An Implementation of Project-Based Learning for Routing Design Course

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Abstract—This paper describes an implementation of project-based learning in routing design course. The total students who enrolled in the class were 48 and were divided into groups of 3～4 students. At the beginning of the course, a survey was conducted to check the student's level of back ground knowledge acquired from the prerequisite courses. At the end of the curse, we also conducted a survey to evaluate the effect of project-based learning. According to the end of course survey, the course was helpful to identify the problems to solve by themselves, to develop the problem solving ability, and to understand the global picture of the subject by integrating knowledge of each chapter into a project. The survey also shows that students recognized the importance of the teamwork skill throughout the project activity.

Index Terms — Dynamips, Network design, Project-based learning, Routing protocol, Teamwork skill.

I. INTRODUCTION

Problem-based Learning (PBL) is an innovative instructional strategy. It is a pedagogical strategy for posing significant, contextualized, real world situations, and providing resources, guidance, and instruction to students as they develop content knowledge and problem-solving skills [1]. It is a method that encourages independent learning, gives students practice in tackling puzzling situations and help them to define their own gaps in understanding the context of relevant problems. PBL was first introduced at the faculty of medicine, McMaster University in Canada in the mid-1960s. It has subsequently been adopted in many different fields such as nursing, engineering, law, and business but less common in computer science and information technology education [2].

PBL is different from the traditional instructional method. The focus in traditional instructional method is on the context. On the other hand, PBL focuses on the student and the authentic problems. The subject for a PBL activity is the group of students, rather than instructors. The students play major roles in the activities whereas the instructor's role is to facilitate them to the right path and to ensure that the learning objectives are achievable [3]. The objective of the PBL activity is to provide a problem that students have to solve by themselves with instructor's guidance. PBL focuses the students to learn the fundamental principles of the subject in the context of needing it to solve a problem. Students were encouraged and supported in the development of the core skills such as problem solving, critical thinking, communication, information gathering, time management, computing and team-work. Project based learning is a kind of PBL.

Our department had adopted Cisco networking academy program in our regular course since 2003 [4]. The course consists of two basic subjects, one subject for each semester of the sophomore course, and four advanced subjects, one subject for each semester of the junior and senior course respectively. Since 2008, our department has been implementing the accreditation system for engineering education of Korean [5]. In the accreditation system, engineering design is one of important core factors. For the first time in spring semester of 2008, we implemented a network design project in "Network application and Lab 1" subject of the junior course. We put a network design project problem, which had some design constraints, to the class students. But they have to decide or specify other things that had not been mentioned in the project problem, such as scenario, network topology, and network size etc. At the end of the semester, we found that the students had difficulties in integrating individual networking technologies into their project and getting the global picture of the subject.

In this paper, to solve these problems, we tried to implement some part of PBL processes in the same course in Spring Semester 2009.

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For the PBL in the network design class, providing enough network equipment to the students is crucial. However it requires big budget. Network simulator such as Packet Tracer can be used but it is not suitable for advanced network design project due to limited functionality [6]. In this paper, we suggest some economical solution.

In the following chapters, the class descriptions, PBL evaluation and the results, and finally conclusion were described in order.

Ⅱ. CLASS DESCRIPTION

Subject: Network application and Lab 1, an elective course of 3 credits for junior students. Students are expected to have some background knowledge about networking technology. The module description and operational details are summarized in Table 1.

Lab presentation: Clarity of oral presentation, visual presentation, correct approach in analysis, and use of teamwork in presentation. Each 5 points

Design project: Presentation 10 points, report 20 point (report framework and description 10 points, meet the requirements 10 points)

Table 1 Module Description

Module Title	Level	Credit (hour)	# of Students	Mode of Assessment
Network application and lab 1	Junior, undergraduate course (elective)	3(4)	48	Final Exam : 40% Lab presentation : 20% Design project : 30% Attendance : 10%

The object of the subject:

1. Can configure routing protocols on a router and monitor the running status of the router by using some appropriate IOS commands.
2. Can optimize routing update.
3. Acquire some abilities to handle real router.

