workbooks designed to ensure that educational objectives, implementation strategies, and measurable outcomes are adequately identified and linked to the respective college mission. Over 50 engineering departments and hundreds of faculty have used these workbooks to help define and document educational objectives and outcomes. (Copies of these workbooks can be downloaded from the Gateway Coalition Web Site: [www.gatewaycoalition.org](http://www.gatewaycoalition.org).)

Step 2. Identify and select assessment methods. After educational objectives, strategies, and outcomes have been defined, participants begin to identify the assessment methods to be implemented. Most administrators and faculty find this step to be the most difficult. However, from our experience, if the first step is conducted properly, the identification of what types of assessment are required, will go smoothly. Both traditional and non-traditional assessment methodologies should be reviewed for each outcome. While describing the various approaches of assessment is beyond the scope of this paper, there are several alternatives for potential application. These approaches include: surveys, portfolio approaches, capstone projects, embedded work samples, interviews, self and peer assessment, and industrial advisory boards. [2,3,4]

Multiple criteria to select potential measurement strategies should be employed. We reviewed assessment methods for psychometric properties such as reliability and validity - in other words will the method actually predict differences in student performance consistently. Another major criterion for selection was whether the measurement approach yields information that would be found useful by the people involved. Collecting data in an educational environment is an easy thing to accomplish, but applying the results is quite another thing. Finally, all assessment methods were evaluated for ease of administration and cost effectiveness. As will be discussed later, these issues become more important once there is a need to expand the use to a larger group of students, faculty or alumni.

For this step, we developed a matrix linking various measurement strategies to educational outcomes. The matrix includes a description of the assessment method, the target audience, source of the data, frequency of data gathering, and

how the data will support continuous improvement. We found this last category to be most helpful. Staff and faculty had to identify how resulting information would be communicated to relevant parties and used in making future academic decisions.

Most universities have several existing assessment systems in place. One of the first things an assessment team can accomplish during this step is the identification of all existing assessment activities both in and out of the classroom. It is quite common to find that data is already being collected on faculty, students, and alumni, sometimes in a number of locations across the campus. An inventory of these assessment activities should be taken. This inventory should provide information on the type of assessment, who and/or what outcomes are measured, and how the results are used for improvement. Additionally, any samples of instruments and reports should be collected.

Step 3. Developing and pilot testing new assessment methods. This step focuses on the initial development and "piloting" of new assessment methods. During this step, new methods can be tested to ensure that they meet certain criteria for effectiveness such as reliability and validity, cost-effectiveness, ease of administration, perceived fairness, and information leading to improvement.

From our experience, we have found that once all educational outcomes are identified, two or three assessment methods can provide an adequate start for evaluation and improvement purposes. In many of our institutions, the assessment methods most commonly piloted included competency-based surveys for project-oriented courses, CO-OP and alumni surveys, and course evaluations. We discovered that assessment programs built around these initiatives provide an institution with a broad degree of information on student performance, course effectiveness, and employer and alumni perception of curriculum effectiveness. [1] If the institution does place some limits on the number of assessment activities implemented, a bureaucratic nightmare may be a future consequence.

Step 4. Expanding assessment processes. The post pilot testing step takes newly developed assessment methods and expands their use to a larger audience. In effect, the methods in question become part of the overall educational process. There are many important aspects to the activities during this phase. One of the most important lessons we have learned is that educating all involved is critical. As you expand an assessment process to involve many constituents, the training needs to become more formal. Typically, training can remain somewhat informal during the pilot testing phase. However, once the number of people involved increases, there is a need to formally explain the purpose of the assessment, how it works, and how results will be reported and applied towards improvement.

Another important aspect of this expansion phase is the changing requirement for resources, which may have been anticipated, but not required during pilot testing. Many good assessment processes are not viable once you go beyond one section of a specific course. New Jersey Institute of Technology learned this the hard way. In trying to expand the use of a portfolio process to a broader undergraduate population, the lack of resources and commitment became quickly evident. [1]

Our experience tells us that the necessary resource requirements, including faculty time, material costs, data analysis and report generation costs - must be clearly explained to all involved. Only then can one be sure that there are no hidden resource constraints on the assessment program proposed.

Step 5. Applying results for improvement. The final step of our process involves the collection and use of information derived from implemented assessment programs. Many institutions do not take advantage of the information provided. How the data is used and applied for continuous improvement is the focus of this last step. Of course, how the information will be used for improvement is a question that must be answered in earlier steps. However, the implementation of continuous improvement processes has its own set of unique issues. For example, at Columbia University, we are developing a process that encourages faculty to take action to improve courses and teaching style as a result of course evaluations. In order for this to take place, changes must occur in both process and culture.

All of our institutions are following this structured process. This is an on-going and dynamic process. The tasks within each step can take several months to accomplish successfully. The assessment process cycle is continuous.

**Strategy #2. Provide Assessment Education for Faculty and Students.** To inculcate the structured process in the university environment, frequent seminars and workshops must be delivered to staff, faculty, and students. These developmental initiatives help to enroll everyone into the process through understanding and constructive debate. Professional development activities focus on the skills required in the operation of a comprehensive assessment program. These skills range from developing valid assessment methods to providing outcome performance feedback to students in the classroom.

