AC 2010-144: DEVELOPING AN ENGINEERING TECHNOLOGY CURRICULUM: A CASE STUDY AT WESTERN CAROLINA UNIVERSITY

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Developing an Engineering Technology Curriculum: A Case Study at Western Carolina University

Abstract

Institutions providing engineering technology programs have been adjusting to changing needs of their students and industry, and that those institutions which are not responding to market needs on a timely basis are discontinuing their programs. Recent growth in student enrollment in engineering programs may explain a part of the shift by some institutions away from engineering technology programs which are sometimes considered a lower subset of engineering. Engineering technology two year associate degree programs as well as four year bachelor degree programs are common in the United States, and are generally more hands-on, less theoretical programs than engineering programs which are almost always four year bachelors programs. Engineering technology courses generally require less math in their curriculum than engineering courses to obtain accreditation. While the job prospects for technologists are very good, engineering graduates are sometimes considered more valuable by some employers.

At Western Carolina University in North Carolina, program administrators have developed a distance format, engineering technology program for working professionals which provides a flexible curriculum that promotes transfer of two-year community college credits into a four-year program to foster bachelor degree completion in the shortest amount of time. The program administrators desire to accredit the program through the Accreditation Board of Engineering Technology (ABET). This paper provides a discussion of the considerations which must be taken to apply for ABET accreditation for a nontraditional, general engineering technology program.

Introduction

According to the Accreditation Board for Engineering and Technology, in Baltimore, Maryland, there has been a 16 percent decrease in the number of accredited engineering technology programs since 1995. During 2005 there were 371 associate degree and 369 bachelor degree accredited engineering technology programs at 220 postsecondary educational institutions. The number of institutions offering engineering technology has also dropped nearly every year since 1997 when there were 250 institutions with accredited engineering technology programs. Technical educational programs in environmental, computer, materials and manufacturing fields have seen growth in the number of accredited programs during the 1995-2005 period.[1]

Recently, there has been an upward trend in the number of college students in four year educational programs in the United States. There were about 14 million students at four year

institutions in 2004.[2] Undergraduate enrollment in technical fields has also been on the increase since 2000 after a period of declining enrollments in the mid and late 1990s.[3]
During the 2003-2004 year, there were about 400,000 undergraduate students enrolled in engineering, engineering technology, computer science and other technical, postsecondary educational programs, but, "Some engineering technology programs in the United States are [still] struggling with low enrollments."[3]

Given the above information, one might conclude that institutions providing engineering technology programs have been adjusting to changing needs of their students and industry, and that those institutions which are not responding to market needs on a timely basis are discontinuing their programs. Growth in enrollment in engineering programs may explain a part of the shift by some institutions away from engineering technology programs which are sometimes considered a lower subset of engineering. Engineering technology two year associate degree programs as well as four year bachelor degree programs are common, and are generally more hands-on, less theoretical programs than engineering programs which are almost always four year bachelors programs. Engineering technology courses generally require less math in their curriculum than engineering and are considered less rigorous programs of study. While the job prospects for technologists are very good, engineering graduates are sometimes considered more valuable by some employers.

In North Carolina there are numerous technical programs which are not accredited, but there are four community colleges in the state that offer 11 accredited two year associate degree programs in engineering technology, and two universities, the University of North Carolina, Charlotte and Western Carolina University, which offer six accredited bachelor degree programs in engineering technology. Of these 17 total programs, three have been accredited since 1990.[1] In contrast, Duke University, North Carolina Agricultural and Technical University, the University of North Carolina, and North Carolina State University offer 32 accredited bachelor degrees in engineering. Fifteen of these programs were first accredited after 1990.[1] Engineering technology program administrators in North Carolina must become more responsive to market needs to best serve the citizens of the state as exemplified by the number of new programs in engineering.

Discussion

At Western Carolina University, there are two accredited bachelor degree engineering technology programs: Electrical and Computer Engineering Technology; and Engineering Technology. The Engineering Technology program was first accredited in 1985 as Manufacturing Engineering Technology. The name was changed in 2003 to Engineering Technology to facilitate improved recruiting. The program is offered on-campus and at night as a distance education program at four remote sites in western North Carolina to provide educational services to working adults and community college students. The program has an enrollment of about 180 students and is administered by six fulltime faculty members. About half of the students are distance learners.