Actual time that students spent on the PBL scenario was about 4 weeks. The weekly activities for the entire course were summarized in the table 2.

Table 2 Weekly Activities Schedule

Week	Activities
1st	-Survey about student's background knowledge of network. -Introduces the basics of problem based learning. -A tutorial on network emulator Dynamips.
2nd	Chapter 1 : Scalable network design Chapter 2 : Eigrp – part 1
3rd	Chapter 2 : Eigrp – part 2
4th	Chapter 3 : OSPF – part 1
5th	Chapter 3 : OSPF – part 2
6th	Chapter 4 : Router optimization – part 1
7th	Chapter 4 : Router optimization – part 2
8th	Chapter 5 : BGP – part 1
9th	Network design project midterm presentation
10th	Chapter 5 : BGP – part 2
11th	Chapter 6 : IPv6
12th	PBL Group discussion
13th	PBL Group discussion
14th	Network design project final presentation
15th	Final exam.

Class method and structure

To make the students identify required skills and knowledge to carry out the project by themselves, at the beginning of semester, two similar network design problems which include network topology, scenario, and design specification was released. Each team chooses one of the two proposed problems. A sample of the design project problem is shown in Appendix.

Among 15 weeks course period, 4 weeks was assigned for project activities, 1 week for skill test, 1 week for final exam, and other weeks for lab presentation and lectures. Project activities include orientation for the project, mid-term presentation, final presentation, and team discussion. Lecture topics include EIGRP, OSPF, BGP, Routing Optimization techniques, and IPv6.

To get all of the class students involved in the project actively, securing real network equipments such as routers and switches enough to carry out the project in parallel is very important. Because it requires big budget, it is very difficult to carry out team work project with real network equipment. Even though Cisco provides network simulator Packet Tracer, it is not adequate for advance network design project due to limited functionality [6]. Dynamips provide a network lab environment in a PC and do a lab as if using a real network equipments [7]. In the Dynamips environment, users can use real Cisco IOS (Internetwork Operating System), setup network topology, configure the network equipment, verify configurations, and debug networking activities. It would be a good solution to built network lab environment with small budget. Dynamips is just the free software. But it is required to buy Cisco ISO. All students of our class used Dynamips in their PBL project.

III. PBL EVALUATION AND THE RESULTS

At the beginning of the course, a survey was conducted to check the student's level of back ground knowledge acquired from the prerequisite course. Followings are background knowledge survey questions and the results.

Table 3 Background Knowledge Survey

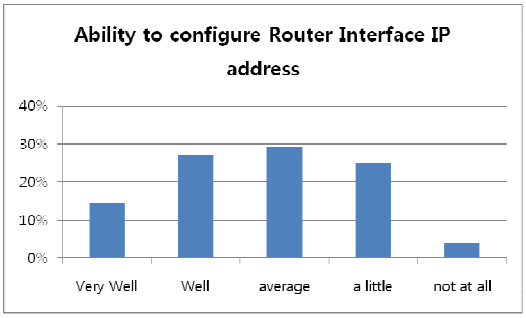
Questions	Yes	No
I can configure IP addresses on a router interfaces	95.8	4.2
I can subnet a major network into subnets to accommodate given number of hosts.	54.2	45.8
I know the procedures of RIP routing protocol configuration on a Cisco router.	29.2	70.8
I can understand the configuration statements of RIP routing protocol	35.4	64.6
I know the procedures of EIGRP routing protocol configuration on a Cisco router.	10.4	89.6
I can understand the configuration statements of EIGRP routing protocol	14.6	85.4
I know the procedures of OSPF routing protocol configuration on a Cisco router.	18.8	81.3
I can understand the configuration statements of OSPF routing protocol	16.7	83.3

Analysis: Almost 96 % of the class students have enough ability to configure IP address on a router interface, and 54% have ability to subnet appropriately to meet required number of hosts. But very small knowledge and low level of configuration abilities for routing protocol, RIP, EIGRP, and OSPF.

