ISSN: 1545-679X

Information Systems Education Journal

Volume 5, Number 22 **http://isedj.org/5/22/** **June 8, 2007**

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Recommended Citation: Krishnamoorthy (2007). An Experience Designing and Teaching a Hands-on Project-based Networking Technologies Course for IS and IT. *Information Systems Education Journal, 5* (22). http://isedj.org/5/22/. ISSN: 1545-679X. (Also appears in *The Proceedings of ISECON 2006:* §3112. ISSN: 1542-7382.)

This issue is on the Internet at **http://isedj.org/5/22/**

The **Information Systems Education Journal** (ISEDJ) is a peer-reviewed academic journal published by the Education Special Interest Group (EDSIG) of the Association of Information Technology Professionals (AITP, Chicago, Illinois). • ISSN: 1545-679X. • First issue: 8 Sep 2003. • Title: Information Systems Education Journal. Variants: IS Education Journal; ISEDJ. • Physical format: online. • Publishing frequency: irregular; as each article is approved, it is published immediately and constitutes a complete separate issue of the current volume. • Single issue price: free. • Subscription address: subscribe@isedj.org. • Subscription price: free. • Electronic access: http://isedj.org/ • Contact person: Don Colton (editor@isedj.org)

EDSIG activities include the publication of ISEDJ, the organization and execution of the annual ISECON conference held each fall, the publication of the Journal of Information Systems Education (JISE), and the designation and honoring of an IS Educator of the Year. • The Foundation for Information Technology Education has been the key sponsor of ISECON over the years. • The Association for Information Technology Professionals (AITP) provides the corporate umbrella under which EDSIG operates.

An Experience Designing and Teaching a Hands-on Project-based Networking Technologies Course for IS and IT

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Abstract

Networks have evolved and have become an integral part of computing environments today. Knowledge and experience in networking have been advocated as essential components of Information Systems and Information Technology programs by ACM-IEEE computing curricula working groups. The Information Systems and Information Technology students are more organization-centric and prefer little or no programming. A hands-on project-based networking course that was designed and offered to cater to the needs of these programs and the responses of students is described in this paper. In addition to course content, various issues, such as varying student backgrounds, enrollments, lab equipment for hands-on experience, lab maintenance, lab space, and lab access are also described.

Keywords: information systems, information technology, networking technologies, course design, hands-on project

1. INTRODUCTION

When computing curricula CC1991 was published in 1991, networking was not considered a major topic area for computer science. Only 6 core hours were devoted to networking. Since then, networking has evolved and the Internet has grown exponentially. The World-Wide Web has become a "mass-market phenomenon." Now, networking is an integral and critical part of the computing environment. Nowadays many students come as Internet-application-savvy users. Due to the rapid decline in the cost of wireless systems, many families are setting up wireless networks in their homes. Today, networking has become an essential component of all major computing programs.

1.1 ACM-IEEE Curricula Review

To get some perspective and understanding of the content of the networking course described later, let us briefly review the ACM-IEEE computing curricula for the Information Systems (IS) and the Information Technology (IT) programs. It may also help those who are thinking of accreditation of their IS and IT programs. Tables 1, 2, and 3 were constructed after reviewing the recent ACM-IEEE CC 2005, IT 2005 and IS 2002 curricula documents and extracting the appropriate networking information from them (Computing 2005, ACM Computing 2005, ACM 2002). Table 1 shows the relative importance of various networking topics for the IS and the IT programs. In this table, "*min* represents minimum emphasis and *max* represents maximum emphasis" as judged by the CC2005 Joint Task Force. On a scale of 1 to 5, minimum emphasis is 1 and maximum emphasis is 5.

Table 2 shows the expected relative networking performance capabilities for computing graduates of these two programs. It is on a scale of 0 to 5, where zero represents no expectation and five represents the highest expectation from the graduates.