The program has a strong liberal studies component which is required for all bachelor degree programs at Western Carolina University. The courses required for accreditation by the Accreditation Board for Engineering and Technology are included in the curriculum. The on-campus program has a strong rapid prototyping and design track which includes three dimensional drafting and design coursework as well as manufacturing related courses. The distance program requires only manufacturing coursework and may or may not include the rapid prototyping and design courses for graduation. The name of the distance program is Distance Engineering Technology and is not accredited. The distance program incorporates associate in applied sciences degrees from two year community colleges in North Carolina for much of the program requirements and a 33 credit hour, junior and senior level technical course core content to provide students with a two plus two year program. The problem is that the graduation requirements for the two programs are different, but the names are the similar. A common core of courses for the program might be chosen to obtain accreditation by the Accreditation Board for Engineering and Technology for the Distance Engineering Technology program. Lists of required courses for both programs are shown on the following pages.

Engineering Technology Major
Distance Program

Liberal Studies (30 hours)

C1: ENGL I	(3)
C1: ENGL II	(3)
C2: MATH (3)	Waive
C3: Oral Comm.	(3)
C4: Wellness	(3)
C5: Science (3)	Waive
C5: Science (3)	Waive
P1: Soc. Science	(3)
P1: Soc. Science	(3)
P3: History	(3)
P4: Humanities	(3)
P5: Fine/Perf Arts	(3)
P6: World Cult.	(3)

WCU ET Courses (33 hrs Upper Level)

ENGL 305 Tech. Writing	(3)
ECET 301 Elec. Sys.	(3)
ET 331 Quality Sys.	(3)
ET 351 Eng. Anal.	(3)
ET 436 Eng. Econ.	(3)
ET 441 Pwr Trns Sys.	(3)
ET 461 Proj. Mgt.	(3)
ET 472 Int. Con. Sys.	(3)
ET 478 Int. Sys. Proj.	(3)
ET 4xx UL Elective	(3)
ET 4yy UL Elective	(3)

General Electives (42 hours minimum)

Taken from 2 year Associate of Applied Science program of study

Math/Science Requirements (19 hours)

Trigonometry	(3)
Statistics	(3)
Calculus	(5)
Physics	(4)
Chemistry	(4)

Total Hours: 124

Engineering Technology Major
On-campus Program
Engineering Systems Concentration

Liberal Studies (33 hours)

C1: ENGL I	(3)	
C1: ENGL II	(3)	
C2: MATH	(3)	Waive
C3: Oral Comm.	(3)	
C4: Wellness	(3)	
C5: Science	(3)	Waive
C5: Science	(3)	Waive
P1: Soc. Science	(3)	
P1: Soc. Science	(3)	
P3: History	(3)	
P4: Humanities	(3)	
First Year Sem.	(3)	
P5: Fine/Perf Arts	(3)	
P6: World Cult.	(3)	

Engineering Tech Courses (60 Hours)

ET 132 Engineering Graphics	(3)
ET 141 Engineeirng Materials	(3)
ET 231 3D Computer Modeling	(3)
ET-232 Statics and Strength	(3)
ET 335 Occupational Safety	(3)
ECET 301 Elec. Sys.	(3)
ET 349 Rapid Tooling & Prototyping	(3)
ET 351 Eng. Anal.	(3)
ET 362 Engr Logistics	(3)
ET 425 Metrology	(3)
ET 331 Quality Sys.	(3)
ET 420 Polymer Technology	(3)
ET 441 Pwr Trns Sys.	(3)
ET 436 Eng. Econ.	(3)
ET 461 Proj. Mgt.	(3)
ET 449 Advanced Tooling	(3)
ET 472 Integrated Controls	(3)
ET 478 Integrated Systems	(3)
ENGL 305 Tech. Writing	(3)
ET 410 Advanced 3D Modeling	(3)

Math/Science Requirements (19 hours)

Trigonometry	(3)
Statistics	(3)
Calculus	(5)
Physics	(4)
Chemistry	(4)

Electives (12 Hours)

General Elective	(3)
General Elective	(3)
General Elective	(3)
Technical Elective	(3)

Total Hours: 124

Accreditation Issues

When determining the content of a new curriculum, program objectives must first be considered. The mission of the Engineering Technology (ET) program is to prepare graduates with the technical and managerial skills necessary to enter careers in process and systems design, technical sales, manufacturing operations, maintenance or service functions of a manufacturing enterprise. Further, the program supports the University's mission and commitment to the community as it provides industries in North Carolina and the region with graduates capable of being immediately productive, and a faculty responsive to the region's economic changes and growth. All coursework in the ET program must support this mission. Graduates capable of being immediately productive must be produced. Many of the on-campus courses meet this immediate requirement such as Engineering Graphics, and 3-D Computer modeling.

