Choosing a Telecommunications Curriculum for Electrical Engineering Technology

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Abstract

Southern Polytechnic State University's Electrical and Computer Engineering Technology Department initiated a new multidisciplinary Baccalaureate degree program in Telecommunication Engineering Technology during the Fall Semester of 1998. The degree program includes five new ECET courses and four from the School of Management. The degree program meets industry needs in the areas of local-area computer networking, wide-area network systems, and Internet applications as well as providing basic management skills. A grant from the Georgia Board of Regents provided the resources to develop the lab facilities and the new courses. This paper discusses the challenges of developing a comprehensive technical curriculum meeting the needs of companies hiring degree graduates as well as the implications of competition from industry-sponsored certificate-based networking training programs such as the Cisco Academy.

Introduction

With the recent advances in telecommunications technology and applications, companies are increasingly dependent on local area networks (LANs) and wide-area networks (WANs) to share information within the organization, as an information resource for customers, and as a revenue source. Traditional programs within the Electrical and Computer Engineering Technology (ECET) department at Southern Polytechnic State University (SPSU) provided graduates for the telecommunications industry in the Atlanta, Georgia area and beyond for some time. These companies include local and long-distance telephone companies, telecommunications equipment suppliers, companies requiring support for their own internal networks, as well as companies operating in the E-commerce arena.

The growth of the telecommunications industry as well as initiatives by the State of Georgia to further expand this industry, such as the Yamacraw program,[1] presented an opportunity for the ECET department to develop a unique degree program. Recognizing that new business models require synergy between groups within an organization, such as finance, marketing, information services and network operations, the multidisciplinary Bachelor of Science degree in Telecommunications Engineering Technology (BSTCET) was designed to be predominantly technical with a significant management component. The semester-based curriculum adds five new technical courses and four management courses to a core of ECET, mathematics, English, and social science courses. The degree was approved in 1998 and funded through a 2-year grant from the Board of Regents' Intellectual Capital Partnership Program (ICAPP)[2] economic development program, enabling support for curriculum development and laboratory equipment purchases.

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One of the most difficult challenges facing the development of the new program was the choice of topics for the ECET courses. The approach taken was to design the curriculum to provide students with a broad background in voice and data telecommunications. An important influence on curriculum development came from industry-sponsored certificate-based training programs such as those for Microsoft Windows networks, Novell NetWare networks, and Cisco networks. The first two companies produce workstation and server network operating system software and the last manufactures network infrastructure equipment. All three companies have a major influence on computer networking and each develops educational materials for continuing education certificate programs. Due to the stature of these companies, it is important that institutions with technology programs, such as SPSU, examine the content of the certificate programs and consider including similar topics in their academic programs.

Cisco is unique in that it develops and aggressively markets educational programs aimed at high-school and post-secondary school students through their Cisco Networking Academy.[3] Cisco encourages high schools, community colleges, technical institutes and four-year colleges and universities to adopt their computer networking curriculum. This creates an interesting dilemma among faculty at technology and engineering institutions who develop their own curricula in this area. The dilemma is exacerbated because incoming students are aware of the influence these companies have on telecommunications and computer networking and want to learn how to use their software and hardware in their degree program.

This paper discusses the BSTCET program's telecommunications curriculum and the affect that the corporate certificate-based education programs had on its development. Emphasis is placed on the influence of Cisco's Networking Academy since it directly targets students considering enrolling at institutions like SPSU. Also, implications of using educational curricula developed by private corporations in a university program are considered.

BSTCET Program Technical Curriculum

The technical portion of the BSTCET program was designed to match the capabilities of engineering technology students. Generally, these students respond more readily when course content is pragmatic and less abstract. Laboratory exercises are used extensively to reinforce classroom presentations.

The program was structured within the 130 semester credit hour limit imposed 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 topics listed in Table 1 were considered to be critical to the overall body of knowledge conveyed to the students. 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.

A significant portion of the ICAPP grant funds was used to purchase laboratory equipment for the new telecommunications courses. The equipment choices were intended to support basic laboratory exercises and also provide the opportunity for advanced, special project students to extend their knowledge through independent research. Some of the acquisitions included 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.

