A Comparative Study of Student Learning Outcomes Before and After Taking a Network Management Course

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Abstract
A computer network management course was offered in the undergraduate program for students who concentrate on information and computer technology. The course covered a variety of topics dealing with the management of computer networks. In order to prepare students with 21st century knowledge and skills related to network management, we combined lecture-based learning, lab-based learning, inquiry-based learning, and project-based learning as the pedagogical method. At the end of the semester, a survey was conducted to evaluate whether the course content was suitable and helpful to students’ learning. The survey questions asked students about the degree of proficiency in subjects of network management before and after they took the course. This paper discussed the analysis of the survey results. The results revealed that our pedagogical method successfully provided an effective way to help students in learning the subjects of network management.

Introduction
Network management has become an important issue with the rapid growth of the size of computer networks. Network management covers a broad range of tasks, such as planning, monitoring, maintenance, provision, and administration, and a variety of network management models have been proposed [1, 2]. Among them, the Open Systems Interconnection (OSI) network management model (NMM) is the most popularly recognized of all the models [3]. It is an International Organization for Standardization (ISO) standard and also referred to as the OSI Telecommunication NMM.

The OSI NMM architecture consists of four models: organization model, information model, communication model, and functional model. The organization model covers an overview of the network management that includes its components, functions, and infrastructure. It also discusses activities that can be performed to support network management. The information model focuses on the information management structure, relationship, and storage. It provides a framework to model and store the managed information. The communication model deals with how the information is exchanged among managed systems and different layers. The functional model elaborates the operations of fault management, accounting management, configuration management, performance management, security management, which is generally named as FCAPS [4].

A course associated with network management was offered in the undergraduate program for students who studied in the program of Information and Computer Technology (ICT) in the Department of Technology Systems (TSYS) at East Carolina University (ECU). The course covered a broad range of subjects relating to the OSI NMM architecture, such as network management strategies and categories, network management functions and reference models, monitoring and troubleshooting, network management protocols, Simple Network Management Protocol (SNMP), network management software and hardware, desktop management, Management Information Base (MIB), Structure of Management Information (SMI), SNMP operations, events, traps, remote monitoring (RMON), and SNMP message analysis.

In order to prepare students with both theoretical knowledge and practical skills of all the models defined in the OSI NMM, we combined lecture-based learning, lab-based learning, inquiry-based learning, and project-based learning as the pedagogical method. Exams, readings, labs, and projects were used as the learning tools. In the past, a survey regarding the effectiveness of project...
implementation has been performed in the academic years 2015 and 2016 [5]. At the end of the spring semester of the 2017 academic year, a survey was designed to assess whether the pedagogical method was helpful to students’ learning of OSI NMM architecture. We hoped that the survey would help us identify whether the course content was appropriate to students’ learning. In addition, the survey results could be used as guidance to improve the course quality in future classes.

This paper is organized as follows: Section 2 presents the framework designed for the course. Section 3 describes project requirements. We then demonstrate the assessment method, followed by a discussion of results and findings. Finally, we conclude our work in the last section.

Course Framework

In order to help students effectively acquire the knowledge of the models defined in the OSI NMM, we combined four learning techniques as the pedagogical method in the courses: lecture-based learning, lab-based learning, inquiry-based learning, and project-based learning. The lecture-based learning involved the introduction of key concepts and principles of network management to students. In order to provide students with the latest knowledge of network management, we not only presented existing network management models and protocols, but also introduced the most up-to-date techniques and examples in real world scenarios. Exams and quizzes were used to help students review important topics and refresh the knowledge they have learned.

For lab-based learning, hands-on lab activities provided students with the opportunities to practice what they have learned from lecture-based learning. An experimental network environment was created for students conducting lab activities. The environment was implemented in Netlab [6] and incorporated both physical network equipment and multiple VMware [7] virtual machines. In addition, detailed lab manuals were developed to help students carry out their lab activities in a step-by-step fashion [8].

Network management covers a vast array of topics and it is impossible to teach all of them in a single semester. Therefore, inquiry-based learning was used to compensate for the missing part. Articles related to the core aspects of the course were posted weekly. Each student was required to read the article and to leave a comment. The comment included a summary of the article, what the student has learned from the article, and which part of the article could be improved or emphasized.

