Network Administration: Course Implementation and Delivery

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In this manuscript, we describe the implementation and delivery of a networking administration course and provide suggestions and recommendations by practitioners who have taught in the information systems (IS) area. The development and implementation of this course follows a module in the newly-redesigned version of the Organizational and End-user Information Systems (OEIS) Model Curriculum, specifically OEIS 10 - Network Administration.

The potential for growth in IS has resulted in an increase in technology jobs. However, the challenges of end-user support and IT implementation go far beyond solving technical problems. Network administration involves principles, practices, processes, and management of equipment and users. The Organizational Systems Research Association (OSRA), a research organization consisting of innovative business practitioners and IS faculty, redesigned and implemented a curriculum model that meets the needs of those entering into the technology-based 21st century. The goal of the OEIS curriculum is to provide a cornerstone on which IS graduates can build a successful career in end-user information systems.

This article looks specifically at the Network Administration course (OEIS 10), the implementation of such a course into the curriculum, and lessons learned from this implementation. The purpose of this manuscript is to provide network administration instructors with the knowledge acquired from previous experience gained throughout the years through the trials and tribulations of those who have gone before and taught network administration in a variety of ways.

Importance of Implementation

Courses in network administration are more important today than ever before. Computer networks were once reserved for the large corporate and academic institutions. However, current home networks, small office-home office (SOHO) networks, as well as large networks, abound. The U.S. Small Business Administration (SBA) (2003) noted that 83.2% of the self-employed had Internet access, whereas 64.3% of all self-employed households had one computer, 23% had two, and 12.4% had three or more computers in 2000. Furthermore, according to the U.S. Small Business Administration (2000), small businesses with fewer than 100 employees spent $9 billion on network hardware and businesses with 100-999 employees spent an estimated $14 billion in 1999. Much of this network proliferation is due to the increase of broadband, high-speed Internet connections and the desire to share those connections with several computers. According to Pociask (2004), only

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27% of small businesses did not subscribe to any Internet connectivity while 48% subscribed to some form of broadband connectivity. Network administration courses can provide the theoretical base for students to create and run a personal network, as well as prepare them for positions with organizations dealing with network management. Consequently, IS educators need to understand what should be included in a network administration course and how the course should be delivered for maximum effectiveness.

LITERATURE REVIEW

Over a decade ago, Trauth, Farwell, and Lee (1993) identified a gap between industry expectations and academic preparation. Curriculum and course updates are necessary to provide students with the essential skills needed upon graduation. Therefore, educational institutions must be willing to review and revamp curricula to produce technically competent students who have the skills necessary to succeed in the business world. "The number of workers in the computer and software industries has almost tripled in the past decade" (Freeman & Aspray, 1999, p. 35). However, in 2002 with the downfall in the economy and reduction in employee compensation in the IT environment, certifications not only became important, but also helped in determining which positions were most important. In 2003 Roberts and Zarley noted the top 10 jobs in demand. The top four included: 1) general sales, 2) software development/ programming/engineering, 3) customer service/ technical support services, and 4) network engineering/administration. The high ranking of network engineering/administration lends further support to focus on this body of knowledge in IT. Moreover, job growth in the IT area "will continue to be driven by the continued expansion of the computer system design and related services industry, which is projected to remain one of the fastest growing industries in the U.S. economy, despite recent job losses" (U.S. Department of Labor, 2004).

The U.S. Department of Labor Bureau of Statistics (2004) predicted that between 2002 through 2012:

> Computer support specialists and systems administrators are projected to be among the fastest growing occupations. Job prospects should be best for college graduates who are up to date with the latest skills and technologies; certifications and practical experience are essential for persons without degrees (p. 1).

Therefore, academia continues to face the arduous task of providing an up-to-date curriculum in an environment that is constantly changing. The U.S. Department of Labor Bureau of Statistics (2004) also noted that of the 758,000 jobs in computer support and system administrators area in 2002, approximately 251,000 were network and computer systems administrators.

