Today’s e-commerce environment requires our computer science and information systems students to have hands-on skills in developing and managing information systems to support the Internet based business of any size. It requires our students to be able to handle the client-side jobs such as application development and other programming related tasks as well as server-side operations such as network and system administration. To meet the requirements of the IT industry, our students must have hands-on practice on software and hardware used in an IT infrastructure. Therefore, various computer labs are needed to support the hands-on practice in various technology-based courses.

On each campus, large or small, computer labs are the key component for a computer science or computer information systems department. The construction of computer labs involves various technologies. A computer lab consists of computers, operating systems, application software, system and network management software, security management software, remote access software, network equipment, storage devices, and remote access gears. These technologies are used to provide services, such as supporting a computing environment for students to perform hands-on practice, allowing faculty members to demonstrate the use of new technologies and to develop new course materials, supporting various online courses, storing teaching materials, and providing remote access service for students to remotely log on to the computer labs on campus.
More and more courses are taught online now. Many academic fields have developed effective solutions for online teaching and learning. Generally, for classes with no lab activities such as English, history, and education, the implementation of online courses are relatively easy. Many commercial software packages such as WebCT are available to support course setup for these types of courses.

Given the fact that online teaching has become the mainstream in higher education, one may assume that most of the technology-based courses that require hands-on practice have already been taught online now. However, not many papers and reports are about online teaching in this area, especially about courses that require server-side hands-on practice. For many information systems courses, WebCT or similar software packages are not sufficient because these software packages do not support hands-on practice on IT products which is a very important part of the information systems curriculum. Unlike a WebCT-based online course which mainly processes online course content through client-side application software, for a technology related curriculum, the online courses need to develop and maintain server-side projects through the Internet, such as managing operating systems, building client-server computing architecture, developing enterprise-level database servers, and providing e-mail services. An online technology-based course needs an online computer teaching lab whose implementation is a challenging task.

The IT industry is a rapidly developing industry. Each year, even each month, new technologies are created. To teach students the knowledge that is not obsolete, computer labs need to be updated according to trends. Faculty members have to keep adding new course content to the materials for teaching and hands-on practice and to request that the computer labs be updated accordingly.

People who are specialized in various technology fields are involved in the lab development and management. Employees of technology consulting companies, managers and technicians in computer service departments, administrators at different levels of a university system, computer science or information systems faculty members and students are all involved in the construction, development, and management of online computer labs. The development of online computer labs requires various skills and specialties such as management skills of administrators and IT managers; it needs technicians with specialties in networking, system administration, database administration, application development, and security management. It often requires faculty members to participate in the construction and management of an online computer lab since the online computer lab is used to support classes taught by faculty members. Students are the ultimate users of computer labs. More importantly, the development of online computer labs needs support from the university’s top administrators. People who are involved in the online computer lab development process need to have a strategic view about the computer lab. It is helpful for these people to understand the theory and practice of Web-based teaching while developing the online computer lab. They need to know the technologies involved in the process, and they need to know how to efficiently manage the online computer lab and know the current technology trend.
The development and management of online computer labs needs financial support. They usually take a large portion of a university’s budget. The cost of software, hardware, lab maintenance, and labor can be significantly high. We need an annual budget to cover these costs. Therefore, developing online computer labs requires knowledge in financial planning, expenditure monitoring, equipment purchasing, and on how to allocate resources for the labs. We need an accountant from the university’s finance department to keep track of the costs and to make sure that all the spending follows the regulations set by the government and the university.

As mentioned above, an online computer lab itself is a complex project. It usually requires a great deal of effort to construct, develop, and manage an online computer lab. It is crucial to know the strategies in developing online computer labs. This book is designed to address these issues. It will help the reader, either a veteran administrator or someone who has just started his/her IT career, to get a deeper understanding of developing online computer labs and to be able to handle enterprise-level computer lab development tasks.

This book investigates technology-based courses that require online computer labs to support teaching and hands-on practice. It discusses the difficulties of online computer lab implementation and management. It also talks about the online computer lab planning and budget related issues. The book presents different approaches to accomplish the lab construction tasks. It provides information about different types of online computer labs and the technologies used in these computer labs. It gives comparisons on the advantages and disadvantages of each type of lab.

This book provides related information and technologies to help faculty members develop teaching materials that require online hands-on practice. The book shows instructors how to create online lab activities in today’s Web-based teaching environment. It also provides information to help technicians and faculty members manage online computer labs, especially, security management and lab update strategies.

For teaching and learning with online computer labs, this book discusses various methods and tools for lab testing and evaluation. For future development of online computer labs, the book gives information about the trends in Web-based teaching and technologies that can potentially improve Web-based teaching and learning.