	IS	IT
Networking Topics	**Min Max**	**Min Max**
Net-centric principles and design	1 3	3 4
Net-centric use and configuration	2 4	4 5
Security: issues and principles	2 3	1 3
Security implementation and mgt.	1 3	3 5

Table 1. Comparative weight of networking topics

Performance Capability	IS	IT
Design network configuration	3	4
Select network components	4	5
Install computer network	3	5
Manage computer networks	3	5
Implement communication software	1	1
Manage communication resources	3	5
Implement mobile computing system	0	1
Manage mobile computing resources	2	4

Table 2. Networking performance capabilities of graduates

Table 3 gives the list of networking topics for the IS and the IT programs. The twenty core hours of networking to be covered for the IT program are shown in parentheses.

In addition to the above topics, the ACM-IEEE IS and IT curricula also emphasize the importance of the following:

- Preparing students for jobs
- Working in teams
- Effective written and oral communications

One of the ways that graduates can be made ready for jobs is by making the computing and networking resources of these programs "mimic" the work environment.

IS Networking Topics	IT Networking Topics
• Telecommunication configurations • Network and web applications • Distributed systems • Wired and wireless architectures, topologies, and protocols • Installation, configuration, and operation of bridges, routers, switches, and gateways • Devices including media, modems, multiplexers, computer interfaces • Network performance tuning • Privacy, security, firewalls, reliability • Installation and configuration of networks • Monitoring and management of networks • Communication standards and communication providers	• Foundations of Networking (3) • Routing & Switching (8) • Physical Layer (6) • Security (2) • Application area (1) • Network Management (Required core hours = 20)

Table 3. ACM Curricula 2005 networking topics for IS and IT

1.2 Institutional IS and IT Program Development

This section briefly describes the history of development of the IS and the IT programs at our institution. Around 1998-99, the Board of Higher Education, having realized the importance of having a strong IT base, started a commission to review all the computing programs in public institutions of higher education in the state. As part of this initiative, institutions were asked to look into accrediting their programs. At that time,

our department had a four-year undergraduate program in computer science. In addition to the burst of the "dot com" bubble in the year 2000, we also saw a major shift in the computing industry, to outsource/offshore software development. We also observed that a sizeable percentage of our incoming students were interested in programs with less software development and more services, such as system and network administration and IT management. Hence, we thought about ways to serve the interests of both groups of students. At the same time, our institution was also interested in creating a new major with both the business and the IT components. After extensive discussions between the CS department, the business department, and the administration, it was decided to modify the CS program to have dual concentrations, one CS-oriented and the other IS-oriented, and to create a new major called Business and Information Technology (BIT). The BIT major would be offered by the business department in collaboration with the CS department.

Some of the major issues raised during the discussions were the impact of splitting CS students among the two concentrations on course enrollment; the effect of some of the CS students moving to the business department; the new courses to be created; the resources such as faculty, lab, and support staff; the accreditation of the programs; and the necessity of running courses without cancellation even if enrollment is low, until the establishment of the programs.

2. CREATION OF A NETWORKING TECHNOLOGIES COURSE

Discussions were held to decide whether or not we should create two separate networking courses, one for the IS concentration and another for the BIT major. After looking at the ACM-IEEE curricula for the IS and IT programs, the expected (low) enrollment figures in the early stages of the programs, and the fact that our courses are four credits, we decided to create one course, called Networking Technologies, which satisfies the requirements of both the IS and the BIT programs.

2.1 Course Content

Most of the students in the IS and IT programs want to become system administrators, network administrators, quality assurance engineers, graphic designers, tech writers, systems analysts, helpdesk technical staff, and technical managers. Even though they are not interested in mainstream software development, they like having non-programming-oriented hands–on experience.

ACM-IEEE curricula recommendations, students' interests, accreditation, and input from the computing industry obtained through the department advisory board and alumni were taken into consideration while selecting the topics for the course. The topics included were: wired and wireless data networks (LAN, MAN, WAN, SAN, and PAN), VPN, various aspects of telecommunication networks, voice and video over IP, multimedia networks, Internet, net-centric computing, network and web applications, network devices, network management, security, network performance, DNS, DCHP, cabling, topologies, internetworking, routing, OSI seven-layer model, TCP/IP protocol stack, and IEEE LAN standards. Because of the increasingly global economy, global telecommunication policies and standards were included. The business and organizational aspects of networking were also added to the course.