NEED FOR EFFECTIVE NETWORK ADMINISTRATION

The current literature relative to the need for effective network administration is sparse. However, the literature that does exist deals with specific network problems, such as security, risk assessment, and management. In addition, several authors discuss the need for certification in networking. For example, Brandel (2001) recommended the Cisco Certified Internetworking Expert (CCIE) certification, which provides five areas in which a person can be certified: routing and switching, wide-area network switching, ISP Dial, SNA/IP, and integration and design. Roberts and Zarley (2003) found that those technicians who hold multiple certifications receive a higher salary and higher increases in compensation than those who hold a single certification. Through their study of 1,142 solution provider personnel, they found that technicians with multiple certifications received approximately 12% more in salary than those with a single certification. Additionally, with the downturn in the IT economy in 2002, multiple certifications led to approximately a 7% compensation increase where a single certification realized an approximate 1% decline.

The OEIS Model Curriculum originally developed by the Office Systems Research Association (now known as the Organizational Systems Research Association (OSRA)) in 1986 and updated in 1996 and 2004 was designed "...to challenge students to understand their information system's role from an organizational viewpoint, the perspectives and needs of the individuals they support, and technologies used or accessed at the desktop" (OSRA, 1996, Setting the Stage section, ¶ 5). Because of recent trends in IT, the most recent iteration of the curriculum now includes a course in network administration (OSRA, 2004).

Network Administration Instruction

The limited current literature dealing with instructional strategies supporting network administration instruction is discussed in this section. One article by Chen (2003) discussed a methodology using a constructivist approach to teaching and its implications to teaching computer networking principles. With this method, teachers incorporate instructional techniques so that concepts and phenomena are interesting and deemed important by the students. As applied to the teaching of networking principles, Chen (2003) suggested that the class be organized so that students work in groups to develop good teamwork experience and to allow time for them to work out their differences and manage conflicts. Further, Chen offered practical suggestions for teaching specific networking principles, such as network topology and architecture. These suggestions involved providing student groups with objects to manipulate to better understand the key concepts.

Corbesero (2003) described how a network administration course at a small college was designed that provides computer science students with practical and hands-on experiences. Through this experience students are provided with a wide spectrum of knowledge and activities relating to creating and managing a coherent and useful collection of networked computers. Sample activities included building a working server and client pair, installing server operating system software, and configuring typical application software packages for electronic mail, Web services, and file sharing. After completing required laboratory exercises, student groups were directed to submit an informal written report and demonstrate that the hardware and software were working as specified by the assignment. This method not only emphasized hands-on experience but group work as well.

The network environment is not the only environment in technology that is continually changing. Consequently, as networking becomes more essential to business and personal life, academics need to produce competent students to move into network administration positions. Newly-hired graduates need to know the technology as well as the management of that technology. Moreover, those responsible for teaching key courses in IS must ensure that the curriculum and courses result in the achievement of the requisite critical skills to advance in the job market or to continue toward an advanced degree. The continued developments in e-commerce, wireless networks, and emerging technologies will augment the need to update those skills.

Telecommunications and Network Usage

Telecommunications and networking courses may be thought to be the same course. They are interrelated, but yet they are different courses. Gehris and Szul (2002) defined telecommunications as "...communications via electronic, electromagnetic, or photonic means over a distance" (p. 4). The information that is communicated can include a mix of text, pictures, voice, and video over long distances. Telecommunications uses technology which plays a large role in communications in today's business world. Along with the development and increased use of communication devices, one of the primary ways that technology enhances the communication process is through networking. Networking occurs whenever communication devices are linked together.

There is a strong relationship between telecommunications and networking. This relationship makes it advisable for students to obtain an understanding of telecommunications

principles in order to master networking concepts. The OEIS 5 - Telecommunications and Networking Foundations course in the OEIS Model Curriculum provides foundation information and skills relating to telecommunications and networking in the business environment. This includes conceptual information, telecommunication applications, networking fundamentals, and Internet/Intranet usage (OSRA, 2004).