The project-based learning method required each student to submit a project at the end of the semester. There were two types of projects: a theoretical research project or a hands-on lab project. The theoretical research project involved in-depth research of a specific topic. Students were required to read relevant literature, examine the work, summarize the work, and then comment on the work accordingly. The hands-on lab project involved the investigation of a real-world problem. Students were required to create their own network environments and conduct hand-on experiments. Project-based learning broadened students’ knowledge of network management. In addition, it benefited students’ in the development of their skills of problem-solving and critical thinking. Figure 1 outlines the topics covered in the OSI NMM models and the main learning methods.

Assessment Method

In order to assess the learning outcomes of the course, a survey was distributed for student access on Blackboard at the end of the semester. The survey was designed by using Google Forms, which is free for the usage of creating and analyzing surveys. The question types included Likert response scale, multiple choice, and short answer. The Likert response scale questions were measured on five interval levels. The questions were grouped into seven parts in the survey. Questions from the first to third parts asked students to self-assess their knowledge level in specific subjects and the overall knowledge of the course content before and after they took the course. The fourth part of the survey was given to evaluate the course workload. The fifth part of the survey was concerned with learning objectives and outcome. The sixth part reviewed students’ study habit. Lastly, short questions were asked for students’ comments of the course design. This paper focused on the degree of proficiency in course subjects in the four models of OSI NMM before and after students took the course.
Results and Findings

The survey was conducted in a distance education (DE) class at the end of the spring semester of the 2017 academic year. In order to encourage students to participate in the survey activity, one-point extra credit was added to the final grade for those who successfully completed the survey as incentive. There were 37 students in the class and a total of 31 completed the survey questionnaires that were collected, and resulting in a response rate of 83.8%. The following explores the comparison between the pre- and post-assessment results of students’ knowledge level of OSI NMM models. Table 1 shows the questions in the first and the second parts of the survey.

Table 1. Survey questions regarding OSI NMM models

<table>
<thead>
<tr>
<th>Model</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Organization model</td>
<td>Q1. The degree of proficient in the subject of network management strategies and categories</td>
</tr>
<tr>
<td></td>
<td>Q2. The degree of proficient in the subject of three versions of SNMP</td>
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<td></td>
<td>Q3. The degree of proficient in the subject of network management tools</td>
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<td></td>
<td>Q4. The degree of proficient in the subject of desktop management</td>
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<tr>
<td>2 Information model</td>
<td>Q1. The degree of proficient in the subject of MIB and SMI</td>
</tr>
<tr>
<td></td>
<td>Q2. The degree of proficient in the subject of SNMP operations using MIB browser and command line</td>
</tr>
<tr>
<td></td>
<td>Q3. The degree of proficient in the subject of managing network systems using batches and scripts</td>
</tr>
<tr>
<td>3 Communication model</td>
<td>Q1. The degree of proficient in the subject of events and traps</td>
</tr>
<tr>
<td></td>
<td>Q2. The degree of proficient in the subject of RMON</td>
</tr>
<tr>
<td></td>
<td>Q3. The degree of proficient in the subject of the analysis SNMP messages</td>
</tr>
<tr>
<td>4 Functional model</td>
<td>Q1. The readings helped me broaden my perspectives of enterprise information technology management from different points of view.</td>
</tr>
<tr>
<td></td>
<td>Q2. The reading comment helped me grasp key ideas in the article.</td>
</tr>
<tr>
<td></td>
<td>Q3. The project helped me acquire a deeper understanding of the subject I researched.</td>
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</tbody>
</table>

Figure 1. OSI NMM models
Figure 2 shows the survey results of students’ self-assessment of knowledge level of organization model before and after taking the course. For Q1.3 and Q1.4, the results showed over half of respondents felt that they were comfortable with the use of network and desktop management tools before taking the course. We believed that this was because the course was offered in the senior level; hence students already had more or less experience in the usage of computer networking and information technology tools when they took the course. On the contrary, for Q1.1 and Q1.2 due to the fact that knowledge of network management strategies and categories and three versions of SNMP were not introduced in other courses, most of the respondents revealed that they were not familiar with them before they took the course. Having completed the course, the majority of the respondents responded that their knowledge level of organization model was obviously increased. For Q1.1, the result showed that above good response was increased from 48.4% to 93.5%. For Q1.2, above good response was increased from 32.3% to 90.3%.

