Alternative Delivery of Distance Engineering Technology Programs

Aaron K. Ball[1] and William L. McDaniel[2]

Abstract – Equitable delivery of quality distance education for engineering technology programs relative to traditional on-campus programs continues to be a challenge for many programs. Western Carolina University has sought to insure the delivery of quality instruction through multiple delivery systems. These include taking the baccalaureate engineering technology program on-site to regional community colleges, hybrid, Interactive Televised Learning (ITV), web-enhanced, on-line courses, and laboratories available to students 24 hours per day via the Virtual Computer Laboratory (VCL). This paper will provide a brief history, curriculum, and delivery methods Engineering Technology distance education programs at Western Carolina University. Emphasis will be placed on instructional alternative methods including face-to-face, web-enhanced, ITV, and laboratory instruction using VCL. Educational merits of these methods will be presented.

Keywords: Distance education, distance learning, Engineering Technology curriculum, Interactive Televised Learning (ITV), Virtual Computing Laboratory (VCL).

BRIEF HISTORY

During the mid-1960's, growth in the manufacturing sector of the western North Carolina (WNC) region created a need for technical and management skills to bridge an expanding gap. 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 educate 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 [McDaniel, 7].

Based on steady growth in manufacturing, coupled with the rise in high tech applications, the university established a Manufacturing Engineering Technology (MET) curriculum in 1977. The MET curriculum sought and was granted ABET accreditation shortly thereafter. 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. The Department of Industrial Engineering and Technology served the region well for over 20 years. Graduates with B.S. degrees in Industrial Technology, Manufacturing Engineering Technology, Electronics Engineering Technology, and Industrial Distribution were actively recruited and employed by regional industry. However, in recent years, these traditionally strong programs began to experience problems of low enrollment, resource dispersion, and less relevance to industry needs due to a downturn in the manufacturing sector of the economy. This trend resulted in part, from global economic factors, outsourcing of manufacturing and high tech jobs, and niche competition [McGraw, 8].

[1] Professor, 332 Belk, Western Carolina University, Cullowhee, NC 28723, ballaaron@wcu.edu

[2] Associate Professor, 230 Belk, Western Carolina University, Cullowhee, NC 28723, mcdaniel@wcu.edu

In 2002, as a result of regular program assessment, faculty in the Department of Engineering Technology at WCU began to detect a downward trend in enrollment. Faculty and administrators made the decision to develop a new program that would offer traditional core engineering technology courses coupled with courses that 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 preparing students to respond to the rapidly changing industrial scene. The BS in Engineering Technology is currently preparing students for employment in the rapidly changing manufacturing and public service sector in Western North Carolina.

Development of Distance Programs

In the mid-70's, it became apparent that not all students who needed technical degrees were being served. With the end of the Vietnam War, many veterans were returning to the workforce under prepared. Many had earned educational assistance through the GI Bill. Western Carolina University responded to these non-traditional students with the development of the "in-service" program, a curriculum designed to award the B.S. in Industrial Technology degree on weekends. This approach evolved into the first "distance" program in Manufacturing Engineering Technology in the Morganton/Hickory area of North Carolina in the early 1980's. That program, along with Electronics Engineering Technology was offered in Asheville, North Carolina soon thereafter.

CURRENT STATUS

Rationale for Distance Learning

Not unlike many regions of the country, Western North Carolina has been particularly hard-hit by layoffs due to the increased globalization of furniture, textiles, heavy metals and other traditional manufacturing. Industry in Western North Carolina has had to undergo significant changes due to those global economic factors and the subsequent loss of thousands of manufacturing jobs between the years of 1999 and today [Klein, 6]. In April of 2002, North Carolina had the third highest unemployment rate in the country and 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, 6]." In 2002, the total employment in North Carolina decreased by 91,100 jobs [The Rural Center, 13]. Many counties in Western North Carolina had not experienced such dire economic conditions since the Great Depression [Western Carolina University, 14]. Job loss has continued and the August 2010 unemployment rate for the 25 counties in Western North Carolina hovers around 11.0%, where it has been for the past 2 years [Center for Economic Research, 5].

The current economic crises, coupled with the university's long-standing commitment to economic development in Western North Carolina, led the university to establish a campus-wide mandate for engagement with regional business and industry. Engagement activities focus on sustaining regional businesses and boosting entrepreneurial startups through innovative and creative projects that develop intellectual capital and technology transfer [Bardo, 3, 4, 2]. Additionally, current research suggests that creative and innovative engagement projects must be coupled with student learning to strengthen the competencies of ET graduates [Snellenberger, 11].

