A Comprehensive Telecommunications Degree for Engineering Technology

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Abstract

Southern Polytechnic State University's (SPSU) Electrical and Computer Engineering Technology (ECET) Department has a new multidisciplinary Baccalaureate degree program in Telecommunication Engineering Technology (BSTCET). The degree program includes five new ECET courses and four from the School of Management. The primary objective of the program is to provide the student with a strong practical and theoretical foundation in telecommunications.

The five technical courses in the BSTCET degree are designed to teach students about such topics as communication protocols, wide- and local-area networks, managing network resources, Internet-related concepts and development, and network security issues. These courses are supported by numerous hands-on laboratory experiences. The four management courses provide students with the principles necessary to manage people and projects. This paper discusses issues considered during the development of the program, classroom and laboratory curricula, problems confronting the program today, and assessment.

I. Introduction

Tremendous growth in the telecommunications industry has inspired a similar growth in education curricula supporting the requirements of this industry. Corporations use the Internet as a means to reach customers, as a wide-area network (WAN) to share information between organizational entities, and increasingly as a medium to transport voice and video information. Corporations today are increasingly dependent on their LANs (local area networks) and WANs as an information resource as well as for revenue generation. In particular, World-Wide Web and Internet applications are being developed and refined so that customers can receive all necessary product information, place orders, and receive product support directly from the computers in their offices and homes, reducing or eliminating the need to interact with the vendor's staff.

This new business model requires synergy between a number of groups within a corporation that traditionally operate in a more autonomous fashion. One of the most valuable assets in this new type of corporation is an employee that has a good understanding of the technical aspects of a computer network, how networks under gird server-based applications, and how to manage and optimize these resources.[1]

The State of Georgia is actively involved in fostering the growth of the telecommunications industry within the state through its Yamacraw program.[2] The Board of Regents of the University System of Georgia is seeking ways to support this initiative, one of which is through new degree programs. Recognizing this opportunity, the ECET department at SPSU proposed a new multidisciplinary Bachelor of Science in Telecommunications Engineering Technology (BSTCET) degree intended to produce graduates meeting the needs of corporations dependent on telecommunications networks. The semester-based curriculum adds five new technical courses and four management courses to a core of ECET, mathematics, English, and social sciences courses. The degree was approved in 1998 and funded through a 2-year grant from the Board of Regents' Intellectual Capital Partnership Program (ICAPP),[3] enabling support for curriculum development and laboratory equipment purchases.

II. Program Development Methodology and Considerations

The BSTCET program was designed to match the capabilities and strengths of engineering technology students. Generally, these students respond more readily when course content is pragmatic and less abstract. Hands-on laboratory exercises are used extensively to reinforce classroom presentations. The laboratory experiences contribute significantly to students' abilities and confidence.

The program was structured within the 130 credit-hour limit set by the Board of Regents. Of these, 19 are allocated to the new telecommunications-specific courses created for the program; 43 hours constitute a core of ECET technical courses; 12 are for the four management courses required by the degree, and 56 are for the mathematics, physics, English, and social science core.

During initial curriculum development, the technical topics in Table 1 were considered to be critical to the overall body of knowledge conveyed to the students during the program. The topics are covered in four of the five new telecommunications courses. The fifth is a capstone course with a design project whose objectives vary each time it is taught. Curriculum details are discussed in the next section.

Discussions with the School of Management led to the selection of four courses to give students a basic understanding of project management. The motivation for creating a multidisciplinary degree combining ECET and management courses was twofold. First, after graduation, students are usually employed on project teams under an experienced manager. As they gain more experience and responsibility, they are required to manage project budgets and personnel themselves. It is intended that the management courses give students a sufficient background to permit them to step into team management roles earlier in their careers than might otherwise occur. Second, multidisciplinary courses and degree programs have received attention lately due to the diverse skill set required in technology-dependent corporations, as well as the ABET EC-2000 criteria.[4,5,6,7,8] Although technology programs are not subject to EC-2000, it is likely that similar accreditation criteria will be applied soon.[9]

Table 1. Key BSTCET program technical topics.

LAN and WAN data network infrastructure components and design
Voice network infrastructure components and design
Open-systems interconnect (OSI) model
TCP/IP protocol (protocol of the Internet)
LAN data-link protocols, e.g. Ethernet
WAN data-link and network protocols, e.g. ATM, Frame Relay
Network management
Network security and virtual private networks
Government regulations and industry standards
Microsoft Windows NT/2000 network administration
Unix/Linux
Distributed client/server applications
World Wide Web server applications
Web page design

The completion of five management courses is required to obtain a minor in management; some students opt to take an additional course. Unfortunately, the required 3-hour management courses replace what would ordinarily be three 4-hour ECET technical electives. The result is that the BSTCET program has no electives. This has been a concern since the inception of the program and its ramifications are discussed in a later section.

