ABET Program Accreditation Criteria Applied in a School of Mathematics, Science, and Engineering

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Abstract

Degree programs in mathematics and the natural sciences have similar characteristics of engineering programs. Many of the program differences can be explained by differences in the requirements of governing professional societies and the research emphasis of the program. Typically, engineering programs have more emphasis on applied science and mathematics.

Because many of the characteristics of industrial engineering and engineering management graduates that are desirable in industry also apply to mathematics and science program graduates, it seems reasonable that the ABET 2000 Criteria can be applied directly to mathematics and natural science degree programs.

This paper presents results of implementing the ABET 2000 Criteria in a School of Mathematics, Science, and Engineering in a small, liberal arts based institution. The implementation is in the context of developing an industrial engineering program and long range plans for engineering management at the graduate level.

Introduction

The University of the Incarnate Word (UIW) is a small, predominately Hispanic, Catholic institution in San Antonio, Texas. At this institution, professional degree programs are embedded in a liberal arts environment. The University recently reorganized the School of Arts and Sciences into the College of Humanities, Arts, and Social Sciences and the School of Mathematics, Science, and Engineering (MSE). As part of the re-organization, the School of MSE was charged with developing an organizational structure and program management procedures within the context of the University policy and procedures.

There are approximately twenty-five full-time equivalent faculty in the School. The School administers degree programs in Biology, Chemistry, Computer Science, Environmental Science, and Mathematics. Efforts are underway to develop engineering and computer information systems degree programs.

The mathematics, computer science, and natural sciences degree programs at UIW have characteristics similar to the proposed engineering program. For example, advanced topics in mathematics, computer science, engineering, and natural science programs have similar basic mathematics and natural science degree requirements. The engineering and computer science degree programs have more emphasis on applied mathematics. In general, differences can be explained by requirements of the governing societies and the program research emphasis.

The Accreditation Board for Engineering and Technology promulgates benchmarking standards for administering engineering and technology programs[1]. Until the 2000-01 academic year programs could elect to apply for accreditation using ABET's *Conventional Criteria* for program accreditation. The *Conventional Criteria* was based on a prescription for program accreditation. As of fall 2001, all accreditation visits were conducted using the ABET *2000 Criteria*[2]. The *2000 Criteria* provides much more program flexibility[3] because the focus is on a systematic approach to program management.

Integral components[4] of the ABET *2000 Criteria* include formulating program outcomes and objectives; developing and working a strategic plan; and assessing the effectiveness of the plan and related activities to accomplish the desired outcomes and objectives. Demonstrating that program constituents have participated in the process is also an important part of the program management process.

The ABET 2000 program management features described above, number of faculty in the School, nature of the degree programs offered, and the decision to develop an engineering degree program were major factors that influenced the faculty's decision to adopt the ABET *2000 Criteria* for program management. The remaining sections detail the implementation of the ABET *2000 Criteria* in the School of MSE at UIW.

Strategic Planning

A paradigm shift that must accompany an implementation of the ABET *2000 Criteria* is that the emphasis becomes program management rather than course management. Figure 1 presents the School's organization chart as of the fall 2001 academic semester that facilitates the change in emphasis. Division Directors have primary responsibility for daily operations and immediate supervision of faculty in that Division. Staff Directors have traditional staff responsibilities to support the academic divisions. All Directors and Committee Chairs share a coordination role with the Dean for strategic planning and program implementation and evaluation. The Coordinator of Strategic Planning serves as Chair of Curriculum Committee. This ensures that curriculum development activities are consistent with the School's strategic plan. The Curriculum Committee is charged with reviewing all requests for new programs, new courses, and changes in courses, curricula, and programs that affect degree programs administered in the School of Math, Science, and Engineering. The development and role of the School Advisory Board are discussed in a later section.

