Quality Documentation and Records in Engineering Education

Sanjiv Sarin
Department of Industrial Engineering
North Carolina A&T State University
Greensboro, NC 27411

Abstract **-** This paper discusses the importance of documentation and records in the administration of an engineering program. The new trends in academic program evaluation for accreditation indicate an ever increasing role of documented procedures and systematic data collection and reporting to support curriculum reform. The paper also recommends a documentation structure that is borrowed from the generally accepted principles of document management in the context of quality systems standards.

Introduction

Engineering education in the United States is being restructured to address the demands placed on it by industry and business. Employers are looking for engineering graduates who are not only technically competent, but also possess superior communication skills, cross-disciplinary team ability, desire for continuing education, and several other attributes. These requirements are an integral part of the new accreditation criteria. In particular, academic programs will be required not only to measure the achievement of these attributes in graduates, but to also show continuous improvement in these measures. Appropriate documentation of the academic processes along with methodical collection and storage of data related to the quality of the academic program will be essential activities in this regard.

The paper outlines the types of documents that are needed to adequately specify academic processes. In addition, recommendations are made for a comprehensive list of records that would support the continuous improvement activity in an academic environment. Suggestions are made on formats and data to be contained in the documents and records along with guidelines on administration issues. The suggestions and recommendations are based on the author's experiences with business documentation/record systems, auditing quality systems based on international quality standards, as well as a close association with undergraduate engineering teaching, curriculum planning, and advising.

Current Practices in Documentation of Engineering Programs

Whether driven by accreditation bodies or by a need to publicize their programs, all engineering programs have some formal documentation in place already. For instance, every program's minimum admission standards, curriculum requirements, procedures and policies on transfer credits, etc. are listed in the university bulletin. Furthermore, most programs also publish some aspects of their strategic plans either in the university bulletin or in a separate publication. However, often various academic processes such as curriculum revision, transfer credit evaluation, etc. remain oblivious to and mostly independent of the strategic plan. This leads to a disconnect between what is the university leadership's vision of the future and what the faculty consider important in curriculum design, teaching and advising.

The records maintained by a university and its academic programs are usually quite extensive and fairly accurate. However, rarely is there any feedback to the academic faculty based on the data collected that would lead to systemic improvements in the design and delivery of education. For this reason, the nature of records maintained are those that are requested by students, funding agencies, or recruiting companies. Typical examples of university records are student grades, enrollment levels, attrition and retention rates, etc. Spurred on by accrediting bodies, colleges and universities have now begun to assess the quality of educational services by analyzing survey data and this information is also part of the university records system.

ABET Criteria 2000

The new ABET (Accreditation Board for Engineering and Technology) Criteria 2000 [1] for accreditation of engineering programs is scheduled for full implementation in Fall 2001. Inherent in the new accreditation system is an on-going process of assessing the quality of the program and a focus on continuous improvement. The quality of an academic program is defined in terms of the objectives of the program. Since different programs have distinct objectives and operate in

a variety of environments and cultures, Criteria 2000 allows academic programs the freedom to define their own individually tailored assessment plans.

The new ABET Criteria were developed through a collaboration between academia and industry. The criteria are essentially a set of quality standards reminiscent of the ISO-9000 standards. The traditional requirements of older ABET criteria are still present. These include curriculum requirements (mathematics, basic sciences, engineering topics and general education), faculty qualifications, adequate classroom, laboratory, library and computing equipment, overall institutional support, and financial resources. However, there are significant changes that focus on quality assurance and continuous quality improvement.

As in older ABET criteria, academic programs are required to document program objectives and an assessment of the objectives. However, instead of viewing this as a separate and "stand-alone" component of the Self Study report, the new criteria demand that there be a system of ongoing evaluation of the achievement of the objectives and that the results of such an evaluation be used to improve the effectiveness of the program.

Documentation and Records Requirements in ABET Criteria 2000

The Criteria 2000 accreditation standard adopted by ABET for implementation in 2001 places a special requirement on academic programs to maintain and control a variety of documents and records. While some documentation requirements are quite explicit, many others are implied. Consider the second of the eight criteria in the brief three page standard.