The main vehicle for extending the university's offerings to Western North Carolina's unskilled or underskilled workforce is through the current distance learning curriculum in Engineering Technology. After the development of the new on-campus Engineering Technology curriculum in 2002, a new distance curriculum also emerged. Western Carolina University had built a strong reputation for service to the region's workforce by offering a face-to-face, site-based curriculum since the inception of off-campus offerings in the early 1980's. However, due to revenue shortfalls, economic downturns, and more workers returned to education for careen changes, alternative methods of delivery were implemented. The distance program is currently delivered to approximately 100 students through combinations of on-site, web-enhanced, on-line, ITV and VCL. Similarly, the number of resident on-campus students in the Engineering Technology program is 125.

Program Components

The current distance program in Engineering Technology enables place-bound individuals employed in business, industry and government-related occupations to pursue their four-year degree through part-time evening study. The program combines the benefits of the established on-site Engineering Technology curriculum with the convenience

of locations near the students' homes. Instructional delivery is still primarily through face-to-face classes supplemented by online components and interactive video. The intent of the degree program is to provide an appropriate educational experience that will qualify graduates for career advancement. Western Carolina currently has three off-campus locations for its Engineering Technology distance program including Asheville, Spindale, and Hickory/Morganton. Incidentally, these locations have been particularly hard-hit by the recent economic downturn.

Applicants to the off-site Engineering Technology program must have an Associate's degree in Pre-Engineering or an Associate of Applied Science in Engineering Technology. The student must complete a total of 124 semester hours of study, including the university's 42 hour liberal study component, math and science program requirements, and 45 hours of upper and lower level engineering technology classes. Specific curriculum requirements are:

Liberal Studies Requirements **42 hours**

May be taken at a local community college

C1: ENGL I	3 hours
C1: ENGL II	3 hours
C2: MATH	3 hours
C3: Oral Communication	3 hours
C4: Wellness	3 hours
C5: Science	3 hours
C5: Science	3 hours
P1: Social Science	3 hours
P1: Social Science	3 hours
P3: History	3 hours
P4: Humanities	3 hours
P5: Fine Arts	3 hours
P6: World Cultures	3 hours
First Year Seminar	3 hours

Upper Level Requirement (one perspective must be 300-400 level)

Program Requirements **19 hours**

Trigonometry
Statistics
Calculus
Physics
Chemistry

Transferred Lower Level Engineering Courses **18 hours**

Must include Engineering Graphics and Engineering Materials

Transferred Upper Level Engineering Courses **12 hours**

Must include Statics/Strength of Materials and CAD/ 3-D Modeling

WCU Engineering Technology Courses **33 hours**

Must complete 11 classes of the following:

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
Total		**124 hours**

The primary focus of the Engineering Technology curriculum is on engineered systems with a secondary focus on product development. The revised program should fit the new Accrediting Board for Engineering and Technology (ABET) program criteria by offering a strong core based on traditional ET courses coupled with a broad exposure to technology. The BS degree in Engineering Technology 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 that ensures that graduates have proficiency in materials, prototyping and modeling. The program is currently accredited under the old MET criteria and will be considered for reaccreditation in 2008 with a three year report requirement [ABET, 1].

METHODS OF DELIVERY

On-Site Instruction

The role of the local community college is critical to the success of the off campus Engineering Technology curriculum at Western Carolina University. Applicants to the off-site Engineering Technology program must have an Associate of Arts or Associate of Science degree in Pre-Engineering or an Associate of Applied Science in an Engineering Technology. Additionally, the student will be given credit for 18 hours of lower level (100-level) engineering technology courses and 12 hours of upper level (200-level) engineering technology courses that were taken as a component of their 2-year engineering technology degree. All of the Liberal Studies requirements (with the exception of the upper-level requirement) may be taken through the community college system. In addition, all of the Program Requirements can be taken at the community college as well. The option to take courses locally provides a "win-win" opportunity for both students and the local community college. Students benefit by remaining employed and taking courses at times that best fit their schedules. The community colleges benefit from increased enrollment, which in turn, results in increased funding from the state. Students must take their ETO lower level requirements at their local community college. They include Engineering Graphics, Engineering Materials, 3D Modeling, and Statics/Strengths of Materials.