The College Mission, Vision, and School Objectives are based on *Ex-Corde Ecclesiae*, the Papal guidelines for higher education in Catholic institutions. A draft of the Mission Statement, Vision, and School Objectives was developed over the summer of 2001 and adopted, after some editorial revisions, by the MSE faculty early in the fall semester. Consistent with the University Mission, the School's Mission is to:

- Ensure that the education process is directed toward the development of the whole person.
- Help create economic and industrial growth for the good of the individual and society.
- Conduct scholarly activity with a concern for the ethical and moral implications.

The Vision for the School is to be a Christian leader in mathematics, science, and engineering education in South Texas and other areas deemed appropriate by the University. The School Objectives are to:

- Prepare graduates to be of Christian service to others and promote social justice.
- Prepare graduates with expertise to help create economic and industrial growth for the good of the individual and society.
- Conduct scholarly activities in discovery, integration, application, and teaching that enhance the graduate and undergraduate educational experience.
- Perform scholarly activities in education that enhance the infrastructure in mathematics, science, and engineering education in South Texas.

After the Mission Statement, Vision, and School Objectives were adopted by the faculty and approved by the University administration, Program Outcomes for degree programs administered by the School were developed using the outcomes in ABET 2000 Criterion 3 a-k as a template. In addition to graduates participating in a major senior research/design project as an integral part of their educational experience, each degree program must also demonstrate that graduates have a(n):

- Ability to apply knowledge of math and science to solve problems.
- Ability to design and conduct experiments.
- Ability to analyze and interpret data.
- Capability to design system, component or processes to meet system requirements.
- Ability to function on multidisciplinary teams.
- Ability to identify, formulate, and solve math and science problems.
- Understanding of professional and ethical responsibility.
- Ability to communicate effectively.
- Knowledge and skills derived from a liberal arts education.
- Recognition of the need to engage in life-long learning.
- Knowledge of contemporary issues.
- Ability to use techniques, skills, and tools related to the discipline.
- Understanding of leadership and engagement in leadership activities.
- Knowledge of the University and School Mission.

Individual degree program objectives and outcomes presented and discussed in the next section are derived from the School Objectives and Outcomes.

Degree Program Management

The Curriculum Committee ensures that, as curriculum and/or course changes are forwarded to the University Curriculum committee, all course requirements and objectives are detailed in the syllabus and the course contents are consistent with and linked directly to program outcomes and objectives of the degree program(s) affected by the changes. In addition to broader responsibilities, the Strategic Planning Committee assists the Curriculum Committee to determine how the School's strategic objectives and outcomes are influenced by curriculum

and/or course changes being considered by the Curriculum Committee. The remainder of this section describes School efforts during the fall 2001 semester.

Table 1 presents the Degree Program Objectives for current and proposed degree programs. Objectives for the biology, chemistry, and mathematics degrees reflect several degree options. Table 2 presents Degree Program Outcomes for each degree. The degree program outcomes focus on components of the curriculum. The common objectives, or signature, of the academic degree programs administered by the School are that all graduates have a(n):

- Ability to function on multidisciplinary teams.
- Understanding of professional and ethical responsibility.
- Ability to communicate effectively.
- Knowledge and skills derived from a liberal arts education.
- Recognition of the need to engagement in life-long learning.
- Understanding of leadership and engagement in leadership activities.

As part of the degree program management activities, degree programs are being analyzed to determine how interdisciplinary degree requirements can be used for program outcomes and more efficiently utilize School resources. Alternatives for these are to:

- Recruit faculty who can teach courses in more than one degree program.
- Specify discipline minors that are portable between degree programs.
- Develop technical electives that apply to several degree programs.
- Develop common courses to meet common degree program outcomes.

Courses being considered by faculty that would be common to all degree programs administered by the School are Ethics, Applied Statistics, Speech, Senior Design/Research Project, and Leadership and Project Management.

