The Development and Implementation of an Assessment Plan
For Engineering Programs:
A Model for Continuous Improvement

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Abstract

The development and implementation of an assessment plan requires input and active participation by faculty and staff at all levels. This paper examines: 1) How an assessment infrastructure can be established to provide leadership to all units of the university; 2) The role of faculty in the development program assessment plans; and 3) how continuous improvement can be achieved through the identification of student outcomes and measurement techniques.

Examples will be presented where changes have been made based on analysis of the results. Since the plans were developed over a period of five years it is now necessary to revisit the plans to determine how the plans can be enhanced in light of the eleven attributes defined in ABET Criteria 2000.

I. Introduction

The motivation for the development of new and improved products is driven by the needs of the consumer. Our ability to compete in the global marketplace has been articulated in the engineering and design as the Product Realization Process \(^1\). This process begins with the proper identification of an existing need and then fulfilling this need through the design process that involves interdisciplinary teams. In academia we not only have the need but the responsibility of preparing our students so that they will be able to function effectively as engineers throughout their careers. Thus, we must design our curricula and our delivery to meet the needs of our stakeholders.

As stated by ASEE President Winfred Phillips “Are we doing a good job of teaching basic engineering skills; but also are we doing enough to prepare our students to survive and thrive in the next century’s workplace?” \(^2\) Phillips further identifies the professional environment that will be needed, including working with interdisciplinary teams and the need for effective verbal and written communication. He concludes his discussion with the attributes recommended for engineering graduates in Criteria 2000 as developed by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology’s (EAC of ABET) Criteria 2000. These attributes have been widely publicized and include not only the ability to apply knowledge of the sciences, conduct experiments and design systems and components but to also function in multidisciplinary teams, understand the importance of lifelong learning and understand their professional and ethical responsibility. He states that this is a good start but not the final word.
The Technology Accreditation Commission (TAC) of ABET has also addressed these issues by incorporating assessment techniques within their existing criteria. A study of the assessment process was presented to the TAC Commission in 1995 which lead to the proposed revision of the general criteria. In the past it was necessary to conduct elements of assessment as part of the accreditation process through the use of surveys to determine the graduates satisfaction of the program, the potential mobility of the graduate and the satisfaction of the employer with the education of the graduate. This has been expanded to include documentation that the program has well defined goals and that these goals are being achieved. Another major component of assessment is the evaluation of student work, which includes many of the characteristics found in portfolios.

The required competencies of graduates have been identified by practicing engineers in the ASME publication “Incorporating the Product Realization Process in the Engineering Curriculum”. Major competencies include the ability to work in interdisciplinary teams and the ability to communicate verbally and in writing. Many of the top ten issues were not related to “technical” competencies. A major attribute that is included in this document but not as yet addressed by ABET is the need for graduates to function in a business environment.

The purpose for identifying the attributes and competencies is to set the framework for the development of outcomes and their associate measures.

As a preface to describing assessment techniques it is important to note that assessment is not just another bureaucratic exercise that will go away in the near future. This is an approach that involves establishing a plan with goals and then measuring them. The loop is complete when modifications are made to meet the goals – the process of continuous improvement. If the approach is to do this just for ABET and regional accreditation then it will become merely a bureaucratic exercise. If it is done for taking responsibility for the future of our graduates by making upgrades to provide the best possible education then we have been successful. The procedures described in this paper are those that I have worked with for nearly four years.

II. Institutional Assessment

From a global perspective it is necessary to have a plan within the institution (university) that defines how assessment will affect the institution and the process that will be followed. In many instances departments and programs have performed assessment in a fragmented way for decades. This has been done under the guidelines prescribed by accreditation agencies but seldom in a systematic way by an entire institution. The driving forces produced by the accreditation agencies of the professional schools and regional accreditation have provided an opportunity for the institutions to develop a systematic approach to continuous improvement. The characteristics of an assessment program have been defined by North Central Accreditation –NCA. These are:

Flows from the institution’s mission.
Has a conceptual framework.
Has faculty ownership/responsibility
Has institution-wide support
Uses multiple measures
Provides feedback to institution
Is cost-effective
Does not restrict institution’s goals
Leads to improvement
Process in place to evaluate assessment

This is followed by five evaluative questions related to the assessment plans. These questions are paraphrased below.