In addition to the mission statement of the program, administrators must also consider that a program accredited by the Accreditation Board for Engineering and Technology (ABET) must also meet the standards of the ABET code which are shown below, taken directly from the ABET standard which may be found on-line at ABET.org.[1]

> "1. Program Outcomes are statements that describe what units of knowledge or skill students are expected to acquire from the program to prepare them to achieve the program educational objectives. These are typically demonstrated by the student and measured by the program at the time of graduation.
>
> An engineering technology program must demonstrate that graduates have:
>
> a. an appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines,
> b. an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering and technology,
> c. an ability to conduct, analyze and interpret experiments and apply experimental results to improve processes,
> d. an ability to apply creativity in the design of systems, components or processes appropriate to program objectives,
> e. an ability to function effectively on teams,
> f. an ability to identify, analyze and solve technical problems,
> g. an ability to communicate effectively,
> h. a recognition of the need for, and an ability to engage in lifelong learning,
> i. an ability to understand professional, ethical and social responsibilities,
> j. a respect for diversity and a knowledge of contemporary professional, societal and global issues, and
> k. a commitment to quality, timeliness, and continuous improvement.
>
> 2. Program Characteristics
>
> The program must provide an integrated educational experience that develops the ability of graduates to apply pertinent knowledge to solving problems in the engineering technology specialty. The ABET standards specify subject areas and minimum total credit hours essential to all engineering technology programs. The curriculum must

appropriately and effectively develop these subject areas in support of program and institutional objectives.

a. Total Credits: Baccalaureate programs must consist of a minimum of 124 semester hours or 186 quarter hours of credit. Associate degree programs must consist of a minimum of 64 semester hours or 96 quarter hours of credit.

b. Communications: The communications content must develop the ability of graduates to:

i. plan, organize, prepare, and deliver effective technical reports in written, oral, and other formats appropriate to the discipline and goals of the program,
ii. incorporate communications skills throughout the technical content of the program,
iii. utilize the appropriate technical literature and use it as a principal means of staying current in their chosen technology, and
iv. utilize the interpersonal skills required to work effectively in teams.

c. Mathematics: The level and focus of the mathematics content must provide students with the skills to solve technical problems appropriate to the discipline and the program objectives. Algebra, trigonometry, and an introduction to mathematics above the level of algebra and trigonometry constitute the foundation mathematics for an associate degree program. Integral and differential calculus, or other appropriate mathematics above the level of algebra and trigonometry, constitutes the foundation mathematics for baccalaureate programs.

d. Physical and Natural Science: The basic science content can include physics, chemistry, or life and earth sciences that support program objectives. This component must include laboratory experiences which develop expertise in experimentation, observation, measurement and documentation.

e. Social Sciences and Humanities: The social sciences and humanities content must support technical education by broadening student perspective and imparting an understanding of diversity and the global and societal impacts of technology.

f. Technical Content: The technical content of a program must focus on the applied aspects of science and engineering in that portion of the technological spectrum closest to product improvement, manufacturing, construction and engineering operational functions. The technical content must develop the skills, knowledge, methods, procedures, and techniques associated with the technical discipline and appropriate to the goals of the program.

The technical content develops the depth of technical specialty and must represent at least 1/3 of the total credit hours for the program. In order to accommodate the essential mathematics, sciences, communications, and humanities components, the technical content is limited to no more than 2/3 the total credit hours for the program.

i. The technical content of the curriculum consists of a technical core and the increasingly complex technical specialties found later in the curriculum.