Web-enhanced and Hybrid Instruction

Web-enhanced learning is a modification of hybrid delivery method that incorporates face-to-face contact and alternative communication methods. Thus, web-enhanced courses emphasize human communication through a variety of teacher-student and student-student formats. This combination of distance learning and hybrid learning provides a means to offer multiple media for varying learning styles, but it does not imply that interaction is somehow more important in the modified online environment. As pointed out by Sorensen and Baylen, for any instructional medium selected, high-quality interaction in the educational relationship continues to be regarded as critical for successful distance education [Sorensen, 12]. Through WCU, web-enhanced instruction is employed in a manner to provide alternate methods that enable students to review self-paced tutorials, review posted course notes, view videos of technical operations and engineering systems, and review slides of material covered in and outside of lecture.

ITV and VCL approach

Through both Interactive Televised Learning (ITV) and the PolyCom system, WCU uses communication technology to connect classrooms, and conference centers across the service region. Serviced through the North Carolina Research & Education Network [NCREN, 13] as shown in Figures 1 and 2, these methods allow for two-way video and audio teleconferencing and links local campus centers to distant sites and vice-versa. Both students and faculty are able to communicate in real-time in an environment similar to live on-campus settings. Advantages to this approach are obvious in that the faculty member can deliver the same course from one central location. Students meet in local cluster groups and can interact within their group or between other clusters. Further, class sessions can be video-taped and made available for access at a later time for both students and faculty to review. However, there are drawbacks to this approach in that students are often reluctant to "speak-up" when poised in front on a camera. Faculty members have also indicated that the ITV approach creates a more sterile environment when students do not participate to open discussions.

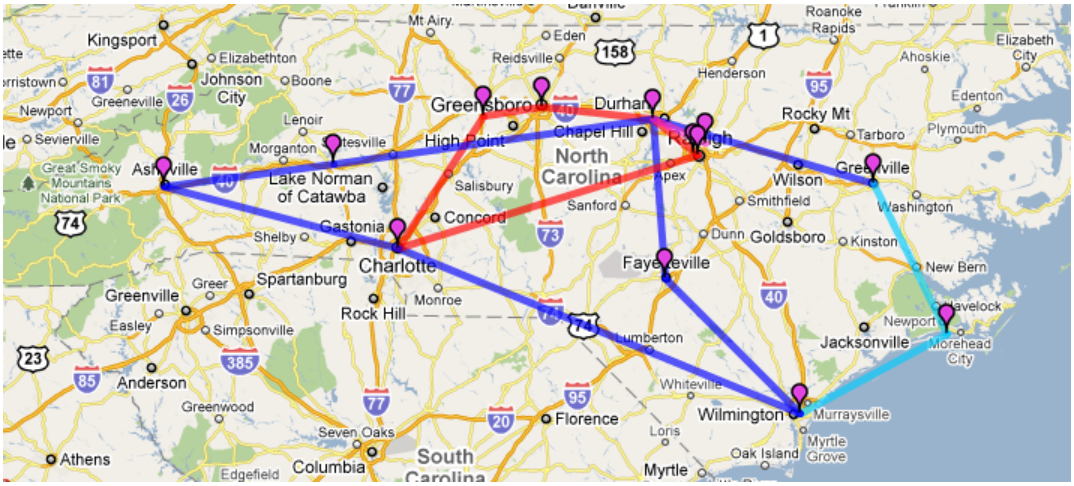

Figure 1: Map of the NC-REN "Information Super Highway"

Virtual Computing Laboratory (VCL)

VCL is a relatively new approach for Western Carolina University. Through a partnership with North Carolina State University and the North Carolina Educational VCL Consortium (see list of members shown below), a high speed bank of computer servers provides a method for housing multiple software packages that are accessible by students and faculty through any internet connection 24 hours per day.

The NC Education VCL Consortium

Academic Partners

Higher Education Institutions

Duke University

*East Carolina University

*Johnston Community College

*Wake Technical Community College

*Western Carolina University

*North Carolina Central University

University of North Carolina at Chapel Hill

*University of North Carolina at Greensboro

Software packages are installed and run on Blade servers and accessed via Remote Desktop on local personal computers. The number of seats made available at any given time is restricted to the number of licensed seats for any given software. Examples of software currently running the VCL system at WCU include SolidWorks, Pro/Engineer Wildfire™, Automation Studio™, LabView™, MiniTab™, and Siemens MicroWin™, and a variety of general purpose packages.