Degree Program(s) Assessment

In order to assess the effectiveness of the strategic plan and related activities to accomplish the desired degree program objectives and outcomes, the School must develop program metrics and data collection instruments. Therefore, major milestones for the early part of the spring 2001 semester are to:

- Develop course objectives using levels of understanding from Bloom's taxonomy.
- Map course objectives to degree programs outcomes.
- Map degree program outcomes to degree programs objectives.
- Develop assessment metrics for the degree program objectives and outcomes.
- Develop data collection instruments for the metrics.

Examples of assessment tools that must be developed are student surveys, senior exit interviews, and standardized test scores. Because of the similarity between degree program objectives and outcomes, many of the assessment tools will be common to all of the degree programs administered by the School.

External Advisory Boards have become an excellent source of assessment data. The Industrial Advisory Board for the Department of Industrial and Manufacturing Engineering at Tennessee Technological University has been actively assisting the Department for several years with strategic planning and program evaluation[5]. Another major spring semester milestone for the School at UIW is to charter an MSE Advisory Board. Details of this effort and role of an advisory board are described in the following section.

School Advisory Board

Another important component of the ABET *2000 Criteria* is demonstrating that degree program constituents have participated in the strategic planning process. An Advisory Board can ensure active participation in the strategic planning process by alumni, industry, government, and current students.

The role and scope of the MSE Advisory Board will be to provide advice and counsel to the School and University on program activities. The Board will consist of fifteen to twenty management level professionals from industry, government, and other academic institutions. These individuals will be recognized leaders in their organizations with experience in any combination of the performance, evaluation, or supervision of activities that may be performed by graduates of degree programs administered by the School and who have a special interest in our School. There will also be several students on the Board.

Topics to be addressed by the Board may include but will not be limited to School and/or degree program(s) goals and objectives, local industry needs for instructional programs (e.g., seminars, and continuing education), internships and co-op programs, research programs, scholarship programs, and faculty development opportunities. Board members could assist with evaluating the senior design projects by independently assessing the degree program outcomes presented in Table 2.

A distinct advantage of an Advisory Board in the current environment at UIW is that the School can select advisory board members with interests that match the degree program(s) objectives. Changing the emphasis of an existing engineering program is particularly challenging because of the effort to change program constituents.

Organizations that have been approached to participate in an MSE advisory board include HD Zachry, Howard E. Butt, Southwestern Bell Corporation, UT Health Science Center, Brooks Air Force Base, and Valero Energy. In preliminary discussions with representatives of these organizations, it became apparent that those signature attributes of program graduates identified in the section on strategic planning are in fact common to all mathematics, sciences, industrial engineering, and engineering management graduates.

Degree Program(s) Evaluation

The loop on the strategic planning cycle is complete when the program objectives and outcome metrics are evaluated and, based on the analysis, any appropriate changes to the program are

made. The evaluation may suggest changes in the curriculum, management process, metrics, or data collection instruments.

The Advisory Board must be an active participant in closing the loop. Assessment metrics for goals and objectives and preliminary monitoring data, including exit interviews and surveys, will be presented and discussed during the annual Advisory Board Meeting. There must be an assessment and reconciliation of performance characteristics of each degree program.

Conclusions

The ABET *2000 Criteria* provides for program flexibility because of the focus on a systematic approach to program management. The School of MSE is in the process of adapting the ABET Criteria and using it as a tool for degree program management. There has been a modest amount of faculty effort to learn the terminology. The expected trade-offs are that there will be a common program management process within the School and many of the assessment tools will be common among degree programs. This will enable the School to manage resources to administer the degree programs more efficiently. More importantly, those signature attributes of program outcomes identified in the section on strategic planning are in fact desirable qualities that are common to all mathematics, sciences, industrial engineering, and engineering management graduates.

There was another important benefit derived from implementing an adaptation of the ABET *2000 Criteria* in the School. The process of articulating and comparing degree program objectives and outcomes facilitated the effort to develop synergism among the degree programs. If this can be accomplished in a School of MSE with diverse programs, then the opportunities should be even greater within a College of Engineering.

