Engineering Technology: A Vision for the Future at Western Carolina University

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Abstract – The Engineering Technology curriculum at Western Carolina University has undergone major changes in the last three years. These changes are in response to several factors including a changing industrial climate in the region, extended engagement mandated by the university system, and recent program restructuring within the department. A brief history of the Engineering Technology department will be presented along with rationale for the curriculum changes. The current status, as well as the future of Engineering Technology at Western Carolina University will be discussed.

Keywords: Engineering Technology, curriculum development

INTRODUCTION

Recent trends in the global economy have forced American industry and education to rethink the way business is done. The outsourcing of manufacturing jobs has driven industry to integrate lean manufacturing methods in an effort to control costs and become more competitive through the development of innovative technology and intellectual property. Similarly, Engineering Technology (ET) curricula must not remain passive, but must also change to reflect the changing needs of the industry. Industry in Western North Carolina has undergone significant changes due to those global economic factors and the region has lost thousands of manufacturing jobs between the years of 1999 and 2004 [Klein, 1]. With these job losses, many of the employment opportunities for WCU graduates disappeared as well. As a result, traditional manufacturing related majors at the university began to decline. Clearly, it was time for the university to reevaluate the currency and effectiveness of its engineering and technology curricula.

BRIEF HISTORY

Western Carolina University was founded in 1889 as a semi-public high school. Four years later a normal department was established and in 1905, the institution became Cullowhee Normal and Industrial School, a title it held for twenty years. During its normal years, the school grew to equivalence of a junior college and in 1929, was elevated to the baccalaureate level and renamed Western Carolina Teachers College. The addition of graduate degrees led to a further change in name in 1953 to Western Carolina College, and in 1967, the institution was granted full university status [Western Carolina University, 2].

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Western Carolina University has a long history of service to the region's businesses and industries. Even in the Cullowhee Normal and Industrial School era, certain "industrial" courses were taught, although no degree was granted. In 1948, the Division of Fine and Industrial Arts was created and a B.S. Ed. degree in Industrial Arts was offered for potential teachers of industrial subjects in high schools in the region. A non-teaching option was also developed for those who chose to enter the rapidly-growing industrial sector in Western North Carolina. By 1950, 17 courses were offered by the college including the areas of drafting, metals/welding, woods/furniture technology, and electricity.

In 1965, new and expanded shop and laboratory space, and the creation of a B.S. in Industrial Technology enabled the institution to enhance course offerings to train potential engineers, managers, supervisors, and technicians for employment in the region. A new facility was completed in 1971 that included state-of the art classrooms and labs in Graphic Arts, Drafting, Electricity/Electronics, Construction, Metals/Welding, Machine Shop, and Environmental Safety.

Steady growth in manufacturing, coupled with the rise in high tech applications, led to the establishment of a Manufacturing Engineering Technology curriculum in 1977. The curriculum sought and was granted ABET accreditation shortly thereafter. In 1980, a national advisory committee was formed to evaluate the possibility of establishing a degree in Industrial Distribution. After much deliberation and input, it was decided that the B. S. in Industrial Distribution would be added to the degree offerings in the department of Industrial Education and Technology. In response to the need for more Electronics personnel in the WNC region, a B.S. degree in Electronics Engineering Technology was approved in 1988. About the same time, the degree in Industrial Arts Education was discontinued. From then until 2002, the Department of Industrial Engineering and Technology served the region well, providing graduates with B. S. degrees in Industrial Technology, Manufacturing Engineering Technology, Electronics Engineering Technology, and Industrial Distribution. However, in recent years, these traditionally strong programs began to experience problems of low enrollment, resource dispersion, and less relevance to industry needs.