At the beginning of each semester, students are assigned access rights for the duration of the term. Students and faculty can reserve sessions 24 hours per day from work or home making the system a value tool for performing virtual labs. A major advantage is also the cost to access ratio. Since the number of active seats available at any given time is restricted to the license agreement for each installed software package, infringement rights are not violated, and more students can be served at a much lower cost. From an administrative perspective, the VCL system appears to be a win-win and cost savings approach to both on-campus and distance delivery of Engineering and Engineering Technology programs. A diagram showing the connectivity of the VCL system is shown in Figure 2 below [NCSU,14]. However, problems regarding high traffic volume, response time, and connectivity issues make the system less attractive to both faculty and students. Slow response time is particularly common on software programs that implement simulation such as Automation Studio™, SolidWorks™, and LabVIEW™.

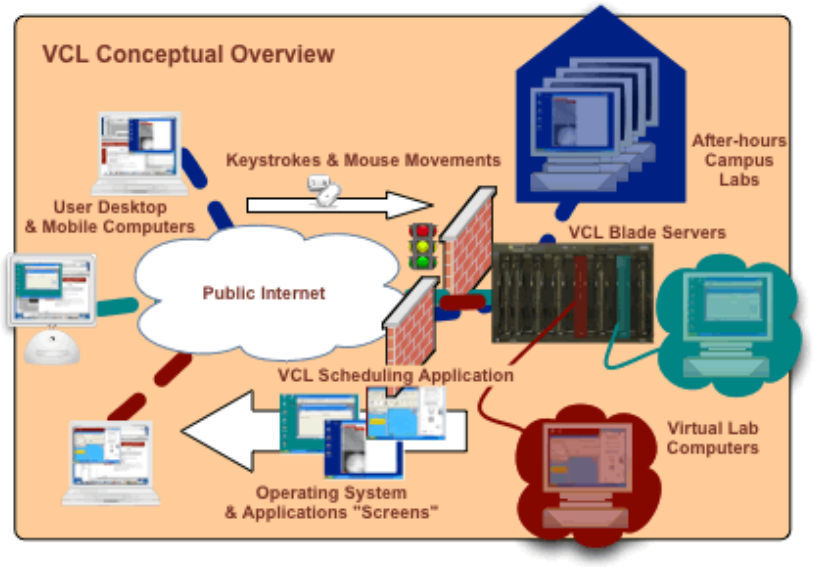

Figure 2: NCSU VCL Computer Architecture

Successes and Further Opportunities

The off-campus Engineering Technology program continues to be successful and students continue to take advantage of offerings at distance locations. The potential for new students remains high in all areas of Western North Carolina. Success of the current program also hinges upon articulation and transfer of the student's 2-year degree. This articulation leads to a minimum of courses that need to be taken at the more expensive university. Students can take classes at the community college for $56.50 per hour as opposed to $100.00 per hour at the university. Potentially, a student would only need to take 33 hours of the more expensive classes through the university.

There has been a great deal of satisfaction in graduates of the program. Focus groups and advisory committee feedback indicate that graduates are promoted into engineering and/or engineering management positions as soon as they complete their degree. Current students also indicate a high degree of satisfaction in the quality of the instructors and the program as a whole. A common reason given for satisfaction is the face-to-face delivery of

Western's curriculum with some advantages for alternative methods of delivery. However, face-to-face still remains the preferred method of delivery. At present, WCU is the only university in North Carolina to deliver Engineering Technology at a distance using live professors.

SUMMARY AND CONCLUSION

The distance program in Engineering Technology at Western Carolina University is currently enjoying growth and success. In order for that success to continue, adequate resources must be committed to sustain and further grow the program. One of the major factors for its success is the personal interaction between advisors/faculty and the students. The face-to-face delivery of instruction by tenured WCU faculty ensures a constant link to the main campus. Students believe they are getting the same quality instruction as their on-campus counterparts. Advisors regularly schedule visits to their classrooms and maintain regular office hours at each location. Some alternative methods of delivery have been more successful that others. Web-enhanced methods along with on-site instruction are preferred over ITV and web-based interactive video. VCL opens the door for extended methods of laboratory instruction and software access that was previously not available; however the response rate and reliability of the system has made this approach less that desirable. With high investments into the infrastructure for running VCL, efforts will continue to improve the performance of this delivery approach.

Successes include a high-quality, face-to-face, curriculum taught by highly qualified tenured/tenure-track professors. Western's commitment to engagement with the region is admirable, and faculty /administrators are to be commended for their contributions toward building a strong distance program. Continued success of the program is also attributed to excellent community college partners who are committed to the success of their graduates. Another factor in the success of the off-campus program is its low cost and high value.