Significance of Network Usage

The growth in the use of networks and network-based applications has been phenomenal. Worldwide Internet usage estimates in 2002 ranged from 580 million to 655 million people with projections of 709 million to 945 million by 2004. In the United States, 280.5 million individuals and businesses used the Internet. (Jupitermedia Corporation, 2002). A Harris Poll telephone survey ("It's a small world," 2003) revealed that adult Internet users spent an average of eight hours per week online, up from seven hours in 2001, 2000, and 1999.

Clearly, organizations are able to save money and realize other advantages because of the effective use of network infrastructures in place. Networks help organizations share files, resources, and programs, as well as enable businesses and users to share information with others via networked computers. With improved worker efficiency and productivity, users are able to share resources using such peripherals as printers and CD-ROM drives, resulting in the necessity to purchase less hardware. Moreover, placing software programs on a shared network reduces the necessity to keep separate copies of programs on each user's computer.

THE OEIS Model Curriculum

OSRA's updated model curriculum is intended to keep pace with current IT requirements and to address the shortcomings of IT education. The 2004 OEIS Curriculum Task Force focused on the competencies that an IS professional working with organizational and performance technologies needs to possess. The model, a major update of the OSRA 1996 Model Curriculum, emphasizes organizational and technology issues needed to support the emerging technologies of the 21st century. The curriculum model in Figure 1 was designed to challenge IT students to understand their dynamic role in an organization regarding business functions, IT, and end-user computing. The OEIS Model Curriculum offers specialization in an up-to-date fashion with current descriptions of IT and end-user support areas. "Technology is more an approach to learning and knowledge and its application than it is a curriculum area dominated by content" (Watts, 1999, p. 1). Further investigation led to discovering that technology was defined in the Australian Education Council's (AEC) initial statements as "The purposeful application of knowledge, experience and resources to create products and processes to meet human needs" (p. 1). This not only incorporates the need for technological knowledge but also the necessity to take human factors into consideration. The expected outcome of the OEIS curriculum is a set of competent students that will meet the needs of employers involved with IT and end-users (OSRA, 2004).

The curriculum is designed for a four-year college and best fits in a school of business where students have a liberal arts foundation and study the core business curriculum. However, it may be effectively implemented in other schools (e.g., information management, computer science, technical support, technology management, etc.) where the business common body of knowledge (accounting, economics, marketing, management, business law, business communications, and statistics) is included. It is also recommended that skills relating to using a business application development language be included. Interpersonal skills, teamwork, communications skills, information security, and ethical considerations should be developed and practiced across the entire curriculum.

For flexibility in this model, courses and their titles are meant only to provide casings for competencies and instructional modules. The curriculum is presented in a framework of modules within semester courses. However, in actual implementation, it is expected that modules will be mixed and matched to fit other timeframes

(e.g., quarters or one- or two-credit courses) and course goals. Such alterations are considered consistent with the intent of this model. Seven core courses (OEIS 1-7) contain the competencies that are considered vital. The six optional courses (OEIS 8-12) are provided as suggestions for a more in-depth evolution into specialty areas and/or field experiences. Universities can customize courses to meet the needs of their students and the mission of their respective schools. The OEIS Model Curriculum assumes that general education requirements are completed (OSRA, 2004).

OEIS 10 - Network Administration is described as a course designed to develop senior-level OEIS students' advanced network administration skills. Both client and server applications are dealt with and a strong emphasis is placed on network operating system software. Students are also exposed to multi-vendor networking topics.

Within this structure, students will develop skills to design, analyze, and actually implement and administer a computer network. This will provide students with a more practical foundation of solid telecommunications, networking, and technology management skills (OSRA, 2004).

Delivering the Curriculum

When examining specific curricula, it is apparent that network administration courses may consist of a variety of topics, including general theory to hands-on network server configuration. One of our educational institutions provides three courses in networking. The first course is a thorough introduction to networking theory, concepts, and design. This course typically includes the following topics:

- Introduction to computer networking terminology
- Network topologies (star, bus, mesh, ring)
- Network cabling and infrastructure (hardware)
- Networking theory and the OSI networking model
- Network protocols (TCP/IP, IPX/SPX)
- Overview of network software
- Network architectures
- Wide Area Networking technologies
- Large scale networks and remote access (including VPN technologies)