A significant portion of the grant funds was used to purchase equipment to support the laboratory component of the new telecommunications courses. The equipment choices made were intended to support basic laboratory exercises and provide the opportunity for interested students to extend their knowledge through independent projects. Some of the acquisitions include routers with firewall and voice-over-IP capability, Ethernet switches capable of virtual LAN configuration, asynchronous transfer mode (ATM) switches for LAN backbone applications, wireless LANs, a frame-relay WAN switch, CSU/DSU interfaces for T1 WAN networks, workstations, servers, network operating system software, specialized web-server software, and network protocol analyzer software.

Perhaps the most challenging curriculum-development task has been the design of laboratory exercises. With such a diverse collection of networking equipment and software, creating a large number of well-written exercises is difficult and time consuming. For example, routers are essentially sophisticated, specialized computers and properly configuring networks around them is not always easy. Written instructions for the exercises must be concise, take into account the potential sources of error students may encounter, and guide them effectively in the right direction. In addition, key concepts that may take only a few minutes to explain in a lecture can be quite difficult to implement in a laboratory exercise.

From the beginning of the BSTCET program, the laboratory curriculum development process relied heavily on student support. Interested students are given unfunded, independent-study research projects with the goal of developing one or more laboratory exercises on topics of mutual interest to the faculty advisor and the students. The students' work is graded and they

receive 1 to 4 semester hours of credit. In general, the process has been quite successful, but since special projects are only one semester in duration, it is difficult to design complex exercises.

Observations from this methodology of laboratory exercise development led to the following conclusions:

- The best students have a high grade point average, are self-motivated, and have either work and/or hobby-related experience in computer networking.
- Students possessing a medium grade point average generally do well if they have computer-networking experience.
- Close supervision is important since the projects are short-term.
- It is beneficial to split up a 4-credit hour, one-semester project into two 2-hour projects that span two consecutive semesters.
- Students tend to over-estimate the scope of their project and have time-management difficulties.

Other avenues of laboratory exercise development will be pursued in the future. One approach is to seek private or government funding for curriculum development, which may entail funding for the faculty advisor and a student or just for the student. Another is to recruit ECET graduate students to work on the more complex tasks as part of their program of study. Unfortunately, the latter approach has several problems. First, the ECET master's program is small and most of the students have full-time employment. Second, ECET graduate students have the option in their program of study to include either a one-semester literature search on a topic of their interest or to engage in a two-semester hands-on design project. Students who choose the latter are qualified for telecommunications laboratory exercise development. However, most choose to do the literature search because, it is the easier path.

III. BSTCET Curriculum Details

The BSTCET program began when the Board of Regents was converting the university system from quarters to semesters. Two existing ECET quarter courses already had content that integrated well with the BSTCET objectives. One was entitled Data Communications and introduced students to line codes, modem design, data-link protocols, and the open-systems interconnect (OSI) computer communications model. The second, Digital Communication Networks, covered LAN and WAN network architectures, interfaces, management, and security.

Data Communications was converted to a semester version almost intact, with some enhancements. It is required for all ECET students and is not one of the new telecommunications courses created for the BSTCET program. The topics in Digital Communication Networks were divided among four of the five new telecommunications courses. Existing topics were expanded considerably and new topics added. There is some overlap in topics between the courses when greater emphasis is needed.

Table 2 lists the ECET courses that are part of the BSTCET degree in order by the semester in which they are taken. The new telecommunications courses are identified. The weekly lecture

hours, laboratory hours, and total credit hours are also given. Note that laboratory exercises are conducted for 12 out of the 15 weeks in each semester.

Table 2. ECET courses in the BSTCET degree program.

Course Name	Semester Number	Weekly Lecture Hours	Weekly Laboratory Hours	Credit Hours
Orientation	1	2	0	2
Fundamentals	1	1	3	2
Circuits I	2	3	3	4
Digital I	2	3	3	4
Circuits II	3	3	3	4
Electronics I	3	3	3	4
Introduction to Telecommunications*	4	3	0	3
Digital II	4	3	3	4
Electronics II	4	3	3	4
Data Communications	5	3	3	4
High Frequency Systems	5	3	3	4
Applications of C++, JAVA and HTML	5	2	3	3
Digital III	6	3	3	4
Communications Networks and the Internet*	6	3	3	4
Telecommunications Management*	7	3	3	4
Advanced Telecommunications*	7	3	3	4
Telecommunications Project*	8	3	3	4

*Indicates new telecommunications course

Tables 3 through 8 list the main lecture and laboratory topics for the five new telecommunications courses and Data Communications. The time allocated for each topic is not shown, and in several instances the topics for laboratory exercises may take more than one laboratory session to finish.

For completeness, Table 9 lists the four management courses included in the BSTCET program and gives their descriptions. These courses were already part of the School of Management's curriculum and did not undergo any revision when included in the BSTCET program.

Table 3. Main topics in the Introduction to Telecommunications course.