Today's successes provide tomorrow's challenges. In order for the off-campus program to continue to thrive, steps must be taken to ensure that challenges do not become inhibiting problems. Adequate faculty resources will allow the distance program to provide quality instruction to those who need it. In addition, adequate classroom and laboratory facilities will provide safe, high quality instruction to the deserving place-bound students who cannot commute to campus. Finally, proper program evaluation and assessment will provide information that will serve as impetus for change, if change is truly warranted.

REFERENCES

[1] ABET Board of Directors, Criteria for Accrediting Engineering Technology Programs, ABET, Inc., Baltimore MD, November 1, 2003.

[2] Bardo, John, A Regional Summit: Meeting Western North Carolina's Needs through Higher Education, February 2003, Retrieved November 7, 2007, from Western Carolina University, Office of the Chancellor Web site: http://www.wcu.edu/chancellor/Presentations/presentations.htm.

[3] Bardo, John, "Western Carolina University's Commitment to Regional Economic and Community Development," Rural Economic Development Conference, November 2000, Retrieved November 7, 2007, from Western Carolina University, Office of the Chancellor Web site: http://www.wcu.edu/chancellor.

[4] Bardo, John, State of the University Address, January 2004, Retrieved November 7, 2007, from Western Carolina University, Office of the Chancellor Web site: http://www.wcu.edu/chancellor/speeches/speeches.htm.

[5] Center for Economic Research and Policy Analysis, Appalachian State University, Retrieved, November 28, 2010 from http://www.cerpa.appstate.edu/wncindex.php.

[6] Klein, Jean C., Chris Beachum and Catherine Moga, Manufacturing Layoffs: Hard Times for Rural Factories, Workers and Communities, The Rural Center, Number 11, April 2002, Retrieved November 21, 2007, from http://www.ncruralcenter.org/pubs/mfglayoffs.pdf.

[7] McDaniel, William L., Aaron K. Ball & Chip W. Ferguson, *Engineering Technology: A Vision for the*

Future at Western Carolina University, [CD-ROM], Proceedings at the American Society for Engineering Education Southeast Section Conference, Chattanooga, TN, 2005.

[8] McGraw, D., "My Job Lies Over the Ocean," ASEE Prism, Volume 13, Number 4, December 2003, pp. 24 -29.

[9] MCNC Organization, Maps of NCREN, Retrieved, November 28, 2010 from http://maps.ncren.net/.

[10] North Carolina State University, Virtual Computing Laboratory, "How-it-works", Retrieved November 20, 2010 from http://NCSU VCL Architecture (http://vcl.ncsu.edu/help/general-information/how-it-works).

[11] Snellenberger, J. M., D. H. Quick, I. T. Davis, J. P. Tidwell, J. O'Brien, R. M. Haynes, et al. Enabling the U.S. Engineering Workforce to Perform: Recognizing the Importance of Industrial Engagement In Professional Graduate Engineering Education, American Society for Engineering Education Annual Conference & Exposition, 2004.

[12] Sorensen, C., & Baylen, D. (2000). Perception versus reality: Views of interaction in distance education. The Quarterly Review of Distance Education, 1(1), 45-58.

[13] The Rural Center, The North Carolina Rural Economy, Volume 2, Number 2, Retrieved November 21, 2007, from http://www.ncruralcenter.org/pubs/ncreconomy.pdf.

[14] Western Carolina University, "Western Pledges to Help Region," *The Reporter*, Office of Public Relations, Western Carolina University, Cullowhee, NC, February 2, 2004, p.1.

Dr. Aaron K. Ball

Dr. Aaron K. Ball is currently a full Professor of Engineering Technology at Western Carolina University in Cullowhee, North Carolina Dr. Ball holds a B.S. and an M.S. from Appalachian State University, and earned his doctorate 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 active in working with manufacturers and distributors in developing automation and training programs in fluid power, quality, and automation. Dr. Ball currently coordinators the thesis for the Master of Science in Technology program and teaches both undergraduate and graduate courses.

Dr. William L. McDaniel

Dr. William L. McDaniel is currently an Associate Professor of Engineering Technology at Western Carolina University in Cullowhee, North Carolina. He is also the Program Director for Distance and Transfer Learning. Dr. McDaniel earned his B.S., Masters, and Ed. S. at Western Carolina University, and his Ed .D. from Clemson University. Prior to his arrival at Western Carolina University, Dr. McDaniel served as Instructor of Mechanical Engineering Technology and Drafting and Design Engineering at Isothermal Community College for 23 years. Dr. McDaniel also has extensive experience consulting with industries such as Parker Hannifin Corporation, Outboard Marine Corporation, Paulding Electric Corporation, and Hanes Printables.