THE PROCESS OF CHANGE

As a result of periodic program assessment, faculty in the Department of Engineering Technology at WCU began to detect a downward trend in enrollment. Subsequently, faculty and administrators, in a concerted effort to revise and update its curricula, completed a thorough review of the Manufacturing Engineering Technology (MET), Industrial Distribution (ID), and the Industrial Technology (IT) programs and determined that changes were necessary to meet student needs, industry expectations, and the department's strategic growth plan. The department believed that changes would produce a more up-to-date curriculum that would parallel the department's desire to bring the highest quality education to its students, engage the region, and strengthen the position of the department. Very early in the process, it was decided that we would initiate dialogue with our industry partners to ensure that the programs were continuing to fulfill their missions, which ultimately were to provide quality employees for the region's industries. At the earliest mention, our Industrial Advisory Committee was supportive of any change to strengthen the programs, and aid in the recovery of regional industry.

Prior to the proposed changes, each program was on low enrollment status; MET 25 majors, ID 18 majors, and IT 14 majors. Departmental resources (faculty, yearly budget allocations, administration services, and equipment resources) were seriously divided between each program causing problems in support. University administration, from the Chancellor to the Department Head, granted the faculty a mandate to "rescue" the programs and align them more fully with the university's changing mission: teaching and learning, engagement and regional service, applied research, and scholarly activities. There has been much emphasis on the role of the university in regional economic development through engagement.

Industry in Western North Carolina continues to undergo significant changes due to global economic factors, outsourcing of manufacturing and high-tech jobs, and niche competition [McGraw, 3]. Job loss in manufacturing

has progressively increased since 1999. In a report entitled, Manufacturing Layoffs: Hard Times for Rural Factories, Workers and Communities, The Rural Center reported in April of 2002 that North Carolina had the third highest unemployment rate in the country and that 50,500 fewer people were employed in manufacturing than in 2000 due to plant closings and layoffs, a problem reported as "near crises proportion [Klein 1)." In 2002 the Center reported the total employment in North Carolina decreased by 91,100 jobs [The Rural Center, 4]. Job loss has continued and the current unemployment rate for North Carolina is at 4.8% [US Department of Labor, 5].

Decisions were made leading the way for the emergence of a redirected program in the Engineering Technology Department. Efforts were made to retain existing core courses and develop new courses that would broaden the scope of the curriculum through a product development systems approach. The new curriculum would no longer specifically target traditional manufacturing markets, but would focus upon training students to respond to the rapidly changing industrial scene.

The university's chancellor, Dr. John Bardo, has established a campus-wide mandate for engagement with regional business and industry. Engagement activities would focus on sustaining regional businesses and boosting entrepreneurial startups through innovative and creative projects that develop intellectual capital and technology transfer [Bardo, 6, 7, 8]. Additionally, current research suggests that creative and innovative engagement projects be coupled with student learning to strengthen the competencies of ET graduates [Snellenberger, 9]. Faculty members decided to create a program that would be flexible enough to accommodate engagement projects through undergraduate applied research.

Additional criteria decided upon by the faculty included:

- The industrial advisory board should be broadened and solicited for suggestions.
- The curriculum should take the best from each program and use those components to develop the new program.
- The curriculum should be innovative enough to attract new students.
- The curriculum should be flexible enough to allow for students to individually engage industry through independent study projects or senior design projects.
- The curriculum and scheduling of courses should allow for collaborative engagement projects between courses.

Faculty and administration provided much of the rationale and criteria for the curriculum change. However, the Industrial Advisory Committee provided the impetus for change. According to Summers, industrial advisory boards are a great source for new program creation, monitoring of curriculum effectiveness, and partnerships [Summers, 10]. The committee for each program met prior to changes being made and after the program creation. Industrial Advisory Committee members represent a variety of industries, including Borg-Warner, Rockwell International, Northrop Grumman, and United Southern Plastics. The majority of the members provided positive feedback and praised the new curriculum as being very proactive for the region.

DEVELOPMENT OF THE CURRENT CURRICULUM

The primary focus of the new 124-hour Engineering Technology Program will be on engineered systems with a secondary focus on product development. Additional concentrations can be earned in engineering sales and distribution or safety systems. Based upon suggestions from the industrial advisory committee, it was decided that the ET core and program requirements would provide: a strong base in analytical and decision making skills, oral, graphical, and written communication skills, and management skills.