ABET Criterion 2: Program Educational Objectives [1]
Each engineering program for which an institution seeks accreditation or re-accreditation must have in place:

(a) detailed published educational objectives that are consistent with the mission of the institution and these criteria
(b) a process based on the needs of the program's various constituencies in which the objectives are determined and periodically evaluated.
(c) a curriculum and process that ensures the achievement of these objectives
(d) *a system of ongoing evaluation that demonstrates achievement of these objectives and uses the results to improve the effectiveness of the program*

Criterion 2 stresses the need to have officially approved program objectives that are published in an official document. Not only should the objectives be published, but evidence is needed to show that the objectives are evaluated periodically with input from stakeholders, that the curriculum is evaluated to study compliance to these objectives, and that there is in place a system of continuous improvement in the academic program. All this clearly points to a need for not only a documentation of procedures but also the maintaining of records of various activities to support this criterion.

As another example, consider the third criterion of ABET EC 2000.

ABET Criterion 3: Program Outcomes and Assessment [1]
Each program must have an assessment process with documented results. Evidence must be given that the results are applied to the further development and improvement of the program. The assessment process must demonstrate that the outcomes important to the mission of the institution and the objectives of the program are being measured. Evidence that may be used includes, but is not limited to, the following: student portfolios, including design projects; nationally-normed subject content examinations; alumni surveys that document professional accomplishments and career development activities; employer surveys; and placement data of graduates.

Engineering programs must demonstrate that their graduates have:

(a) an ability to apply knowledge of mathematics, science and engineering
(b) an ability to design and conduct experiments, as well as analyze and interpret data
(c) an ability to design a system, component or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global/societal context
(i) a recognition of the need for and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) *an ability to use the techniques, skills and modern engineering tools necessary for engineering practice*

The strong emphasis on the use of assessment data to guide improvements in the educational processes is clearly evident in this criterion. The obvious consequence of this criterion is a much greater emphasis on well-documented procedures for assessing outcomes and for storage and retrieval of assessment results. More importantly, when an outcome measure is found to be lacking, there is a need to document actions taken to modify the curriculum so as to lead to a reversal of a previous negative finding.

ISO 9000 Series of Quality Systems Standards

The ISO-9000 series of quality standards [2] were adopted in 1987 (revised 1994) by Technical Committee 176 of the International Organization for Standardization. This organization is responsible for standardization efforts internationally; at present its membership includes the national standards bodies of 91 countries.

Specific standards within the 9000 series are numbered 9001, 9002 and 9003. Companies that are registered to the 9001, 9002 or 9003 standard enjoy worldwide recognition. This is so because customers who buy goods and services from ISO-registered firms are assured that their suppliers practice sound quality management practices that are based on a worldwide accepted written standard. Although this in itself does not guarantee high quality products, it does specify guidelines that are likely to lead to consistently good quality products and services.

The ISO quality standard does not refer to the products or services delivered, instead to the systems that produce them. The standard is generic enough to be applicable to any type of industry. In fact, it is possible for an educational institution to apply for and gain ISO certification, although this has not happened yet. Specifically, the standard focuses on the need for organizational structure, well-documented procedures and commitment of resources to implement quality management. As examples of the twenty clauses of the ISO-9001 standard, the company is expected to demonstrate management leadership and participation in quality activities, the existence of a quality policy, review of contracts, control of design activities, control of data and documents within the company, training of employees, etc. All the required clauses of the standard are aimed at error-proofing the quality system and providing an assurance to the company as well as its customers that good quality products and services will result.

Quality Documentation Architecture in Business to Support ISO 9000 Requirements

The basic structure of a quality documentation and record system in the business sector consists of three tiers. At the top level, the quality manual describes the policy of the company and strategic directions. The second level contains procedural information, for instance, test procedures, work instructions for operating machines, operations sheets, drawings and blueprints, etc. The third level consists of the quality records, for example, material review reports, inspection reports, and quality control charts. The quality of the product is enhanced by managing documents and records. It is well known that the absence of documented procedures and historical records pertaining to quality can severely jeopardize the ability of a company to deliver good quality.