Bibliography

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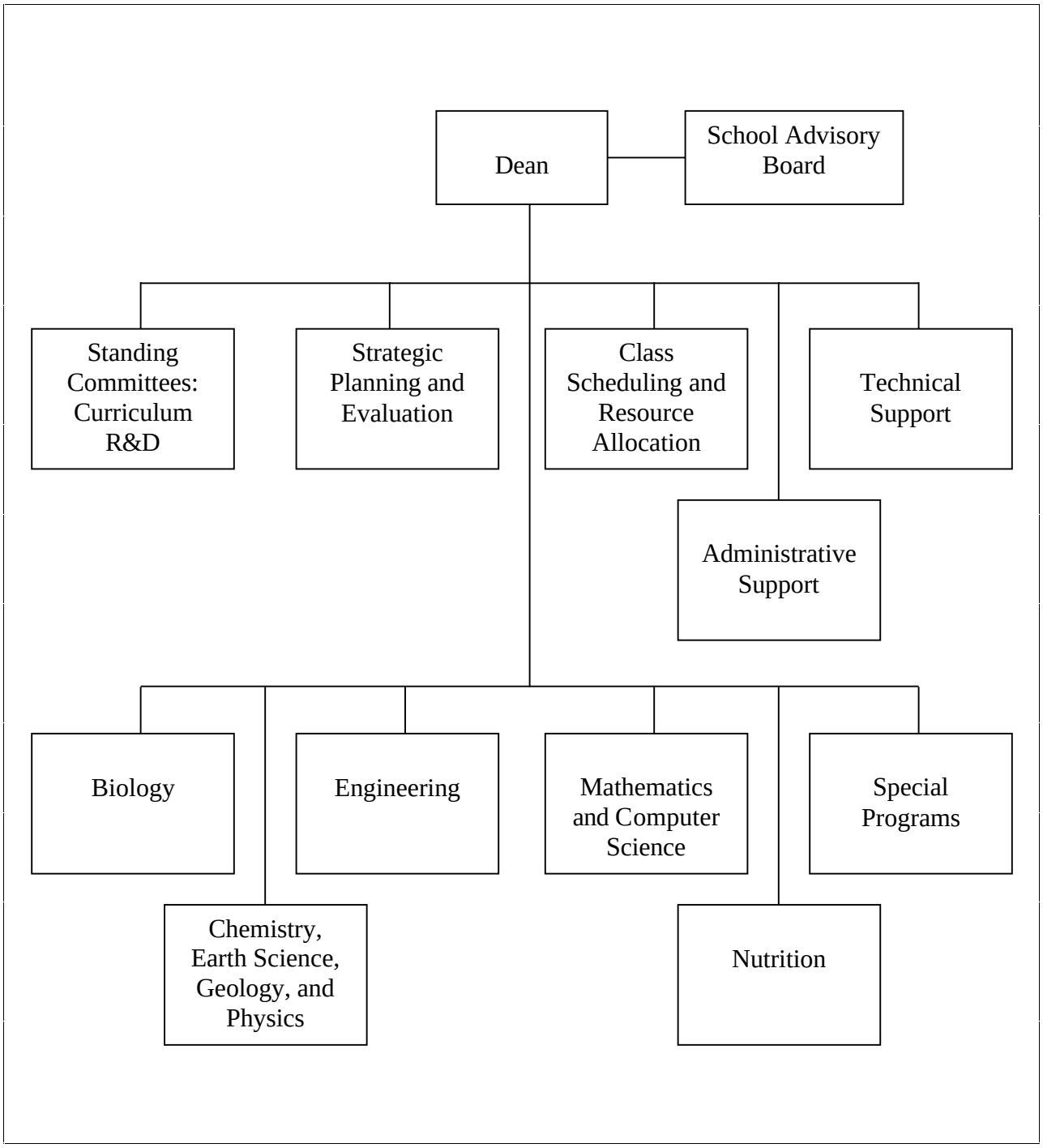

Figure 1. Organization of the School of Mathematics, Science, and Engineering at UIW.