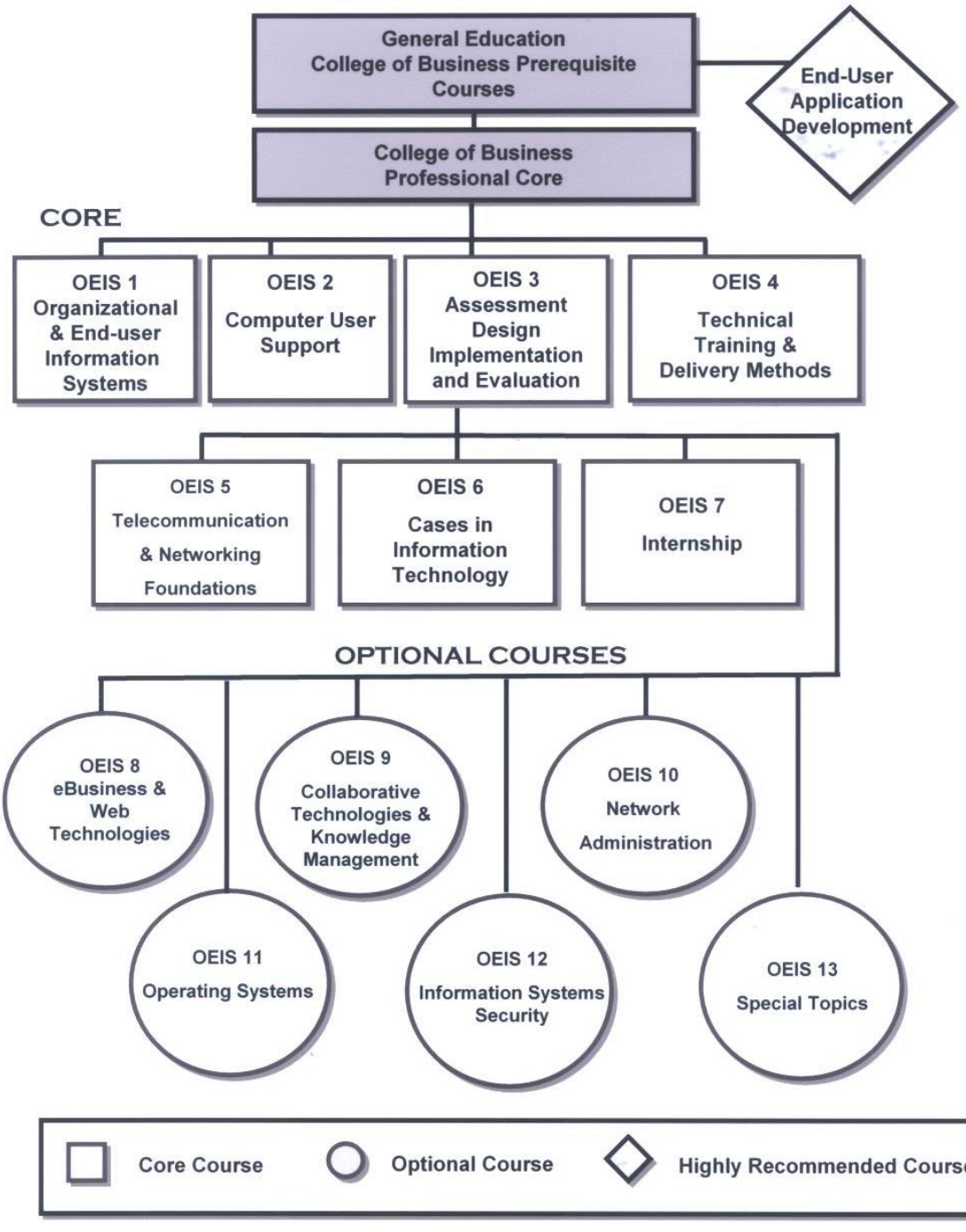
The second course is designed to cover the basic tasks and processes needed in network administration. This course is designed as a hands-on course and includes direct manipulation of a network server and the following topics:

- Specific network operating systems
- Overview of common network administration tasks
- Creation of user and group accounts for authentication
- Creation of folder and share structures to control access to resources
- Managing disks and drive storage
- Configuring backups and fault tolerant drive systems
- Naming conventions and network protocol configurations
- Possible additional topics such as DNS and DHCP

The third course in the sequence is designed to cover more advanced features of network administration and builds directly on the prerequisite knowledge of the second course. The third course is also hands-on and typically includes these topics:

- Dynamic Host Configuration Protocol (DHCP)
- Domain Name Services (DNS)
- Other naming systems such as Windows Internet Naming Service (WINS)
- Managing access to resources through group policy definitions and assignments
- IPSEC (IP security)
- Remote Access services (Dial-up, VPN)
- Routing services and protocols
- Advanced Internet information services (Web, FTP, SMTP, POP/E-mail, NNTP) including the integration of DNS services for multi-site hosting with a single IP

Figure 1: Organizational and End-User Information Systems Curriculum Model (OSRA, 2004)



- Clustering servers
- Multiple vendors' software/hardware

These three courses have proven effective in producing students who are able to obtain

employment directly in the network administration field. One missing element that is currently being addressed is experience with networking hardware (configuration of switches, routers, gateways, etc.).

Resources for Implementation

When delivering this curriculum, resources to provide students with both theoretical and applied learning scenarios are essential. Lab space and appropriate lab design are critical components to allow students to explore the applied portion of the learning. Some software applications, such as Novell Netware, are best configured using remote administration tools (e.g., NWAdmin and Console One). However, other network server applications, such as Microsoft Windows Server applications, which can be administered remotely using Terminal Services, are easiest to configure while sitting in front of the server's graphical user interface (GUI). Instead of dozens of students attempting to administer one server, one university configured a computer lab with 20 workstations and obtained licensing for Windows Server to be installed on each. Therefore, each student had an individual copy of Microsoft Windows Server on his/her computer to manipulate.

The lab was not, however, devoted to just networking administration classes. Through an initial additional expenditure of approximately $150 per computer, computers were ordered with two hard drives in removable drawers (or sleds). Other classes used one set of hard drives and network classes used the second set. Logistically, this worked well. As classes grew and more sections were added, additional hard drive sets were purchased. Hard drive sets were not purchased for each course section, but, instead, each hard drive set contained two installations of the server software (dual-booting), thereby allowing two different course sections per set of hard drives.

Although the hard drive sets could be triple- or quad-booted, through trial and error anything over a dual-booted drive led to logistical problems. This was particularly true if one student corrupted one of the installations and the entire drive had to be rebuilt. For faster recovery and lab rebuilds, Symantec Ghost could be used to image the drives.

While physical hard drive swapping is a popular method to accommodate different configurations on one computer, technologies are appearing and improving that can provide a software solution. One product, VMware (VMWare, 2004), allows the user to create a virtual machine on an existing hard drive configuration. The virtual machine is configured to simulate a complete computer in a window. Once a series of parameters are defined, the virtual machine is booted, runs a BIOS check, and initiates a new operating system install. When complete, the user is left with an untouched main operating system and another operating system running inside a window and completely functional. To remove the virtual machine, approximately three to four files on the hard drive are deleted and the installation is removed. Similarly, if an instructor wants to deploy an identical virtual machine to all students, it only requires the students to copy a few files to their respective hard drives. Microsoft also sells similar virtual machine software called Virtual PC 2004 (Virtual PC, 2004). This virtual machine configuration is currently being utilized in a lab of 50 computers for students in advanced networking.

One of our universities set up a wireless lab in a regular classroom exclusively to teach the network administration course. The lab initially consisted of 12 laptop computers and a desktop computer, which was purchased as the server. The configuration also required wireless network interface cards and a wireless access point. An existing closet in the classroom was redesigned to store the laptop computers. The closet featured an AC source as a convenient way to charge the computers when not in use. It was designed so that students would work in groups (two to a computer). However, when enrollment increased, it was necessary to assign three students to a computer. Additional laptop computers were requested to reduce the number of students working at a computer. After teaching network principles, student teams were given instructions for configuring Windows 98 and Windows Server

software for peer-to-peer and client-server networking.