Lecture Topic
Noise
Modulation: AM, FM, PCM
Coding
Data link protocols
Telephony
LANs
Internet

Table 4. Main topics in the Data Communications course.

Lecture Topic	Laboratory Topic
Modulation schemes used in modems	Line codes
Line codes	Bit error rate
OSI model	Modem operation
Line codes	Spectrum and bandwidth
Trellis coding, data compression, error detection	Protocol analyzer
LANs	
WANs	
WAN protocols, ISDN, X.25, Frame Relay, ATM, SONET	
TCP/IP	

Table 5. Main topics in the Computer Networks and the Internet course.

Lecture Topic	Laboratory Topic
Internet overview and architecture	TCP/IP operation
TCP/IP	Windows NT network administration
LAN architecture and protocols	Introduction to Linux
WAN architecture and protocols	Network protocol analyzer
Internetworking devices: routers, hubs and switches	TCP ports
Wireless technologies	Javascript and XML
World Wide Web: HTML, web pages, servers, browsers, embedded objects	

Table 6. Main topics in the Telecommunications Management course.

Lecture Topic	Laboratory Topic
Importance of telecommunications to business	Data security
Industry standards	Domain and peer network security
Government regulations	Video conferencing and quality of service
Telecommunications carriers and competition	Network protocol analyzer
Voice and data communication review	Field trip to Bell South data network operation center
Media convergence	LAN network design semester project
Network design and management	
Telecommunications department management	

Table 7. Main topics in the Advanced Telecommunications course.

Lecture Topic	Laboratory Topic
Emerging technologies	Configuring virtual LANs
Ethernet	Basic router configuration
Frame relay	RIP routing protocol
ATM	Router interface IP filters
SONET/SDH	Linux firewall
Distributed applications	
Network security	

Table 8. Main topics in the Telecommunications Project course.

Lecture Topic	Laboratory Topic
Topics involve designing a complete E-commerce solution based on objectives Instructor acts as mentor and project director guiding students	Depends on instructor's choice of project

Table 9. Management courses in the BSTCET degree program.

Course Name	Description
Accounting I	A study of the underlying theory and application of financial accounting concepts
Management and Organizational Behavior	Integrates the study of management principles and practices with the study of human behavior within organizations, focusing on organizational effectiveness, efficiency and human resources management
Basic Business Finance	Introduces financial analysis, budgeting, sources and uses of funds, asset management, short and long run financial strategy, and business decision-making based on financial data interpretation.
Project Management	Provides a comprehensive, balanced view of project management, emphasizing both behavioral and quantitative aspects. Includes a study of systems philosophy, systems development process, human organizations and behavior, methods and procedures, and managing systems.

IV. Program Assessment

Considerable attention has been devoted to program assessment in the literature, particularly the new ABET EC-2000 criteria. A number of methodologies have been presented to achieve effective program assessment under these criteria. [5,10,11,12,13,14,15,16] Since migration of some EC-2000 criteria to technology program accreditation is likely, it is important to note the results they have on engineering programs. Nevertheless, a primary objective of assessment is to maintain a

rich, relevant program that attracts students and provides them with the appropriate skills necessary to prepare them for employment.

New programs are likely to have more problems than older, established ones. Thus, it is important to implement assessment tools and evaluate the results as quickly as possible. At this early stage in the evolution of the BSTCET program, much of the assessment has been based on observations of the faculty teaching the courses, informal conversations with some of the students, surveys of the literature, discussions with some industry representatives, and a recently developed survey for BSTCET graduates.

Some of the results from this early assessment were:

- The Introduction to Telecommunications course was moved from the second semester to the fourth so that students' skills would be greater and the content level could be raised.
- The lack of program electives due to the inclusion of the management courses reduces students' scheduling flexibility and the flexibility of the program.
- More network configuration and design laboratory exercises are needed.
- There is some resistance from students to the inclusion of management courses in the program.
- Although topic redundancy reinforces students' knowledge and confidence, some may be unnecessary.

V. Conclusion

The implementation of the BSTCET program has proved to be exciting, fulfilling, and challenging. The growth of the telecommunications industry has made it difficult to choose appropriate topics and organize them in a coherent manner across several courses. Therefore, it is expected that the curriculum will continue to evolve; but it will stabilize and change at a slower pace.

The highest priorities are to streamline the curriculum to remove unnecessary redundancy and to continue developing laboratory exercises. Creating room for electives in the program is also important. One possibility is to change one or two of the management courses from required to elective; however, this would detract from the uniqueness of the program. Changing one or two of the ECET core courses to elective is difficult due to the effect on the prerequisite structure. The mathematics, physics, English, and social science core cannot be altered, due to Board of Regents requirements.

The BSTCET program now has 70+ students and is growing. It just had its first graduates in the spring 2000 semester. Employment placement information lags by one year, so the information for the first graduates will be available after the spring 2001 semester.

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