While the new program bears some resemblance to the old IT, MET, and ID curricula, it has truly been re-engineered. Students are required to complete the university's 42-hour Liberal Studies component, which may

include English Composition I and II, Oral Communications, Law, Economics, History, and Social Science courses. See Appendix 1 for a listing of the former MET, IT, and ID curricula, as well as the new ET curricula.

Program requirements, or degree requirements outside the major department, supplement the major with additional math and science courses that will enhance the student's success in the major, and in practice. Those requirements include Trigonometry, Calculus, Statistics, Physics and Chemistry. The new core ET program dropped Physics II from the former MET curriculum, but added Calculus to the former IT and ID programs. While Physics II was dropped, a new course in Engineering Analysis will provide further study in calculus-based problem-solving, which will be more beneficial in the field of Engineering Technology.

The most dramatic change occurred in the Engineering Technology Core and the specific concentrations. The ET Core now includes Engineering Graphics, Engineering Materials & Processes, Statics & Strength of Materials, Technical Writing, Quality Systems, Engineering Analysis, Engineering Logistics, Engineering Economics, and Engineering Project Management.

The engineering systems concentration will provide for a broad exposure to technology systems and processes, and includes the following courses:
3D Computer Modeling
Statics & Strength Materials
Electrical Systems
Ergonomic and Safety Systems
Rapid Tooling and Prototyping
Advanced 3D Computer Modeling & Rapid Prototyping
Polymer Technology
Metrology & Reverse Engineering
Power Transmission Systems
Advanced Rapid Tooling and Prototyping
Integrated Control Systems
Integrated Systems Project
15 hours of Technical Electives.

Technical electives can be used for completion of two certificate programs within the major: the Engineering Sales and Distribution certificate and the Occupational Safety certificate. Technical Electives can also be tailored to individual student needs as well. The requirements for the certificate programs are listed as follows:

Engineering Sales and Distribution

Principles of Marketing
Introduction to Professional Selling
Consultative Selling
Channels of Distribution

Occupational Safety (co-sponsored by the North Carolina Industrial Commission)

Environmental Health
Health Science
Safety Standards
Environmental Instrumentation

The revised program should fit the new ABET program criteria by offering a strong core based on traditional ET courses coupled with a broad exposure to technology. The BSET degree follows the program criteria for accrediting by the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology (TAC/ABET) in the Manufacturing Engineering Technology field. As specified, the program consists

of coursework which ensures that graduates have proficiency in materials, prototyping and modeling. The program is currently accredited under the old MET criteria and will undergo review for reaccreditation in 2007 [ABET, 11].

CURRENT FACILITIES AND SUPPORT

With a change in curriculum, new requirements must be met in facilities and equipment. Western Carolina University was fortunate to have been able to secure federal funding for the construction of a new facility to house rapid prototyping and other relevant technologies. The $8 million, 28,000 sq. ft. Center for Applied Technologies was completed in 2003, and incorporates rapid prototyping, reverse engineering, telecommunications, and other emerging technologies into the Engineering Technology curriculum. The Belk building, which has been the home to the department since 1971, was also renovated to accommodate the latest in instructional technologies in classrooms and labs.

Equipment to support the new program was procured through grants and donations from state and federal sources, as well as corporate and private benefactors. Equipment recently purchased include: Zeiss Contura HTG Coordinate Measuring Machine; Optical Gaging System, Surface Profiler, Stratasys EDEN 333 PolyJet, Stratasys Fused Deposition Modeler, Z-Corp 3-D, Fifty Dell Engineering Workstations with 21"LCD Monitors, PRO/ENGINEER Wildfire w/ modules, HAAS 2D Laser Cutting Center, Four HAAS Milling Machines, and Three HAAS Lathe Machines. The automation, polymer, and materials laboratories were sufficient enough to support the program prior to change.

A strategic marketing plan was also developed to assist in the promotion of the new curriculum. Specific strategies include open house tours, sneak peek events, local campus recruitment, advertisements, and high school and community college visits. As a result, the ET department has received a multitude of positive comments from local media.