Licensing Issues

With a lab of any substantial size, licensing can quickly become a high-cost barrier to establishing an appropriate lab. Several options are available to most educational institutions and the first, and simplest, is volume licensing. Most educational institutions have some level of negotiated volume licensing for Microsoft products. Volume licensing can potentially bring individual server license costs down from thousands of dollars to hundreds of dollars. Microsoft and other vendors also provide special programs to educational institutions that, for a small yearly fee, provide the academic department with almost all Microsoft software for educational use.

One such program is the Microsoft Developer Network Academic Alliance (MSDNAA) program, which provides academic departments with all of the Microsoft operating system and server platforms, as well as the entire suite of developer tools. All materials are updated monthly for a nominal yearly fee. This particular program also has the added benefit of providing each individual student in the program with the software, as well (MSDNAA, 2003).

Instructional Strategies

Network administration includes not only how to configure network server software but, also, general networking concepts and theory. Students should be taught to understand Dynamic Host Configuration Protocol (DHCP) concepts, where it is used, the pros and cons, and how it integrates with other services, such as Windows Internet Naming Service (WINS) and Domain Name Service (DNS). Simply clicking through the steps to configure DHCP server services is not adequate. An understanding of the underlying concepts, terminology, and theory that make networks work is critical. Concepts, terminology, and theory are often delivered to students in a traditional lecture or discussion format. This format allows the instructor to deliver the terminology directly to the students and generate discussion regarding what it is, how it works, and integration with other networking components.

Lecture and discussion alone, however, would not be an effective mechanism for delivering the steps involved in configuring the specific server software. For students to effectively transfer the concepts of network administration to the actual software, students need to engage the software application in an applied (hands-on) format. Allowing students access to equipment, software, and other networking components is essential to learning. The hands-on learning theory is not a new concept. This concept was brought to life through Dewey (1859-1952) when he expressed his beliefs about education. He believed that students needed to engage and interact with an environment that provides a continual framework for practice (Smith, 2001). With networks available for investigation through this engagement of learning, students have a better grasp of what will be expected of them on the job.

This active type of learning style helps students learn more than just the technology itself. It helps them learn how to troubleshoot, manage, and integrate technology. These are essential skills of a successful network administrator learned through the manipulation of hardware and software. Hands-on learning can also be used so that the instructor can demonstrate a technique prior to the students' trying it on their own. Therefore, the students observe how to do it, listen to how it should be done, and then actually enter a tactile learning environment and manipulate the hardware or software to make it work. As noted by Raths (1999), "Organizations don't want to hire people who can pass a test but who have no hands-on experience" (p. 1). Thus, the need for hands-on learning in a network administration course is essential.

Once the concepts have been delivered in a traditional format, the focus shifts to the application of those concepts in a real-world goal. A laboratory setting, with network server applications installed, is an ideal environment for students to apply their learning. In a laboratory, students can better understand concepts, how they work, why and when to configure domains/zones in a DNS server, the process and

procedure, and the hierarchical nature of DNS. Without conceptual understanding, many students would simply be going through step-by-step motions while learning very little or nothing at all.

Team and Individual Skills

Another critical component of the modern learning environment is team-building skills. Students are expected to work in teams; therefore, it is critical that students learn successful teamwork skills, which are necessary in the IT environment. One university addresses teamwork directly in the laboratory by encouraging students to work with other students, discuss items as a group, and work through lab exercises together. Even though students are allowed to work together, they must individually understand the content so that they can perform adequately on a comprehensive application-based final examination. Team work and team building are also emphasized throughout the OEIS Model Curriculum.

In addition to teamwork, students need to understand how to find answers on their own to problems they encounter. Exploratory learning must be implemented so that students must "work it out" themselves when they encounter an issue by using their content knowledge and outside resources to solve problems. Students can initially become frustrated when this type of exploratory learning occurs, but they will be better prepared to resolve their own problems when they enter the workforce. A hands-on learning environment in which students can work on problems through trial and error enhances this learning process.