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**The Challenges**

For technology-based courses taught online, hands-on practice relies on online computer labs. However, many technology-based courses are still not fully supported by online computer labs. There are some reasons for online computer labs not being able to fully support online technology-based courses. One reason could be lack of funding to purchase necessary equipment for developing a remotely accessible computer lab. For many small campuses, funding for computer labs is very
limited. Online computer labs require reliable remote access service and network equipment to ensure better performance. This necessary equipment costs money. An online computer lab also requires a stable electricity power supply. Additional Uninterruptable Power Supply (UPS) equipment is necessary to keep the servers running.

Lack of experience is another reason for online labs not being able to fully support the online technology-based courses. Web-based teaching has only a short history. Universities have put their main focus on those courses supported by commercially available learning management software packages such as WebCT. It is relatively easy to use WebCT or similar software to support courses that do not require hands-on practice on commercial IT products. On the other hand, for online technology-based courses, we need to do more than just use the commercial learning management software. Putting a local campus computer lab online for technology-based courses is relatively new to many computer service departments. It needs experienced technicians to implement remote access service and enforce security measures to keep the internal network from attacks of Internet hackers. The fast changing technology and course content require the technicians to keep up with the technology trends. Online computer labs are also new to faculty members and students who need training on using technologies involved in online computer labs.

Another reason is that it is difficult to manage an online computer lab. When many students log on to the same computer lab, it significantly slows down the lab performance. The technical support team needs to resolve the bottleneck problem. This team is also expected to help students solve technical problems on the client side. Unlike the help in a computer lab which has the same type of computers, helping online students is a much tougher job since the computer systems on the students’ side are different in brand and model. The students’ computers may have different operating systems installed and may be configured differently. Also, it is difficult to provide technical support remotely since the students are not familiar with the technologies used in the online computer lab and the technical support team may not know the course content well enough to provide helpful advice without face-to-face conversations with the students.

Among the reasons of not being able support a fully online computer lab, lack of support from university administrators is the one that has the greatest impact. It will directly influence the decisions on the computer lab budget and on providing experienced personnel to run the computer lab. It will also influence the decisions on computer lab room maintenance, electricity power supply, class scheduling, release of workload for faculty members to develop the online computer lab, and many other services.

As mentioned above, it is a challenging task to develop an online computer teaching lab for technology-based courses. To face the challenge, extra effort is needed to overcome the difficulties. With the right strategies and tools, most of the difficulties can be overcome.
To develop a successful online computer lab to support teaching and hands-on practice for technology-based courses, the lab designer/developer and manager need to understand the requirements for the teaching and hands-on practice and the overall structure of a Web-based teaching system. The following are some key areas that need to be dealt with during an online computer lab development process.

It is important to know what the requirements are for the online computer lab. The lab should be designed to meet these requirements. Therefore, the first step in the lab developing process is to understand the Web-based teaching environment and practice. Understanding the curriculum of computer science and computer information systems can also help the lab designer/developer and manager make the right decisions in developing the online computer lab. To better understand the use of the online computer lab, the people who are involved in the lab development need to collect information about how students perform their lab activities in the lab.

The lab designer/developer and manager need to collect information about constraints that may impact the design decisions. They need to investigate the limitations on the budget, technical support, size of the computer lab room, and even the power supplies. Before the design process can get started, it is necessary to review the university regulations and security policies.

A design process needs to select the technologies that can be used to achieve the design objectives. However, the selection of technologies is limited by the constraints and university policies. Therefore, careful planning and budgeting are required before the construction of the online computer lab starts. The design should be based on the factors such as maximum number of possible concurrent users, the number of courses that will share the lab resources, the requirements for the computer and network equipment, the requirements for security, and the requirements for performance. Often, a design process is not linear. It requires several rounds of testing and modifications before the final version of the design can be completed.

Once the equipment is purchased, the implementation process can be started. The physical implementation may encounter various technical problems. It requires troubleshooting skills and experience. The implementation process should be closely monitored so that the project does not get behind schedule. It needs strong support from the computer service department and/or software and hardware vendors. Universities may also outsource the lab implementation tasks to a consulting company. In such a case, the collaboration with the consulting company is crucial for the success of the implementation.

When an online computer lab is in use, we must provide helpful technical support and training for lab users. Detailed lab usage instruction should be available to all students and faculty members. A knowledgeable technical support team should be formed to help faculty members and students solve their technical problems. Faculty members may also need a technicians’ help when developing hands-on practice materials.
A well managed online computer lab is the key for success. Security is always the top concern. The lab manager needs to be aware of various security vulnerabilities and know how to enforce security measures to protect the internal network. The lab manager should be familiar with the daily maintenance procedures and know how to deal with emergency problems. Usually, the lab manager and faculty members need to work together to redesign and reconstruct the lab when new course content is added to online courses.

A well-designed online computer lab alone is not enough for successful Web-based teaching. We need the teaching materials to be suitable for Web-based teaching. Due to the fact that there is no face-to-face communication in online courses, the teaching materials for hands-on practice need to be carefully designed to provide as much detail as possible so that ambiguity can be reduced to a minimum. Instructors need to know how multimedia materials can be used to improve online teaching and what the limitations are. They should also know how to use the technologies to develop multimedia course content.