Table 1. Degree Program Objectives.

Degree Program - Option	Objective #1	Objective #2	Objective #3	Objective #4
Biology	Be of Christian service to others and promote social justice.			
Biology --Research Option		Pursue medical school, dental school, optometry school, and other professional programs.	Pursue graduate studies in a basic research degree program.	Provide leadership and technical expertise in biology to a high technology laboratory environment.
Biology --Environmental Science Option		Pursue graduate studies in a professional degree program.	Provide leadership, multi-disciplinary experience, and technical expertise in an environment with an ecological and environmental emphasis on natural resource management and conservation.	Provide leadership, multi-disciplinary experience, and technical expertise to an ecological and environmental organization with an emphasis on hazardous materials management, or soil and air quality.
Biology --Teaching Option		Pursue graduate studies in science education or professional degree program.	Provide leadership and multi-disciplinary experience in a grade 8 -12 science educational system.	

Table 1. Degree Program Objectives (continued).

Degree Program - Option	Objective #1	Objective #2	Objective #3	Objective #4
Chemistry	Be of Christian service to others and promote social justice.			
Chemistry --Research Option		Pursue medical school, dental school, optometry school, and other professional programs.	Pursue graduate studies in a basic research degree program.	Provide leadership and technical expertise in chemistry to a high technology laboratory environment.
Chemistry --Environmental Science Option		Pursue graduate studies in a professional degree program.	Pursue professional career in natural science environment	
Chemistry --Teaching Option		Pursue graduate studies in science education or professional degree program.	Provide leadership and multi-disciplinary experience in a grade 8 -12 science educational system.	
Computer Information Systems	Be of Christian service to others and promote social justice.	Pursue graduate studies in a professional degree program.	Provide leadership and multi-disciplinary experience to plan and design complex information systems.	Provide leadership and technical expertise to design, develop, and maintain complex information systems.
Computer Science	Be of Christian service to others and promote social justice.	Pursue graduate studies in a research or professional degree program.	Provide leadership and multi-disciplinary experience to plan and design complex computer systems.	Provide leadership and technical expertise to design, develop, and maintain complex computer systems.

Table 1. Degree Program Objectives (continued).

Degree Program - Option	Objective #1	Objective #2	Objective #3	Objective #4
Industrial Engineering	Be of Christian service to others and promote social justice.	Pursue graduate studies in a professional degree program.	Provide leadership in planning, designing, developing, and controlling complex production and service systems.	Solve productivity problems using industrial engineering and information systems techniques.
Mathematics	Be of Christian service to others and promote social justice.	Pursue graduate studies in mathematics research or professional degree in areas such as physics, engineering, or computer science.	Provide leadership and multi-disciplinary experience in mathematics for government and industry.	Provide leadership and technical expertise in applied mathematics to a high technology environment.
Mathematics --Computer Science Option		Pursue graduate studies in a professional degree in areas such as physics, engineering, or computer science.	Provide leadership and multi-disciplinary experience in mathematics and computer science for government and industry.	Provide leadership and technical expertise in mathematics and computer science in a high technology environment.
Mathematics --Teaching Option		Pursue graduate studies in mathematics education or professional degree program.	Provide leadership and multi-disciplinary experience in a grade 8 -12 math-science educational system.	

Table 2. Degree Program Outcomes.