Since individual network administration tasks are not accomplished in a vacuum and, in many cases, one individual must complete all aspects of network administration, comprehensive projects and exams are ideal for gauging the students' understanding of the material. Comprehensive project-based learning actively engages students through activities, such as installing and configuring a production server, or involving a comprehensive subtopic, such as configuring a Web site with DNS configurations, which might integrate several network administration tasks.

Instructors use varying methods for assessment in their classrooms and an examination is one such assessment strategy. Typical objective exams focus on conceptual material, including such things as terminology and theory. However, in a skills-oriented course, such as an applied network administration course, it is imperative that students be provided with the opportunity to demonstrate the skills they have learned and their level of competence in the entire network administration course. One university addressed this assessment through comprehensive projects and a final exam that incorporated not only conceptual materials but, also, included a comprehensive application portion that required students to completely configure a working server within the limited exam time frame. This type of comprehensive examination has proven to be an effective measure of the students' comprehension of the material.

Evaluation of Course Implementation

Informal feedback from students regarding the implementation of the aforementioned network administration curriculum model has shown that students are responding well to the hands-on applied focus of the course. Formal end-of-semester course evaluations have also shown positive feedback regarding the students' attitude toward this course. Student feedback yielded the need for access to software and appropriate hardware outside of appointed lab times. It is difficult for students to gain competence in network administration without prolonged exposure to the software. The MSDNAA (2003) program allows universities to provide that necessary software to students; however, students still need adequate hardware to run the software at their residences. Students have also begun responding after their required internship program that they felt more prepared to enter their internship experience or they were able to obtain more desirable internship appointments. Informal discussions with internship (business) supervisors have also proven to reinforce the need for students to leave university programs with more than just a theoretical background, but to

include an actual hands-on skill set. Network administration is one such skill. After obtaining initial employment after graduation, one student wrote:

> I was one of your students in all the networking classes from Fall 2001 to Spring 2003. I'm currently working at the School of Medicine Office for Information Technology. Our team was working late running into problems updating a Terminal Server running on 2000 Server. We would have been there much longer if I didn't remember how to set a reversed loopback address (127.0.0.1) as a forward lookup zone in the DNS MMC, which finally allowed us to set the preferred DNS server with that reserved loopback address in the TCP/IP properties. Basically, I just wanted to assure you that all those long hours of preparation put in to [sic] your instruction are greatly appreciated. Thank You Again! Also, I wanted to ask if you are teaching with Server 2003. I'm sure you know of the University switching to Active Directory and ridding itself of Novell. Some of my co-workers and myself [sic] would be very interested in taking any course offered giving instruction for Windows Server 2003.

This is not the only e-mail or documentation received, but it sets the tone for the students' competence, their willingness for lifelong learning, and the need for a course or courses in network administration.

Conclusions and Recommendations

Setting up a lab is the first step in the process of developing a network administration course, and the use of configuration management software to replicate systems and software rapidly is essential. If the lab contains removable drives, the logistics of changing them before each class has to be dealt with and those incorporating dual-booting systems must be aware of problems, such as corrupt partitions. If laptops and wireless environments are set up, recharging the laptops, storage, and security are all issues.

A debate is continuing about what software to use—Microsoft, Unix and Linux flavors, Novell, etc. Obviously, cost is a factor; however, Unix/Linux is free or reasonable and Novell and Microsoft both have educational programs that include software for a minimal cost. Microsoft still has a large portion of the market share. In fact, according to Wilcox (2002), Microsoft held nearly 49% of the new server licensing market share in 2001 with Linux holding 25% and Unix and Novell both maintaining approximately 12% each. Therefore, Microsoft simply can't be ignored, but neither can Linux, which is quickly gaining market share. Ideally, students need contact with a variety of vendors; therefore, the best classroom would be one created around a multi-vendor environment.

Regardless of whether an institution can create a multi-vendor network laboratory or not, all networking computer labs face logistical issues, such as upgrades. Microsoft, Novell, Linux, and others are constantly generating new versions of their network server applications. New features are added and, at times, the software and interface are redesigned. One question to ask is: When is an upgrade applicable? Ideally, network administration courses are teaching the current release of any software application. Upgrade timing may also be dictated by business and industry. If research shows that the majority of business and industry are waiting on upgrades themselves, this may need to be taken into consideration. On the other hand, if students are prepared with the newest release of the software application, they may be more marketable to those organizations considering an upgrade.