To what extent is the assessment plan linked to the mission, goals and objectives of the institution?
How have faculty participated in the plan development and that the plan is institution-wide?
How has the plan demonstrated that the assessment program will lead to institutional improvement?
Is the timeline for the assessment program appropriate and realistic?
Is there evidence that the plan provides for appropriate administration of the assessment program?

For assessment to be successful it is necessary for the administration to communicate the commitment of the institution to assessment. One way of showing this support is to provide an administrative leader to head the University Assessment Committee.

The University Assessment Committee should be composed of members from each academic unit (e.g. School of Engineering) and each major support unit (e.g. library, student development, etc.). This committee provides leadership by establishing an institution assessment plan and by determining the state of assessment for the institution at any given time. It has been my experience that this committee meets at least every other week throughout the year. Thus, some compensation (e.g. release time) should be provided to allow the coordinators to devote time to the committee activities and be the leader within their academic unit.

Once the direction the university will take is established it must be communicated to the departments. An effective approach is to meet with the leaders in the School of Engineering to provide an overview of assessment and what can be expected. This should be followed by a presentation to the faculty to communicate the importance of assessment.

Each department or program should identify an individual to be the program assessment coordinator. Some academic coordinators are members of the faculty while others are the department chairs. Which is the best way to go? There are advantages and disadvantages with each. The department chair has the best overview of the department and is the recognized leader. This individual can work with the faculty in the development of the plan. However, department chairs view this as an administrative function that is routine and can be delegated. Thus, a member of the teaching faculty would be a logical choice. This individual must be a leader that can make thing happen. This approach makes the process more faculty driven.

An effective approach to leadership and development is to establish a pilot program for the development of department assessment plans. Approximately one-fifth of the departments were
selected to be pilot programs. These departments lead the way with the development of the plans including outcomes and measurements described in the next section.

Once the plans were developed by both the pilots and later by other departments they were submitted to the institution assessment coordinator for initial review. If major problems were encountered they were returned to the departments for revisions. However, in most cases the plans were forwarded to the university assessment committee for review and recommendations. Some plans were approved with revisions while others were returned to the departments for further development. Once a plan is approved progress is tracked using the assessment summary form and the activity form. These forms are presented later.

III. Development of Department Assessment Plans - The Process

One of the first actions of the University Assessment Committee was to perform an inventory of assessment activities within the departments. The purpose of this was to determine the levels of assessment type activities throughout the university. “Not surprisingly, the Committee found that the divisions and programs with formal accreditation from professional education agencies (ABET) had developed systematic assessment programs. While the University Assessment Plan Committee recognized that the academic divisions, departments, and programs had taken significant steps in regards to assessment, it realized that much remained to be done before there was a systematic assessment plan for the University.”

It was documented that one appraisal was that “Mission statements exist, students outcomes exist but are not explicit, and assessment measures exist but are not sufficient and are not adequately tied to outcomes. The challenge now is to examine the mission statement, student outcomes and assessment measures systematically to assure a coherent program that ties these together so that program effectiveness can be assessed and revisions made.” With this as background we were now ready to work with the departments to develop their plans.

Mission

As a first step each academic unit was asked to review and, where necessary, revise their mission statements to flow directly from the University’s Mission. This included the School of Engineering and the departments therein. This initial step in the process of the development of the program assessment plan as depicted in Figure 1. The model is similar to that presented by Nichols. Tied to the university mission are the associated goals some of which may be unique to the institution. An example of such a goal would be that the life and spirit of the university reflects a religious character at the same time welcome the voices of diverse students, scholars and staff.
Figure 1. Assessment of Student Academic Achievement - Flow Diagram
Outcomes

Flowing from the mission and goals are the outcomes. These are definitions and statements that can be measured. Initial attempts at developing plans resulted in some departments providing 20 or more outcomes. It was decided that for our initial development it would be more manageable if the number of outcomes would be held to 6 to 8. An engineering school could begin its outcomes with the eleven attributes defined in Criteria 2000. Thus, an outcome could be that “Our graduates will have the ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.” A challenge for the department may be incorporating the outcomes expected from the ABET and from the institution. Fortunately, in some cases there is an overlap.