Figure 3 illustrates the survey result of students’ self-assessment of knowledge level of information model before and after they took the course. The results of Q2.1 and Q2.2 showed that the respondents had a better understanding in the subjects of MIB, SMI, and SNMP operations compared to the knowledge they had before taking this course. The above good rates jumped from 25.8% to 90.3% and from 16.1% to 87.1% for Q2.1 and Q2.2, respectively. For Q2.3, although the response showed that above good response significantly increased from 25.8% to 71%, there were still 29% of respondents who showed that they were still not confident in using batches and scripts to manage computer networks. We thought this was because our ICT program was more focused on providing students with hands-on practice instead of only offering a few of scripting courses. The results could be improved by introducing more basic concepts relating to various programming languages in courses.
Figure 4 exhibits the survey result of students’ self-assessment of their knowledge level of communication model before and after taking the course. Despite the fact that it was the first time for most of the students to learn about events, traps, RMON, and SNMP message analysis, the respondents demonstrated that they were acquainted with them after taking this course in all of the three questions. The results showed that lecture-based learning and lab-based learning successfully helped students absorb the required knowledge of communication model.

![Figure 4: Students’ self-assessment of knowledge level of communication model](image)

Figure 5 displays the survey result of students’ self-assessment of their knowledge level of the functional model before and after they took the course. In general, the survey revealed that most of the frequent responses to Q4.1 and Q4.2 fell into strongly agreed and agreed categories. Respondents agreed with the reading and reading comments were very helpful for them to broaden their perspectives of network management from different points of view. Compared to the result of Q4.1 and Q4.2, respondents had a lower satisfaction rate (71% above agreed) of the project implementation when answering Q4.3. It indicated that they were not pleased with their final project outcome. In the future, more actions could be taken to help students improve their performance in order to achieve their desired goals. Possible actions include online chatting, classroom discussion, and the use of collaboration tools such as Blackboard’s discussion board.

![Figure 5: Students’ self-assessment of knowledge level of functional model](image)

Three questions regarding students’ overall knowledge of the course content were also asked in the third part of the survey. Q1. Before taking this course, to what extent are you experienced in enterprise information technology management and related issues? Q2. After taking this course, to what extent did this course increase your knowledge of enterprise information technology management and related issues? and Q3. After taking this course, to what extent do you expect to use the knowledge obtained through this course if you became a network administrator in the future? Figure 6 shows the respondents’ knowledge of enterprise information technology management and related issues has increased significantly, from 9.7% above before they took the course to 71% after they took the course. The result also indicated that 74.2% of respondents...
anticipated applying what they have learned in the class if they became a network administrator in the future.

Figure 6. Students’ self-assessment of the overall knowledge level of the course

Conclusions

It is not an easy task to teach network management due to its broad nature, both in theory and in practice. With the aim of providing students with a comprehensive set of skills and knowledge on the subjects of network management, a combination of four learning strategies was proposed in a course: lecture-based learning, lab-based learning, inquiry-based learning, and project-based learning. Both theoretical knowledge and practical skills of OSI NMM were taught with the usage of four pedagogical methods. At the end of the semester, a survey was carried out to evaluate students’ proficiency in the subjects of OSI NMM. The results discovered that the learning strategies achieved a successful outcome. Students have gained a better understanding of the subjects of network management after taking this course.

Bibliography


Biography

TE-SHUN CHOU is an Associate Professor in the Department of Technology Systems at ECU. He received his Bachelor degree in Electronics Engineering at Feng Chia University and both Master’s degree and Doctoral degree in Electrical Engineering at Florida International University. He serves as the program coordinator of the Master program in Network Technology for the Department of Technology Systems and the lead faculty of Digital Communication Systems concentration for the Consortium Universities of the Ph.D. in Technology Management. He is also the point of contact of ECU National Centers of Academic Excellence in Cyber Defense Education (CAE-CDE). Dr. Chou teaches IT related courses, which include network security, network intrusion detection and prevention, wireless communications, and network management. His research interests include machine learning, wireless communications, technology education, and information security, especially in the field of intrusion detection and incident response.