Hands-on experience, projects, and written and verbal communications are important components of this course. Each student must complete the following four projects during the course of the semester:

1. Network design project
2. Technical report writing on Windows or UNIX networking features
3. Hands-on lab
4. Presentation

These four projects made up 55% of the total grade, while examinations carried 40% of the grade, and attendance and class participation made up the remaining 5%.

2.2 Network Design Project

The objectives of this project are: to identify a small business; to analyze and define requirements; to apply current technical concepts; to design LANs with internetworking; to provide WAN connection with firewall security; to evaluate and select different computing, telecommunication and networking systems and application/system software; to

do cost analysis; to develop technical writing skills; and last but not the least, to learn a commercial drawing tool.

For this project, students are told that a small startup company is interested in setting up a network for their business. A typical project description may state the following:

> "The company has 20 employees located on two floors of a building. Each employee has a laptop and a cell phone. There are four servers, the first for engineering development, the second for manufacturing, the third for the company's external website, and the fourth for management, sales, marketing, and personnel. There should be three LANs, one for engineers, one for manufacturing, and one for administration. There should be wired and wireless connections within the company as well as external Internet and telephone connections."

The students are asked to come up with a business of their own and describe the networking requirements. They have to design a network, and create system configuration specifications for laptop and servers that will meet the business requirements of the company. For each component in the network, three different vendor systems must be identified with their features and costs. Then, one of the vendor products should be selected that best suits the business needs, giving appropriate reasons for the selection. The design should take into account fixed and recurring costs. Students then have to compute the overall cost, including installation, configuration, maintenance, ISP, and miscellaneous costs. Depreciation was not considered in the cost computation.

Finally, each student has to write a report for his/her network design as if he or she will be submitting a quote for a "tender" from a company. He or she has to give justification for why his or her design should be selected. The students must draw the network layout using an electronic tool such as MS Visio (Walker 2003), MS Word (Halvorson 2001), or another of their choice. No hand-drawn diagram is accepted. The objective of this requirement is to make the students learn a drawing tool. The network design report should resemble a technical document with proper format. A sample published technical paper is distributed to the students to serve as a reference. Beyond networking features, students will learn some of the business aspects of networking through this project.

2.3 Report Writing with Windows/UNIX Networking Features

One of the objectives of this project is for students to explore and learn the variety of networking features available in a popular commercial network operating system and make them ready for a job. Another important objective of this project is to develop written communication.

UNIX (Stevens 2003) and Windows (Simmons 2002) are, by far, the most popular and widely used operating systems in the world and are encountered in the work place. Both are rich in networking features. Hence, the students are asked to choose one of the two operating systems. They have to do the reading on their own and write a good-sized report. The report should follow the format of a professional technical document.

2.4 Hands-on Lab Project

The objectives of this project are: to give practical experience to students by exposing them to the "real world" computing and networking environment; to learn to work in a team; and to gain hands-on experience in setting up, using, and managing networking and computing systems and tools.

For the hands-on lab project, a networking lab with several computers running Windows or UNIX or dual boot systems, a network interface card (NIC) for each computer, at least one router and one network printer, and cables are required.

Depending on the lab size and the class size, students are divided into small groups, thus learning to work in teams. Each group performs the following tasks:

- Install the network interface card in each computer, if necessary
- Using appropriate cable, wire the systems, including the router and the network printer, to form a Local Area Network (LAN). In setting up a wireless network, wiring becomes a non-issue.

- Perform network configuration such as setting up IP address, subnet mask, hosts file, etc.
- Install appropriate software for the router, as necessary
- Configure the router for security
- Install and configure a print server, as needed
- Learn and practice available network utilities such as netstat, ifconfig, route, ping, nfs utilities, and more.
- Optionally, students can also learn to set up a RJ45 connector to a cable. Experience indicates that this task is sometimes frustrating and ends up wasting several connectors by the time the task is successfully done.