Measures

Measures and criteria need to be developed to assure that outcomes have been met. Each outcome should be accompanied by multiple measures. A list of multiple measures could consist of:

Existing Institutional Data
Portfolios
Capstone Courses
Capstone Projects
Interviews
Surveys
Student Self-Assessment
Classroom Research
External Examiners
Standardized Tests
Industrial Advisory Committees

Many of these will be described later. However, at this point it appears that the most popular measurement method within the School of Engineering is the survey.

Associated with the measure is the notion that there needs to be a criteria associated with the measure. If the measurement method is a survey of graduates a typical measurement might be “In a survey of graduates 90% will strongly agree or agree that my education at the university provided me with the ability to use the techniques, skills, and modern engineering tools necessary for engineering practice”. Thus, the survey addresses the outcome directly by seeking agreement from the graduate. This is further supported by the criteria that 90% of those that responded will affirm this agreement. This outcome has now been supported by one measure. Another measure might be the affirmation by the industrial advisory committee that they believe that the curriculum is providing the necessary tools and techniques. This could also be determined from the examination of portfolios. Referring to Figure 1 we have now developed outcomes and measures. We are now ready to apply them.
When the results are obtained and compared to the criteria the evaluation is contained on the Assessment Activity Form. Using this document it is possible to determine the correlation at a glance and make judgments regarding the necessity for making revisions.

At the end of this form a representative of the department is asked to provide a narrative that analyzes the results and proposes action. The questions are as follows:

What conclusions can be made from the above results?
What are the recommendations?
What if any actions have been taken?
What actions should be taken?
Are additional resources required? If so what?

Continuous Improvement

As shown in Figure 1, continuous improvement is a step in the process. In fact, continuous improvement could describe the entire process. For our purposes the entire process will be defined as the assessment process with continuous improvement being the action taken after the evaluation has been made.

Continuous improvement could take two forms. First, it could be the mechanism that is used to improve the educational process. In this case changes would be made to affect student learning. The second form would be to improve the process by establishing new measures or criteria. Experience with the measurement techniques or the criteria may indicate that initial impressions or guesses were not realistic. Through research and reflection revisions to the plan would need to be made.

Continuous Improvement - Examples

Each department reviews the results of assessment to determine their approach to continuous improvement. One department received feedback that the incorporation of computers in the curriculum and the types of computer hardware/software were not indicative of the level that they might expect in practice. The magnitude of the situation was such that the school could not upgrade these computers immediately. Thus, the department sought donations from industrial partners that regularly hired the department’s graduates. The result was new state-of-the-art computers and software.

Feedback from technical societies and practicing engineers and graduates indicated that engineering graduates needed more experience in working in teams and with communication. A design and manufacturing center was established which seeks industry projects. This has resulted in increasing the number of industry sponsored projects from a few per year to over 30 per year. This also provided more opportunities for written and oral presentations.

The types of computers and software for basic computer instruction and CAD were debated for several years in an industrial advisory committee. Through collaboration with practicing engineers, the type of computer instruction was changed (C++), new software was purchased and
procured (AutoCAD and SDRC I-DEAS) and the curriculum was revised to better reflect the skills that will be required by graduates.

As the result of feedback from surveys of graduates and employers, some laboratory equipment and facilities need to be upgraded. A plan has been established to upgrade this on a continuing basis. Resources have been provided by various sources within the institution as well as from external sources.

We have now completed the assessment – continuous improvement cycle. The mission was established in light of institutional guidelines. The requirements of ABET have been taken into account and the plans have been developed accordingly. Since there are less than 8 outcomes it is now time to expand the process to encompass more outcomes. The number of measures may or may not remain the same. A few new questions may be added to the surveys to address the attributes recommended by ABET.

IV. Measurement Instruments

As stated earlier, perhaps the most utilized measurement instrument is the survey. The reasons for this are that it is easy to concentrate on specific issues, the respondents are usually easy to locate and results can be obtained in a short period of time. We have conducted surveys of undergraduates, graduates at commencement, graduates at 1, 5, 10...years after graduation and employers. With this many surveys it is there is a significant amount of analysis that needs to be performed by the institution. In some cases, there may be research organizations that can perform the surveys. However, this could result in an unclear understanding of what is being sought and effective communication is essential.