Recommended Architecture for Documentation and Records

The types of documents and records recommended here will satisfy, minimally, all documentation and records requirements of Criteria 2000. For international programs that do not seek ABET accreditation, these guidelines should serve as useful tools for continuous improvement of engineering education. The three levels of documentation recommended here are: (i) Program manual, (ii) Documents, and (iii) Records.

Program Manual

The Program Manual should contain the following:

1. General information about the department, address and telephone numbers of department chairperson, historical notes, academic programs offered, accreditation status of programs, laboratory and computing facilities, student organizations, employers of the graduates, alumni accomplishments, names and brief background on faculty and staff, research activities, etc. This section should also include a description of the stakeholders and any special circumstances that make the program unique.
2. Strategic plan (mission, vision, belief statements, goals, and objectives) for the department and all it's academic programs.
3. Consolidated list of all academic policies, regulations and procedures. Details of each policy or procedure may be included in the main program manual. However, to keep the size of the manual manageable, it is preferable to keep the procedures as separate stand alone documents.
4. Curriculum requirements for the academic program. This should include a schedule of required courses with recommended sequence; course descriptions; prerequisite requirements; categorization of courses into design, basic science, mathematics, humanities, social sciences; list of approved elective courses; and a statement on what are the learning objectives of each course.
5. Assessment plan to include the outcomes being monitored, assessment tools used, frequency of data collection, responsibility for assessment activities, and list of people who receive results of assessment. For general guidelines on assessment plans, see [3].
6. Authentication of the manual through the approval signature of the Department Chairperson.

This manual should be treated similar to the quality manual of a business organization. Control should be exercised in revising any part of the manual. Revisions should be formally approved and indicated on the manual. Once revised, faculty should be re-issued new versions and all older versions should be properly disposed.

Documents

A sufficient list of Documents is given below:

1. Procedure to evaluate applications for admission or transfer of new students into the program.
2. Procedure for academic evaluation of students enrolled in the program.
3. Procedure for advising students and monitoring their progression through the program.
4. Procedure for ensuring that students meet all program requirements before they are cleared for graduation.
5. Procedure to study needs of the program's stakeholders and determine and periodically evaluate program objectives.
6. Procedure for evaluating the curriculum to verify that it ensures the achievement of the program objectives.
7. Procedure for taking corrective action in the form of curriculum revision if any outcome assessment result indicates a deficiency. An example procedure is presented as Exhibit A.
8. Procedure for recruiting new faculty and other staff in the department.

Records

The following list summarizes recommended Records as evidence of data collection and analysis:

1. Assessment results. This includes data and findings based on all the assessment instruments in use by the academic program. For example, if surveys are used to collect data on one or more attributes, then statistical summaries of the responses and interpretive conclusions should be part of the records.
2. Records of actions taken to correct inadequate results on assessment studies, and an assessment of the effectiveness of each action.
3. Overall enrollment levels in the program each year.
4. Enrollment level and the instructor for each section of each course for each year.
5. Student retention and graduation rates.
6. History of job placement of graduates, i.e., where did each graduate of the program go upon graduation.
7. Cumulative student academic record to include all courses attempted in chronological order and performance in each course as indicated by a course grade.
8. Data on classroom space and audio-visual teaching resources available.
9. Space dedicated to laboratories and a list of machines and equipment presently available for teaching. Each laboratory should be cross-referenced to one or more course in the program.
10. Description of computing resources made available to students in the program.
11. Data on library resources made available to students in the program.
12. Data on departmental budget for supporting the academic program. Details on amounts spent on travel, laboratory equipment, student assistantships should be included.
13. Records of faculty support for training, attending meetings and conferences and other travel for professional development.
14. Names, qualifications, experience and special expertise of faculty. This may be in the form of a consolidated set of faculty resumes in a standard format. This record should also include courses that each faculty member is affiliated with.
15. Data on support personnel dedicated to support the academic program.

Final Word

Increasingly, the emphasis in ISO 9000 is on maintaining extensive documentation regarding all the procedures and work instructions, sometimes at the expense of actually following up on the written procedures. There is danger of a similar situation in engineering education if priorities are not set and followed by the academic programs. Although ABET 2000 will require a tremendous focus on documentation of assessment efforts, it will be even more important to document and demonstrate how the data so collected was used effectively for bringing about sustained improvements in engineering education.