CONCLUSION

Program direction and curriculum changes have produced positive outcomes from enrollment growth to regional engagement. The program's numbers increased from approximately 57 students to 180 students in two years. Quality faculty have been recruited and are now pro-active in collaborative engagement projects. Students have been provided opportunities to participate in regional projects including new product development with Oak Ridge National Laboratory, product prototyping for patent work with Greentech Inc., an automated mechanical fail-safe system for Caterpillar, and reverse engineering projects with companies including Bombardier, Ball Machining and Manufacturing, and APR Racing.

The revised curriculum is stronger than either of the former curricula, in that it appeals to a broad spectrum of students. While the curriculum is broader, quality and depth were not sacrificed. Students are now exposed to current technology and have moved away from traditional skill sets. For example, no traditional drafting is taught, allowing more time for CAD, solid modeling and rapid prototyping utilizing AutoCAD and Pro/Engineer Wildfire. No manual machining is taught, allowing more emphasis on CNC programming and CAM systems. Additionally, traditional quality control processes have been revised to include metrology and the use of the coordinate measuring machine.

Student feedback and performance has been positive. Integrated projects have provided a vehicle for transferring theoretical knowledge to practical, systematic application. This practical approach has resulted in additional companies seeking student placement in cooperative education and full-time employment. Likewise, advisory committee members have welcomed the changes in the Engineering Technology program as very positive, and look forward to continued partnerships, which will allow them to strengthen their role in the economy and regain their competitive advantage.

FUTURE DIRECTION

Breaking tradition provides challenges and requires further outreach to industry. Educating industry about the merits and strengths of curriculum changes will remain an ongoing task. Convincing employers that the redirected Engineering Technology program is stronger than the traditional Manufacturing Engineering Technology program is expected to remain a challenge in the near future. Similarly, breaking tradition with longstanding accreditation program categories will also provide challenges. The new ET program meets the intent and spirit of ABET accreditation for Manufacturing Engineering Technology. However, there may be merit in seeking a new classification for the Systems Engineering Technology.

Ongoing program assessment will continue to provide feedback on the effectiveness of the new curriculum. The systems approach seems to be successful thus far. However, it will be several years until the full impact of the changes will be felt. Future considerations will be given to offering more focused areas of study. These areas may include HVAC systems, mechanical systems, control systems. The ET program mission addresses regional economic development and engagement and will remain flexible in responding to appropriate needs of the service area.

Efforts will continue to connect engagement activities to individual courses. Live projects provide an excellent opportunity for building on theory, and provide opportunities for practical experience. Efforts will continue for building and strengthening partnerships among industry in Western North Carolina.

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Dr. Aaron K. Ball is currently an Associate Professor of Engineering Technology at Western Carolina University in Cullowhee, North Carolina Dr. Ball holds a B.S. and an M.A. from Appalachian State University, and an Ed. D. from Virginia Polytechnic Institute and State University. Prior to his arrival at Western Carolina University, Dr. Ball worked in production engineering at Chicago Telephone Supply and Vermont American Corporation. He has been a faculty member at Western Carolina University since 1977, and has been active in working with manufacturers and distributors in developing automation and training programs in fluid power. Dr. Ball currently serves as the graduate coordinator for the Master of Science in Technology program and teaches both undergraduate and graduate courses.

APPENDIX 1

Current Major in Engineering Technology, B.S. Degree

Liberal Studies		42 hours

The major requires 67 hours as follows:

MATH 140	Introductory Calculus	5 hours
MATH 145	Trigonometry	3 hours
MATH 170	Statistics	3 hours
PHYS 130	Physics	4 hours

CHEM 132	Chemistry	4 hours
ET 132	Engineering Graphics	3 hours
ET 141	Engineering Materials & Processes	3 hours
ET 231	3D Computer Modeling	3 hours
ET 232	Statics & Strength Materials	3 hours
ECET 301	Electrical Systems	3 hours
ENGL 305	Technical Writing	3 hours
ET 331	Quality Systems	3 hours
ET 335	Safety Systems	3 hours
ET 349	Rapid Tooling and Prototyping	3 hours
ET 351	Engineering Analysis	3 hours
ET 362	Engineering Logistics	3 hours
ET 410	Advanced 3D Computer Modeling & RP	3 hours
ET 420	Polymer Technology	3 hours
ET 425	Metrology & Reverse Engineering	3 hours
ET 436	Engineering Economic Analysis	3 hours
ET 441	Power Transmission Systems	3 hours
ET 449	Advanced Rapid Tooling and Prototyping	3 hours
ET 461	Engineering Project Management	3 hours
ET 472	Integrated Control Systems	3 hours
ET 478	Integrated Systems Project	3 hours