The technical core must provide the prerequisite foundation of knowledge necessary for the technical specialties.

ii. Laboratory activities must develop student competence in the use of analytical and measurement equipment common to the discipline and appropriate to the goals of the program.

iii. Technical courses must develop student knowledge and competence in the use of standard design practices, tools, techniques, and computer hardware and software appropriate to the discipline and goals of the program.

iv. Capstone or other integrating experiences must draw together diverse elements of the curriculum and develop student competence in focusing both technical and nontechnical skills in solving problems.

g. Cooperative Education Cooperative education credit used to satisfy prescribed elements of these criteria must include an appropriate academic component evaluated by the program faculty."

A common core Engineering Technology program at Western Carolina University must include all of these elements. A checklist could be developed to ensure that a new curriculum core will be in compliance with the ABET standard.

Trends in Bachelor Degree ET Programs

As is reflected in the ABET standards discussed previously, adjustments have been made in engineering technology curricula in the United States to ensure ET graduates have sufficient communications and mathematics skills to allow them to be productive contributors to the industry in which they seek employment. In the 1990s, computers were integrated into most engineering technology programs. Law and ethics are another subject area which accrediting agencies in the United States required programs to address during the early 1990s and which is currently under review internationally.[4] Currently, many engineering technology program administrators see a need to cram more and more material into their programs at a time when students want streamlined degrees. Some universities are even combining bachelor and master degree programs in one five year program of study to ensure graduates possess adequate technical knowledge.[5]

A search on the ABET website for other accredited Engineering Technology programs in the United States with similar names and program course requirements yielded three universities with bachelor of science degrees named Engineering Technology: The Community and Technical College at the Institute of Technology at West Virginia University in Montgomery, West Virginia; Lawrence Technological University in Southfield, Michigan; and LeTourneau University in Longview, Texas.

According to their website at http://ctc.wvutech.edu/[6], about 2300 students attend the Community and Technical College at the Institute of Technology at West Virginia University, and about 500 of these students are enrolled in technology programs. They offer 16 associate degree programs in technology areas which include ABET accredited two year programs in Civil, Mechanical, and Electrical Engineering Technology. They also offer an Engineering Technology bachelor degree program with Civil Emphasis, Environmental Emphasis; and

Mechanical Emphasis. Engineering programs are also offered by the University. An emphasis on transfer from the Community and Technical College two year engineering technology programs to West Virginia University is apparent on their website.

Lawrence Technological University's home website is http://www.ltu.edu/.[7] About 5000 students attend the University. The Engineering Technology Department has five full-time faculty members. They offer accredited associate of science in Engineering Technology degrees in Construction, Manufacturing and Mechanical areas. They also offer a bachelor of science degree in Engineering Technology in Computer, Manufacturing, Construction, Mechanical and Electrical concentrations. Engineering programs are also offered by the University. Letourneau University's home website is http://www.letu.edu/.[8] Almost 4000 students attend the University. They offer an accredited associate of science in Design Technology. They also offer a bachelor of science degree in Engineering Technology with Aeronautical, Materials Joining, Mechanical and Electrical concentrations. Engineering programs are also offered by the University in fields which complement their technology concentrations.

Each of the three programs reviewed have two common components: Associate degree programs are supported by their four year Engineering Technology programs; and engineering programs are taught at the same institution. Students interested in an engineering degree, but not capable of completing the rigorous math requirements may elect to enroll in an engineering technology program at the same institution. Engineering Technology program administrators at Western Carolina University should develop a curriculum which will meet accreditation requirements and foster improved enrollment by building upon an in-house engineering program providing an easy path of entry for two year associate degree transfer students and providing concentration options to meet different student needs. A core Engineering Technology curriculum should be developed and implemented at Western Carolina University.

The current Engineering Technology Distance Education program requirements will provide the flexible core curriculum needed. The liberal studies, math and science components as shown in the Distance program are sufficient to meet ABET requirements as outlined previously for an on-campus Engineering Technology program. Only courses currently offered in the Engineering Technology program will be used to develop the new curriculum to keep administrative changes required by the University at a minimum to assist swift implementation of the new program formats. In North Carolina, associate of applied science degrees offered at community colleges are generally 64 credit hours in duration. Students who enter Western Carolina University as a freshman will need 64 additional hours of coursework to meet ABET 124 credit hour requirements. The number of General Electives will need to be changed. Freshman and sophomore courses, Engineering Graphics, Engineering Materials and Processes, 3D Computer Modeling, and Statics courses from the on-campus program could be added into the General Electives category. Occupational Safety, Engineering Logistics and Polymer Technology will be added so that the core Engineering Technology program will be as shown on the next page:

Distance **Engineering Technology Program with Common Core (proposed)**

Liberal Studies (30 hours)		**WCU ET Courses (36 hrs Upper Level)**	
C1: ENGL I	(3)	ENGL 305 Tech. Writing	(3)
C1: ENGL II	(3)	ECET 301 Elec. Sys.	(3)
C2: MATH (3)	Waive	ET 331 Quality Sys.	(3)
C3: Oral Comm.	(3)	ET 351 Eng. Anal.	(3)
C4: Wellness	(3)	ET 436 Eng. Econ.	(3)
C5: Science (3)	Waive	ET 441 Pwr Trns Sys.	(3)
C5: Science (3)	Waive	ET 461 Proj. Mgt.	(3)
P1: Soc. Science	(3)	ET 472 Int. Con. Sys.	(3)
P1: Soc. Science	(3)	ET 478 Int. Sys. Proj.	(3)
P3: History	(3)	ET 420 Polymer Technology	(3)
P4: Humanities	(3)	ET 335 Occupational Safety	(3)
P5: Fine/Perf Arts	(3)	ET 362 Engineering Logistics	(3)
P6: World Cult.	(3)		

General Electives (39 hours minimum)

Taken from two-year Associate of Applied Science program of study or on-campus at Western Carolina University. Must include six hours of technical courses at a minimum to meet ABET requirements.

Math/Science Requirements (19 hours)

Trigonometry	(3)
Statistics	(3)
Calculus	(5)
Physics	(4)
Chemistry	(4)

Total Hours: 124

The current on-campus program is named Engineering Technology: Engineering Systems Concentration. This program will appear as:

Liberal Studies (30 hours)

C1: ENGL I	(3)
C1: ENGL II	(3)
C2: MATH (3)	Waive
C3: Oral Comm.	(3)
C4: Wellness	(3)
C5: Science (3)	Waive
C5: Science (3)	Waive
P1: Soc. Science	(3)
P1: Soc. Science	(3)
P3: History	(3)
P4: Humanities	(3)
P5: Fine/Perf Arts	(3)
P6: World Cult.	(3)

WCU ET Courses (36 hrs Upper Level)

ENGL 305 Tech. Writing	(3)
ECET 301 Elec. Sys.	(3)
ET 331 Quality Sys.	(3)
ET 351 Eng. Anal.	(3)
ET 436 Eng. Econ.	(3)
ET 441 Pwr Trns Sys.	(3)
ET 461 Proj. Mgt.	(3)
ET 472 Int. Con. Sys.	(3)
ET 478 Int. Sys. Proj.	(3)
ET 420 Polymer Technology	(3)
ET 335 Occupational Safety	(3)
ET 362 Engineering Logistics	(3)

Engineering Systems Concentration (24 hours)

ET 132 Engineering Graphics	(3)
ET 141 Engineering Materials & Processes	(3)
ET 231 3D Computer Modeling	(3)
ET 232 Statics	(3)
ET 349 Rapid Tooling	(3)
ET 410 Advanced 3D	(3)
ET 425 Metrology	(3)
ET 449 Advanced Tooling	(3)

General Electives (15 hours minimum)

Taken from two-year Associate of Applied Science program of study or on-campus at Western Carolina University.

Math/Science Requirements (19 hours)

Trigonometry	(3)
Statistics	(3)
Calculus	(5)
Physics	(4)
Chemistry	(4)

Total Hours: 124

This proposed curriculum will fulfill the requirements of a core curriculum and will foster implementation of other 24 credit hour concentrations within the Engineering Technology program such as Construction, Electrical, Computer Science, Business Management or Environmental Technology.

Conclusion

The new program might be implemented over a one year period facilitated by Western Carolina University program change procedures. The faculty, program director, industrial advisory committee, department head, dean and provost must approve the changes in order to provide the programs as proposed, to incoming students. If the program faculty approves the proposed changes, there should be no problem in obtaining approvals from the other constituencies. Other program concentrations may be implemented on a case by case basis as needed to obtain all required approvals.

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