Outcomes	Biology	Chemistry	Computer Information Systems
a	ability to apply knowledge of mathematics and other basic sciences to problem solving	ability to apply knowledge of mathematics and other basic sciences to problem solving	ability to apply knowledge of mathematics and other basic sciences to problem solving
b1	ability to design and conduct biological experiments	ability to design and conduct chemical experiments	ability to design and conduct information systems experiments
b2	ability to analyze and interpret biological data	ability to analyze and interpret chemical data	ability to analyze and interpret information systems data
c	capability to analyze, design, verify, validate laboratory, field and independent research	capability to analyze, design, verify, validate laboratory and independent research	capability to analyze, design, verify, validate, implement, and maintain information systems, in the degree minor
d	ability to function on multi-disciplinary teams	ability to function on multi-disciplinary teams	ability to function on multi-disciplinary teams
e	ability to identify, formulate, and solve biological problems	ability to identify, formulate, and solve chemical problems	ability to identify, formulate, and solve information systems problems
f	understanding of professional and ethical responsibility	understanding of professional and ethical responsibility	Understanding of professional and ethical responsibility
g	ability to communicate effectively	ability to communicate effectively	ability to communicate effectively
h	knowledge and skills derived from a liberal arts education	knowledge and skills derived from a liberal arts education	knowledge and skills derived from a liberal arts education
i	recognition of need an ability to engage in life-long learning	recognition of need and ability to engage in life-long learning	recognition of need an ability to engage in life-long learning
j	knowledge of contemporary issues in biology	knowledge of contemporary issues in chemistry	knowledge of contemporary issues in information systems
k	ability to use techniques, skills, and tools related to biology	ability to use techniques, skills, and tools related to chemistry	ability to use techniques, skills, and tools related to information systems
l	understanding of leadership and engage in leadership activities	understanding of leadership and engage in leadership activities	understanding of leadership and engage in leadership activities
m	knowledge of the University and School Mission	knowledge of the University and School Mission	knowledge of the University and School Mission
n	use of computer technology to complete integrative projects.	use of computer technology to complete integrative projects.	experience on a variety of information systems and proficient in a modern programming language

Table 2. Degree Program Outcomes (continued).

Outcomes	Computer Science	Industrial Engineering	Mathematics
a	ability to apply knowledge of mathematics and basic sciences to problem solving	ability to apply knowledge of mathematics and basic sciences to problem solving	ability to apply knowledge of basic science to problem solving
b1	ability to design and conduct computer science experiments	ability to design and conduct systems engineering experiments	ability to design and conduct experiments on mathematical systems
b2	ability to analyze and interpret computer science data	ability to analyze and interpret systems performance data	ability to analyze and interpret physical systems data
c	capability to analyze, design, verify, validate, implement, and maintain computer systems	capability to analyze, design, verify, validate, implement, and maintain industrial systems, components or processes	capability to analyze, design, verify, and validate mathematical representation of physical systems
d	ability to function on multi-disciplinary teams	ability to function on multi-disciplinary teams	ability to function on multi-disciplinary teams
e	ability to identify, formulate, and solve computer science problems	ability to identify, formulate, and solve industrial engineering problems	ability to identify, formulate, and solve mathematical problems
f	understanding of professional and ethical responsibility	understanding of professional and ethical responsibility	understanding of professional and ethical responsibility
g	ability to communicate effectively	ability to communicate effectively	ability to communicate effectively
h	knowledge and skills derived from a liberal arts education	knowledge and skills derived from a liberal arts education	knowledge and skills derived from a liberal arts education
i	recognition of need an ability to engage in life-long learning	recognition of need an ability to engage in life-long learning	recognition of need and ability to engage in life-long learning
j	knowledge of contemporary issues in computer science	knowledge of contemporary issues in systems engineering	knowledge of contemporary issues in mathematics
k	ability to use techniques, skills, and tools related to computer science	ability to use techniques, skills, and tools related to industrial and information systems	ability to use techniques, skills, and tools related to mathematics
l	understanding of leadership and engage in leadership activities	understanding of leadership and engage in leadership activities	understanding of leadership and engage in leadership activities
m	knowledge of the University and School Mission	knowledge of the University and School Mission	knowledge of the University and School Mission
n	experience on a variety of computing systems and proficient in a modern programming language	specify data requirements and develop software to assess system performance characteristics.	use computer science tools for mathematical modeling.

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