2.5 Presentation project

The objectives of the presentation project are to improve the oral communication and presentation skills of the students, and to expose students to a variety of topics in networking in a short period of time through class presentation. For this project, each student has to search and identify a topic of his or her interest in networking. It should be a narrow topic. The material they have to present cannot be a repetition of what has been covered in the class by the instructor. The same topic cannot be presented by multiple students; in order to ensure this, the students must submit the topic to the instructor and get it approved before starting to work on it. Then they have to do further research on the topic, read the relevant materials, and prepare their own presentation slides. If they take diagrams from a source, the source must be acknowledged in their presentation. The set of references used in preparing the slides must be cited in the presentation. Microsoft PowerPoint [5] is used for presentations, since it is widely available on PCs in colleges and is used in the workplace.

The initial student reaction to making presentations was always negative. They are not inclined to make presentations in front of an audience. Students need to be reminded that employers require effective oral and presentation skills.

The presentation is done towards the end of the semester. The evaluation of the presentation is done by the entire class as well as by the instructor. Hence, attendance is compulsory during the presentation. Those who are absent are penalized. An average is computed from the student evaluations. It is compared to the instructor evaluation. If the student evaluation deviates much from the instructor's evaluation, a minor adjustment is made. Also, an evaluation that gives 100% for all presentations is discarded since it does not reflect the reality. In general, it has been found that the average score comes very close to the instructor's evaluation. The areas used for evaluation are: presentation style, depth of coverage of the subject, quality of the slides, and knowledge of the student on the subject matter. Students solely reading from "note cards" or the slides without directly addressing the audience are given fewer points.

In general, students tend to like the presentation activity after making the presentation. Also, it has been observed that continuing-education students with industrial experience tend to give better presentations than full-time day students who have no work experience.

2.6 Students' Responses

While taking this course, without hands-on lab, students mentioned that the hands-on experience enhances the course compared to only lecture-based teaching. With hands-on lab, it has been observed that some students showed more interest in the hands-on experience than straight lectures. Some students have also expressed that they learned more by "doing" than by just "reading". In general, they mentioned that lecture followed by lab helped them understand what to do in the lab.

3. ISSUES

Several issues have been encountered in the design and offering of the above course. Some of the important issues are listed below: Varying student backgrounds, declining enrollment, overlapping course contents, lab equipment for hands-on experience, lab maintenance, lab space, and lab access.

Enrollment in CS programs has declined over the last few years (CRA 2005). To manage this problem and to avoid class cancellation due to low enrollment, courses have been moved from the day time to the evening

with combined day and evening students. The combined students have varying backgrounds, knowledge and experience. Sometimes students enroll without proper prerequisites, and this causes problems. On the other hand, several evening students come with fairly good knowledge of networking that they obtained from their work experience. Identifying a common ground and pace to teach the course to this mixed population, while keeping them interested and attentive, is challenging.

The field of computing goes through rapid changes. This causes several problems including in remaining current in the field and maintaining the state of the art labs. Some of the problems encountered related to the CS labs are: constant update of lab equipment due to rapid technological changes, lab maintenance, lab space, and lab access. Invariably, the CS department has to depend on the campus IT department for lab update, maintenance, and student support. Sometimes this can be a rocky road because the CS department requirements are much greater than the general campus requirements. The CS department may have to make financial contributions from its budget for lab equipment and maintenance.

Beyond lab equipment and its maintenance, the space for a lab is often hard to come by, particularly, for new labs where campus space is at a premium. Another issue with the lab is getting access to it and ensuring the security of the equipment in the lab. Getting twenty-four hour access seven days a week is almost impossible, in particular, for specialized and isolated labs such as a network lab. To increase access and security, the CS labs may have to be integrated with the general campus labs.

4. CONCLUSION

The hands-on project-based networking technologies course satisfies the core requirements of the IS and IT programs and more. The projects are industry relevant and helpful in gaining industrial experience in the classroom environment. Students have expressed that these courses have a higher workload compared to most other courses; still they can be completed within a semester. The course has been well received by the students. Several alumni mentioned that the course was very helpful in their work environments and that they are happy they took the course. They have also suggested that the hands-on lab part is weaker and could be strengthened. It has been observed that students are less familiar with the format of technical papers and have generally weaker in writing and presentation. Various logistical issues that arise and need to be addressed in offering hands-on networking course have been described briefly.

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