For further improvement, we need the feedback from instructors and students. Lab testing and evaluation are also important for developing and managing a successful online computer lab. The lab manager should be familiar with the procedures of lab testing and evaluation. He/she needs to know how to design an evaluation instrument and the procedure to collect information.

This book will address each of the key areas in online computer lab development. It will give an overview of hands-on practice in a Web-based teaching environment and provide background information about the above key areas. In this book, we will discuss the design strategies, implementation methods, and the effectiveness of online computer labs. The book will present some possible solutions for the challenges raised in an online computer lab development process. It will provide readers with detailed information about the technologies involved in lab construction and management.

Organization of the Book

This book is organized into five main sections. The following is a brief description of each section.

Section I: Introduction

This is an introduction section which includes two chapters.

The first chapter provides background information about Web-based/online teaching and technology-based courses. This chapter discusses the strengths and weak-
nesses of Web-based teaching systems. Then, it analyzes some technology-based courses and their requirements for teaching and hands-on practice. This chapter also investigates how the strengths and weaknesses of Web-based teaching will affect the teaching and learning in technology-based courses.

The second chapter provides information about technologies used in the development of online computer labs. It describes the functionalities of these technologies and the roles played by the technologies.

**Section II: Design of Online Computer Labs**

This section discusses the issues related to the design of online computer labs. It includes Chapters III and IV.

Chapter III presents a systematic way to identify the requirements for an online computer lab. It then discusses the issues related to project planning such as budgeting, scheduling, and organizing.

Chapter IV discusses the strategies for developing online computer labs. The content in Chapter IV is used to prepare lab designers/developers to transfer the design into the technical stage. It covers the modeling process, physical design, and resource sharing issues. The issues on the selection of hardware and software, network equipment, and remote access technologies are also covered in this chapter.

**Section III: Development of Online Computer Labs**

This section covers the issues related to the development and implementation of online computer labs. Chapters V through IX are included in this section.

Chapter V discusses the issues involved in the implementation of servers, used to support the daily operations of an online computer lab. Various server implementation and server deployment plans are presented in this chapter. This chapter also deals with the server-side configuration issues.

Chapter VI is about the network development for an online computer lab. This chapter deals with the issues related to network configurations to meet the teaching and hands-on practice requirements. It discusses the strategies on how to work with a network that consists of different technologies. This chapter talks about the issues related to the implementation of networks for different types of online computer labs. It also provides information about various network equipment.

Chapter VII focuses on the client-side computing environment. It examines the issues related to the installation and configuration of students’ home computers, software, and network devices so that this equipment can be used to remotely access the servers installed in an online computer lab. This chapter provides configuration related information on remote access technologies. It also provides information about the configuration of multimedia devices.
Chapter VIII covers the topics related to security. An online computer lab is exposed to various malicious viruses. It is important to establish security policies for an online computer lab. Therefore, this chapter discusses security policy issues. It also investigates the sources of security vulnerabilities. It provides some strategies in dealing with the vulnerabilities. The technologies used to enforce the security policies are also covered in this chapter. Since some of the technology-based courses require students to have an administrator’s privilege in order to carry out their hands-on practice, this may create a serious security problem. This chapter discusses some possible solutions to resolve the conflict. To educate lab users about security vulnerability prevention, this chapter also presents ideas about how to deliver security instructions to the lab users.

Chapter IX deals with the issues related to the development of online teaching materials. This chapter first looks into the design of lab-based teaching materials to meet the requirements of hands-on practice. The teaching materials for hands-on practice are categorized into three types, text-based, combination of text and figures, or multimedia based materials. This chapter provides strategies on creating and using these three types of teaching materials. It also investigates the limitation of each type of teaching materials. The development of multimedia teaching materials requires additional tools. This chapter demonstrates several approaches to develop multimedia teaching materials. It also includes information about the tools used to develop video and audio course content.

Section IV: Management of Online Computer Labs

This section focuses on the lab management related issues. Chapters X and XI are included in this section.

Chapter X discusses the special maintenance needs for online computer labs. At the beginning of this chapter, it discusses the computer lab policy to be enforced in a computer lab. It also discusses the issues related to the technical support and the daily maintenance. It presents the strategies for system backup, recovery, and performance tuning. Online computer labs often need to be rebuilt after each semester. This chapter provides some solution for accomplishing this task.

Chapter XI is about testing and evaluating an existing computer lab. It begins with the discussion of requirements for testing and evaluation. It then investigates various ways to carry out the testing and evaluation process. An evaluation process can be used to collect feedback from the lab users. This chapter introduces some lab evaluation instruments which can get the job done. The last topic covered by this chapter is about the measurement of effectiveness for using an online computer lab.
Section V: Trends and Advances

Chapter XII is about the trend in Web-based teaching that has the impact on the development of computer labs. This chapter provides information about some of the trends in Web-based teaching and the trend in technologies. These trends reflect the changes in e-learning structures, management, content development, and the software and hardware used in the development of computer labs.