Summary

This paper discusses the importance of proper documentation of procedures and records within an engineering program, especially in view of demands placed by employers, funding agencies, accreditation bodies, and society at large. The paper presents a recommended structure for assembling relevant documents for use in quality assurance as well as for accreditation related self-studies.

Acknowledgment

I gratefully acknowledge the financial support provided to me by the Southeastern University and College

Coalition for Engineering Education (SUCCEED), one of eight coalitions sponsored by the National Science Foundation.

References

1. ABET-EAC, "Criteria For Accrediting Programs In Engineering In The United States", Accreditation Board for Engineering and Technology, Inc., 111 Market Place, Suite 1050, Baltimore, Maryland, 21202-4012. (*http://www.abet.org)*
2. ANSI/ASQC Standards Committee, "Quality Systems -- Model for Quality Assurance in Design, Development, Production, Installation, and Servicing", *ANSI/ASQC Q9001-1994*, American Society for Quality Control, Milwaukee, WI, August 1994. (*http://www.asq.org)*
3. SUCCEED, "ABET 2000 Outcomes Assessment Planning Guide", Southeastern University and College Coalition for Engineering Education, 1997. (*http://www.succeed.vt.edu)*

EXHIBIT A

PROCEDURE FOR CURRICULUM REVISION TO ADDRESS DEFICIENCY IN AN OUTCOME MEASURE	
Reference: ABET 2000 Criterion 2(d), 3	Number: PROC 07
Written by: Sanjiv Sarin, Undergraduate Program Coordinator	Effective: 2-28-98
Approved by: Eui H. Park, Chairperson Industrial Engineering Department	Revision: 1.00
	Supersedes: none
	Page 1 of 2

1.0 PURPOSE:
To provide a system by which shortcomings in the curriculum can be analyzed and revision implemented to assure better assessment results.

2.0 SCOPE:
This procedure applies to all outcomes measured in support of the assessment of the Bachelor of Science in Industrial Engineering program.

3.0 DEFINITIONS:

3.1 OUTCOME: A measurable attribute of an engineer, developed as a result of the educational experience.

3.2 PERFORMANCE TARGET: The desired value of an outcome, stated in a quantitative manner.

4.0 ASSOCIATED MATERIALS:

4.1 Assessment records indicating unsatisfactory results on an outcome measure.

4.2 Records of effectiveness of specific curriculum revision and other strategies used in the past.

5.0 PROCEDURE:

5.1 Curriculum revision will be initiated whenever one or more outcome measures fall below the performance target.

5.2 The assessment results are discussed in the undergraduate program committee. Brainstorming is used to develop strategies for improving outcome measures found deficient. The committee will refer to historical records of strategies that were found effective in resolving similar problems in the past.

5.3 Convergence techniques such as Multivoting or Nominal Group Technique will be applied as needed to reduce and prioritize strategies.

5.4 Recommendations are presented to the department faculty for approval.

5.5 Upon approval by the department faculty, the curriculum modification proposal is routed through the following: the college curriculum committee, the college of engineering faculty, the university curriculum committee, the university senate, faculty forum, and the vice-chancellor for academic affairs.

5.6 Curriculum revision is published in the university bulletin, the department program manual, and on the internet. Notice of changes are communicated to all students currently in the program.

6.0 RESPONSIBILITY:

6.1 The undergraduate program coordinator is responsible for initiating a curriculum revision by calling a special meeting of the undergraduate program committee.

6.2 The undergraduate program committee discusses the assessment results and brainstorms various strategies for improvement.

6.3 The undergraduate coordinator presents recommendations for corrective action to the full department faculty for approval.

6.4 The department chair is responsible for follow-up of the curriculum change package through the college curriculum committee, the college of engineering faculty, the university curriculum committee, the university senate, faculty forum, and the vice-chancellor for academic affairs.

6.5 The vice-chancellor for academic affairs instructs the registrar on curriculum changes.

6.6 The undergraduate coordinator is responsible for reviewing the university bulletin, department program manual and the internet page to ensure changes have been properly posted.