General electives 9 hours

Former Major in Manufacturing Engineering Technology, B.S. Degree

Liberal Studies 42 hours

The major required 81 hours as follows:

CHEM 132	Introduction to Chemistry	4 hours
MATH 145	Applied Trigonometry	3 hours
MATH 146	Pre Calculus	3 hours
MATH 153	Calculus I	4 hours
MATH 170	Applied Statistics	3 hours
PHYS 130	Introductory Physics I	4 hours
PHYS 131	Introductory Physics II	4 hours
CS 130	Introduction to Computing	3 hours
IT 335	Industrial Safety	3 hours
IET 420	Polymers	4 hours
EET 301	DC/AC Electricity	3 hours
EET 302	Industrial Instrumentation and Controls	3 hours
MET 132	Engineering Graphics	3 hours
MET 141	Manufacturing Materials and Processes	3 hours
MET 231	Engineering CAD	3 hours
MEC 242	Machining Processes	3 hours
MET 321	Statics and Strength of Materials	3 hours
MET 331	Quality Control I	3 hours
MET 332	Quality Control II	3 hours
MET 341	CNC Machining	3 hours
MET 342	Manufacturing Analysis and Planning	3 hours
MET 431	Automation	3 hours
MET 436	Engineering Economic Analysis	3 hours

MET 441	Fluid Power Systems Analysis	3 hours
MET 478	Senior Project Proposal	1 hours
MET 479	Senior Project	3 hours
General electives		6 hours

Former Major in Industrial Distribution, B.S. Degree

Liberal Studies, 42 hours

The major required 67 hours as follows:

MATH 130	College Algebra	3 hours
MATH 144	Trigonometry	3 hours
MATH 170	Applied Statistics	3 hours
PHYS 130	Introductory Physics	4 hours
ECON 231	Introductory Microeconomics and Social Issues	3 hours
ID 230	Introduction to Industrial Distribution	3 hours
ID 360	Industrial Distribution Organizations	3 hours
ID 370	Project Management and Inventory Control	3 hours
ID 479	Industrial Distribution Seminar	3 hours
ET 335	Industrial Safety	3 hours
ECET 301	AC/DC Electricity	3 hours
ECET 302	Industrial Instrumentation and Controls	3 hours
MET 441	Fluid Power Systems Analysis	3 hours
ET 420	Polymers	3 hours
MET 132	Engineering Graphics	3 hours
MET 141	Manufacturing Materials and Processes	3 hours
ET 331	Quality Control I	3 hours
MKT 301	Principles of Marketing	3 hours
MKT 306	Introduction to Professional Selling	3 hours
MKT 310	Consultive Selling	3 hours
LAW 230	Legal Environment of Business	3 hours
ACCT 251	Accounting Principles I	3 hours

Electives 17 hours

Former Major in Industrial Technology, B.S. Degree

Liberal Studies 42 hours

The major consisted of a 24 hour core, and an area of concentration (30 hours)

Program requirements

MATH 144	Trigonometry	3 hours
MATH 170	Statistics	3 hours
PHYS 130	Physics	4 hours
CHEM 132	Chemistry	4 hours

Core

CS 130	Introduction to Computing	3 hours
ECON 231	Introductory Microeconomics and Social Issues	3 hours

IT 335	Industrial Safety	3 hours
IT 495	Industrial Technology Seminar	3 hours
MET 132	Engineering Graphics	3 hours
MET 141	Manufacturing Materials & Processes	3 hours
MET 231	Engineering CADD	3 hours
MET 331	Quality Control I	3 hours

Areas of concentration can be from one of four disciplines (select 30 hours):
Safety Science
Industrial Management
Facilities Management
Approved program