A potential solution to this could be to purchase a system to do this independently. A unit could purchase the response cards, the reader and the software for less than $10000. The program is simple enough that once a format has been established it can be applied to multiple surveys. The card reader that has been used successfully is a Scan Mark 2500 that provides input to the Pulse Survey II software for Windows. It is recommended that if this system is used that it be assigned to a permanent employee. In an academic environment it maybe attractive to assign this to a graduate student. However the expertise leaves when the student graduates.

A form used at graduation is brief and can provide much useful information. On the front side the employment status of the graduate along with salary information is obtained. In addition, the future mailing address is provided (for future surveys). Issues related to assessment are contained on the reverse side. With Criteria 2000 this will probably be modified. However, in the few short years we have applied this (at every commencement) significant information and trends have been obtained. The big advantage of this form is that we have nearly a 100% return rate on the form. If a similar form were handed out in class or seminars the return rate would be less that 50%.

The second survey is a 50-question survey form sent to graduates and students (The questions to the students are different). The number of positive responses can be determined easily and subsequently correlated to the assessment plans.
Portfolios are an excellent way to develop a useful way of collecting examples of student work. This fulfills an ABET requirement but also provides an excellent advising vehicle. If students use the portfolio to define their goals and changes to those goals it helps with the course selection and tracking requirements for graduation. Experience with portfolios runs the spectrum of just getting started to having a mature system. Recent approaches seem to lead to course portfolios developed by the lead professors.

Standardized tests are frequently used for GRE and LSAT results in other parts of the university but fall short in the engineering area. A measurement technique that has been successful is that of the Fundamentals of Engineering Exam (FE). In a recent study a slight majority of engineering schools were “in favor of the use of the modified FE as an assessment tool”. As such, it was encouraged that the current FE be modified so that “it can be used both as an educational assessment tool and as the first professional exam”. 6

Industrial advisory committees have provided a great deal of guidance with curriculum and course development. Because of input from the advisory committee, course changes like interdisciplinary projects and teams were developed even before it was recommended by recent studies. This has been the best resource for guidance in the identification and implementation of computer software that our graduates will use in the profession. The measurement criteria for input from the industrial advisory committee proves to be somewhat elusive. Should the measurement criteria state that 60% of the committee should agree with…? Up until now it remains without a quantitative measure and only identifies that the industrial advisory committee will agree that…

In the mechanical design laboratory (capstone course) students are required to provide oral as well as written presentations. A survey of the corporate sponsors provides feedback indicating that the goals of the project were met or nearly met. The appropriateness of the oral and written reports when compared to industry standards is also determined. Continuous communication between student teams and industry mentors is evaluated. This has been proven to be a reliable and efficient method for timely feedback.

V. Conclusions

A need existed at the outset for the establishment of formal assessment procedures. Actually, there are several needs. First there was a need to establish a formalized approach to identify the objectives of the institution and programs and determine if these objectives were being met. In conjunction with this there was the need to deliver the education to prepare our students for successful careers in the next century. The plan outlined here achieves these objectives. As stated earlier, many of the elements of assessment were being implemented but in most cases in a fragmented or unorganized way. This plan organizes these elements and adds the need for follow-up action. With the approach described here the voice of the customer or our stakeholders is sought and included in our planning. Although this is still under development, we have made major advances in providing an organized approach to the process of continuous improvement. (8,9)
IV. Recommendations

The field of “assessment” has come to the forefront only within the last five years. Up until several years ago there were only a few documents that adequately addressed assessment. Knowledge was obtained by reading these documents and some of the earlier attempts at assessment. We have come a long way. New techniques, approaches and requirements have placed the issues of assessment in the forefront of university governance and leadership. With these changes, it is recommended that there be another component of assessment, that of continually monitoring the advances in the field and subsequently modifying the procedures in place. We think that we had a good model two years ago but look back on it now and see that it should be upgraded. First the mission and goals need to be revised. Outcomes need to be revised in light of recent decisions by the accreditation bodies. Processes that are becoming widely accepted need to be examined so that institution plans can be brought into line with contemporary thinking – including terminology.

References

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