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, i.e. Ethernet
WAN data-link and network protocols, i.e. 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

Course Topics

The BSTCET program was begun 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, entitled 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. This course is required for all ECET students and was 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. The existing topics were expanded considerably and new topics added. There is a certain amount of topic overlap between the telecommunications courses when greater emphasis is needed.

Table 2 lists all 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 and 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. Tables 3 through 8 list the main lecture and laboratory topics for the five new telecommunications courses and the Data Communications course. The time allocated for each topic is not given, and in several instances the topics for laboratory exercises may take more than one laboratory session to complete.

From the beginning of the BSTCET program, laboratory curriculum development 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.

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

* New telecommunications course

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	Modems
Line codes	Protocol analyzer
Trellis coding, data compression, error detection	Spectrum and bandwidth
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 design of a complete E-commerce solution based on objectives	Depends on instructor's choice of project
Instructor acts as mentor and project director guiding students	

Cisco Networking Academy and Certification Courses

The Cisco Networking Academy has an Internet-based curriculum, consisting of eight semester courses divided into two sets of four. The purpose of the courses is to teach students to design, build, and maintain computer networks. The first four courses are a general overview of computer networks along with an introduction to using Cisco networking equipment. The main topics of these four semesters are shown in Table 9.[4] The next four courses go into greater detail regarding the design and management of networks with emphasis on using Cisco equipment.

The Cisco Networking Academy programs prepare students for the Cisco Certified Network Associate (CCNA) and Cisco Certified Network Professional (CCNP) certifications. The first four semesters apply to the CCNA and the second four to the CCNP. Other companies such as Global Knowledge Network, Inc.[5] and Information Management Systems, Inc.[6] offer intensive short courses to prepare students for these certifications as well. Such certifications are well respected by companies requiring employees with networking experience.

The first four-course sequence was originally designed for high school and post-secondary level students. It has been adapted to fit into the curriculum of two-year technical institutes and the continuing education departments of four-year technology-focused colleges and universities such as SPSU. In fact, SPSU offers the CCNA version of the Cisco Networking Academy through its Continuing Education department. Table 10 gives the distribution by institution type for the 87 Cisco Networking Academies in Georgia. The institution types are Cisco's.

Cisco's intensive, one-week certification course Interconnecting Cisco Network Devices (ICND) covers essentially the same topics as the first four-course of the Cisco Networking Academy but in less depth. ICND and many other Cisco certification courses are offered by for-profit Cisco training partners such as Global Knowledge. The textbook for the course is available to the public and it includes the hands-on laboratory exercises taught during the ICND course.

Cisco publishes a number of reference books on advanced networking applications in addition to some of their course textbooks, all of which are available to the public.[7,8,9] The books are well written and thorough. The main difference between most of the Cisco publications and texts usually chosen for college and university courses is the lack of problems at the end of chapters. However, almost any of Cisco's books can be used as supplementary texts or even the primary text in a college course.

Table 9. Main topics for the first four semesters of the Cisco Networking Academy.

Semester One
OSI model and industry standards
Network topologies
IP addressing, including subnet masks
Networking components
Basic network design
Semester Two
Beginning router configurations
Routed and routing protocols
Semester Three
Advanced router configurations
LAN switching theory and VLANs
Advanced LAN and LAN switched design
Novell IPX
Threaded case studies
Semester Four
WAN theory and Design
WAN technology, PPP, Frame Relay, ISDN
Network troubleshooting
National SCANS Skills
Threaded case studies

Table 10. Cisco Networking Academies in Georgia.

Institution Type	Number
High school	38
2-year community college	20
Vocational	11
Technical school	8
4-year + university or college	7
Other	3

Influence of Certificate-Based Curricula on the BSTCET Curriculum

Examining the content of the six BSTCET degree courses in Tables 3 through 8 and comparing it to the topics covered by the Cisco Networking Academy in Table 9, one sees some similarities. The scope of the BSTCET curriculum is greater because graduates are employed by companies operating in different areas within the telecommunications industry, not just those working with Cisco-based networks. However, Cisco's training classes are well designed and the course materials are excellent. Cisco's courses integrate networking theory and protocols with network design and troubleshooting. The courses also contain hands-on instruction in using Cisco's Internet Operating System (IOS), the configuration operating system for its routers and switches.