If older versions of an application must be taught, it is imperative that students gather an understanding of how key activities are performed and encouraged to generalize that knowledge to newer versions or other network operating systems. Students who understand what they are doing are more likely to be able to transfer their knowledge to other situations. The timing of the upgrade is important; however, it is also important to remember the cost associated with any upgrade. The upgrade includes not only the cost

of the software, but the cost in labor-intensive hours to install and configure the labs. Drive imaging software, such as Symantec Ghost, can facilitate complete lab re-configurations; however, again, cost becomes a factor. Regardless of the time, place, and cost associated with upgrading networking lab facilities, upgrades must be done in a timely fashion to provide students with the best possible educational environment.

When considering changing or establishing a network administration course, laboratory facilities must be considered as a priority. A lecture course in networking theory and concepts can technically be taught in any lecture-style classroom, but to properly teach a hands-on network administration course, a proper lab is required. The ideal lab would include an individual server-grade computer for each student, but, realistically, cost typically impedes this option. Therefore, the best alternative would be a computer lab with removable hard drives or virtual machine software to simulate any number of different configurations allowing the configurations to be individual to a specific student. If the networking curriculum includes hardware configurations, a separate lab with the necessary hardware (switches, routers, etc.) is the best solution.

In addition to the lab configuration, a determination must be made regarding what software to teach. The ideal solution would match the IT industry. An examination of industry, however, suggests that many companies use a mix of network operating systems including the big three: Microsoft Windows Server, Novell Netware, and Unix (and Linux variations). Therefore, a computer laboratory configured with these network operating systems installed and configured to communicate in a true multi-vendor mixed environment would be best. However, if only one operating system has to be chosen, it should also match the one that maintains the largest market share and install base, which would very likely be Microsoft Windows Server.

Instructional style should also match what students can expect in industry. Industry reports consistently state that employees need to work in teams and collaboratively solve problems. Cooperative learning models would, therefore, be ideal for a network administration course. Students should be allowed to work together and encouraged to work together to solve problems during lab exercises. However, students should still be required to demonstrate their individual competence with the network operating systems. Additionally, instructors should take on the role of facilitator and encourage exploratory learning.

Instructors, however, may not feel prepared to teach all operating systems. No individual can know everything about every system. Instructors should be provided with a core level of training in any technologies they are expected to teach. Since they should be acting as facilitators, problems and questions that arise can be quickly converted to a learning activity for students to explore and solve. Network administration instructors should also be strongly encouraged to complete faculty internships or shadowing experiences on a regular basis with leading-edge networking companies to gain real-world experiences with networking.

The students who succeed in this environment will be those who combine and effectively synthesize technology mastery with core knowledge of business skills and practices. Therefore, educational institutions must be willing to review their own curricula and investigate how to incorporate significant updates to produce technically competent students who have the soft and hard skills necessary to succeed in the business world. New technologies, organizational changes, and accreditation standards are forcing many educational systems to rethink their curriculum at the graduate and undergraduate levels.

The updated OEIS Model Curriculum can serve as a guide and framework for institutions to develop or update their own curricula. It is also imperative that programs remain current with their technology investments and explore partnerships and special software programs to minimize or reduce the costs associated with delivering a highly technical and, perhaps costly, IT program. Academic institutions need to begin to offer classes that fully resemble business and industry—true multi-vendor computer networking labs, for example, that mirror the diverse

networking environments that occur in organizations.

These institutions also need to ensure that students are receiving applied, hands-on experiences with the hardware and software they will likely find in the workplace. Moreover, the IT workplace is constantly changing and IT-based academic programs need to do the same. The OEIS curriculum is just a beginning step to an ever-changing process. Revisions to this framework and any academic program using the model are necessary to provide students with the best educational experience possible. Network administration is only one area of the curriculum, but an important one for business and personal life.

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