We have designed several workshops to support both faculty and student learning about assessment and continuous improvement. The purpose of these sessions is to provide faculty, administrators, and students with an understanding of outcome-driven assessment and what is involved in establishing an assessment program in an educational environment. Special attention is given to ABET Engineering Criteria 2000 and the role that assessment plays in meeting the new requirements. Participants are provided

with a set of construct definitions to allow for a common vocabulary that can be used by all involved. A general framework for designing a comprehensive and integrated assessment process is presented, with each step described. Finally, various assessment strategies and alternative evaluation methods are described. We also provide workshops for department chairs and faculty to support the identification of educational objectives and outcomes.

We find that staff and faculty must be engaged frequently throughout the process. Quarterly sessions seem to provide the right balance of interaction without becoming too time-demanding.

**Strategy #3. Create an Assessment Toolbox.** Once a university has established and defined the learning objectives and related outcomes for its programs, there is a need to create a series of assessment tools to measure the stated outcomes. This can be perceived as a daunting task. The reason for this is that there are usually many outcomes identified, thus seemingly requiring as many, if not more, methods by which to measure the anticipated changes. One of the key assessment strategies at this point is to look for common themes and needs across the institution, and create what we call an assessment “toolbox”. This toolbox contains a number of templates that faculty, students, and staff can select from to support the measurement of identified outcomes. For example, a set of team assessment instruments can readily be developed to support faculty members who use student teams in the classroom. [5]

As noted earlier, our institutions have focused on a common set of assessment methods, most of which have been designed to measure the ABET student learning outcomes. We have designed assessment templates that offer the institution the opportunity to measure general learning outcomes across the curricula while providing faculty with the flexibility to customize these instruments for their specific courses. For example, all of our competency-based surveys allow raters to provide judgements on student performance in ABET related learning outcomes. In addition, each instrument has a section that can be customized by the instructor or person responsible for a specific program. In this way, the institution gets consistent information regarding student performance on the ABET eleven learning outcomes, while the instructor receives context specific data on their program or course. (Samples of all assessment instruments can be downloaded from the Gateway Coalition Web Site: [www.gatewaycoalition.org](http://www.gatewaycoalition.org).)

**Strategy #4. Align Key Institutional Practices with Assessment Program.** Our final strategy is maybe the most important set of actions required to institutionalize a comprehensive assessment program university-wide. There are many institutional practices that must be aligned with the objectives of an assessment program. We have found that there are several policies, procedures, and systems within a

university that can act as barriers for assessment and continuous improvement.

Let's look at a simple example involving a typical promotion and tenure (P&T) practice. Many P&T practices put emphasis on a faculty member's efforts in three areas: research, instruction, and service. An institution may put more emphasis on one of these areas as opposed to the others. If, for example, research is highly prized in an institution, efforts in the classroom may be looked at with less emphasis. Thus a faculty member will be motivated to place more effort in research activities than in the classroom. However, classroom assessment initiatives can take a real commitment (and time) on the part of the faculty member. Thus, there is a real conflict between the tenure policy and assessment practice - one that is usually resolved in favor of promotion and tenure requirements. We have found that the 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.

Our institutions are reviewing many such practices in order to identify which ones will enable or hinder the implementation and eventual institutionalization of an assessment program. Identified practices include, but are not limited to the following: new course approval mechanisms, faculty orientation, reward systems, cross-departmental linkages, and industrial advisory processes. Administration and faculty must work together to modify misalign practices in order for assessment and continuous improvement to become embedded into the educational environment.

## Conclusions

This paper has provided an overview of the work that the Gateway Coalition has achieved towards its goal of embedding a comprehensive assessment process in each of its partner institutions. We have applied a set of integrated strategies in order to implement and institutionalize an assessment program for each engineering program. Each of these strategies must be applied or the success of the assessment program will be questionable. There are many lessons learned from our efforts to date. Based on our experience, four integrated strategies should be implemented to institute a comprehensive assessment program in an educational environment. First, a systematic process must be provided for faculty and staff to follow. There are many synergies that an institution can benefit from if a common approach is facilitated across departmental boundaries. In order to accomplish these synergies, faculty and administration must have a common language and set of expectations. Secondly, a series of formal activities focused on faculty understanding and motivation must be established. Frequent interaction among faculty, administration, and the assessment team must occur throughout the design process. Thirdly, assessment processes must be flexible and integrated. The toolbox approach provides the most flexibility allowing for both

cross-institutional and context-specific measurement. Finally, all parties involved must remember that they are working within a system and that every action will solicit an organizational response. Faculty and administrators should review institutional policies, procedures, and systems to ensure that all enablers and barriers to assessment program success are identified and addressed.

## References

1. McGourty, J, Sebastian, C., & Swart, W. (1998). Developing a comprehensive assessment program for engineering education. *Journal of Engineering Education* (in press).
2. Angelo, T. & Cross, P. (1993). *Classroom Assessment Techniques: A Handbook for College Teachers*. Jossey-Bass Publishers: San Francisco.
3. Nichols, J. (1995). *A Practitioner's Handbook for Institutional Effectiveness and Student Outcomes Assessment Implementation*. Agathon Press, New York.
4. Wiley, D. E., and Haertel, E.H. (1996). Extended assessment tasks: Purposes, definitions, scoring, and accuracy. In M. Kane & R. Mitchell (eds.) *Implementing Performance Assessment: Promises, Problems, and Challenges*. Lawrence Erlbaum Associates: Mahwah, NJ
5. McGourty, J, Sebastian, C., & Reilly, R. (1997). Incorporating student peer review and feedback into the assessment process. Paper presented to the Best Assessment Processes in Engineering Education: A Working Symposium, Rose-Hulman Institute of Technology, Terre Haute, Indiana.