The BSTCET curriculum was initially designed to cover most of the computer networking theory that is covered in the Cisco Networking Academy. However, it was decided to omit detailed instruction on the Cisco's router IOS. This was done because the Cisco networking equipment was not yet purchased at the beginning of the BSTCET program and it was realized that it takes considerable time to develop the laboratory exercises necessary to support that instruction. However, IOS instruction will be incorporated as the laboratory curriculum is developed.

Regarding the network operating systems Microsoft NT/2000 and Novell NetWare, the BSTCET program initially included both. Before Microsoft developed Windows NT, Novell was a dominant player in the network operating system market. Lately Microsoft has taken considerable market share, particularly since NT/2000 can also run application programs, unlike NetWare. The growing popularity of Microsoft NT/2000 as a network operating system and difficulties associated with supporting instruction in two different and complex operating systems led to the elimination of NetWare from the curriculum.

Conclusions

It is difficult to develop a diverse telecommunications curriculum that also gives students significant hands-on experience with different networking equipment and software. There always seems to be too much material to present in too little time. What is important is to give students a strong background in the fundamental concepts and use laboratory exercises to expose them to real systems, giving them confidence in their abilities.

The growth and rapid change in the telecommunications industry, particularly computer networking, has fueled demand for qualified technical professionals capable of operating and managing these systems. Thus, there has been a proliferation of certification courses designed to rapidly educate employees already in the telecommunications field as well as those wishing to change careers. Instructors with considerable industry experience usually teach the courses and the materials are well prepared. Technology programs and even engineering programs must consider adopting some of the curriculum and pedagogy from these courses.

The Cisco Networking Academy represents either a great benefit or a tremendous challenge to traditional technology programs. Those implementing the Academy curriculum within an academic curriculum get a well-designed, state-of-the art product that they can use immediately. Graduates of the Academy programs have the basic skills to design and configure networks using equipment from the leading manufacturer of computer networking equipment in the world. Technical institutions not adopting the Academy program essentially find themselves competing with it. Therefore, they must consider including aspects of it in their own telecommunications curriculum.

Engineering programs do not have the same concerns as technology programs because of their greater emphasis on theoretical principles. Nevertheless, it can be argued that the advanced topics discussed in Cisco's high-level certification courses and its reference books are at the level of engineering courses. They essentially present the application of proven state-of-the-art computer networking theory.

There is another concern regarding adopting a company's educational curriculum within an academic program. It is asserted that one purpose of the courses developed by companies is to create future customers. Cisco realizes that since students are familiar with Cisco equipment, they will tend to specify it in their own network designs. The earlier you indoctrinate the student, i.e. high school, the greater the opportunity to influence them prior to their entering industry.

Based on these observations, the following conclusions are made. First, high-schools will continue to adopt Cisco Networking Academy type programs as elective courses since they often have graduates who enter industry directly and they also realize that such programs are an excellent preparation for college. Second, community colleges, vocational schools and 2-year technical schools, particularly private ones, will continue to encompass Academy type programs within their academic programs since they have a more vocational agenda and their graduates will take industry positions that do not require as many theoretical skills. Third, since four-year technical and engineering institutions have higher accreditation standards, teach more theoretical concepts, and need to produce more academically balanced graduates, they are not likely to adopt an Academy type program within their academic curriculum. However, they are likely to do so within their continuing education departments. Finally, state institutions may be less likely to adopt corporate-sponsored curricula than private institutions in order to avoid the appearance of state sanctioning of a particular corporate agenda.

Thus, it is not likely that the BSTCET curriculum will be modified to teach Cisco-specific topics at the level that the Cisco Networking Academy does. The scope of the topics in the BSTCET program, accreditation concerns, the fact that SPSU is a state institution, and the inclusion of networking equipment from several manufacturers in the laboratory dictate that classroom and laboratory instruction cannot rely heavily on a corporation's educational curriculum.

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