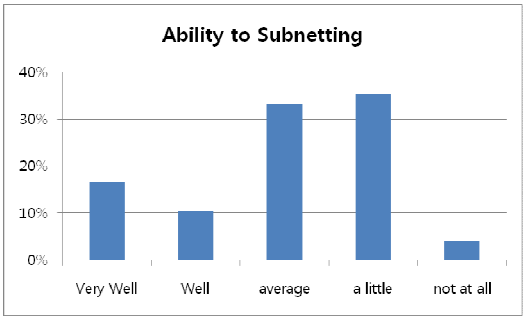
At the end of the curse, we also conducted a survey to evaluate the achievement level of the course. The survey questions are as follows;

1. ~8. Same as the questions of the pre-survey
9. I can understand redistribution.
10. I can configure redistribution on a router.
11. I can understand passive interface, route map, distribution list, and route summary as a network optimization technique.
12. I can apply above optimization techniques of question (11) to a network design.

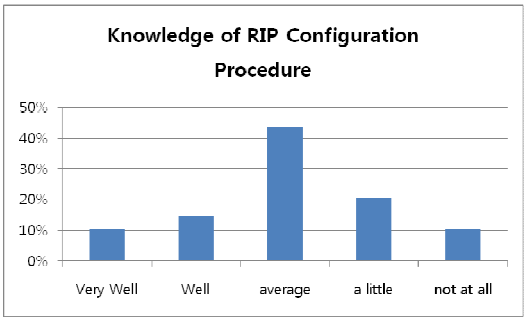
Figure 1 shows the results of survey at the end of the course.



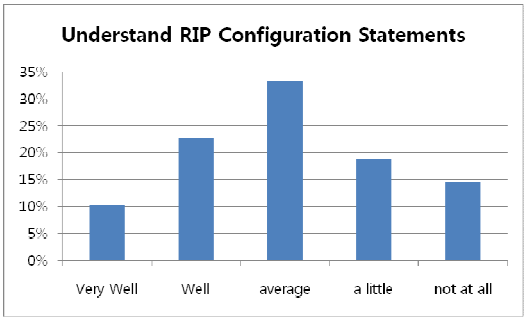
(a) Ability to configure router interface IP address



(b) Ability to subnetting



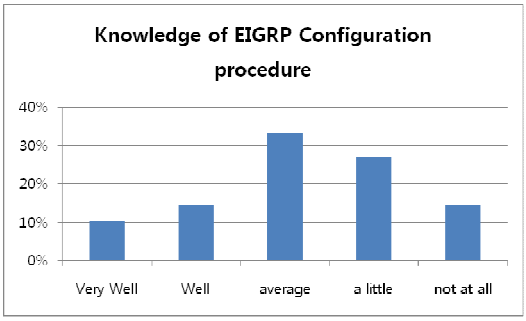
(c) Knowledge of RIP configuration procedure



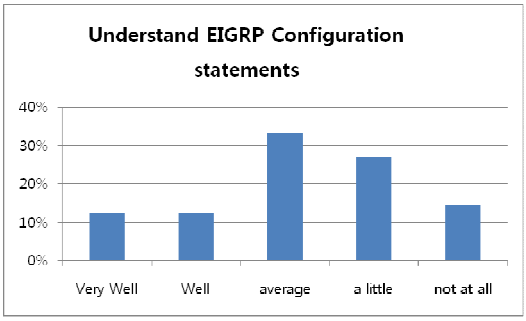
(d) Understand RIP configuration Statements

Figure 1 Results of the survey at the end of the course.

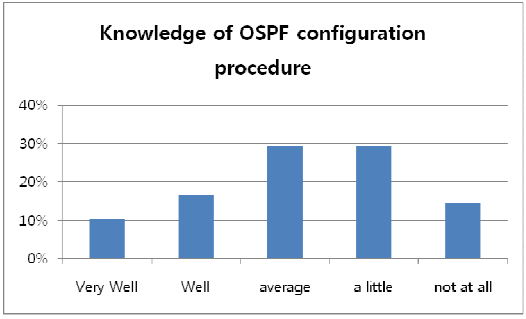
(Figure 1 Continue)



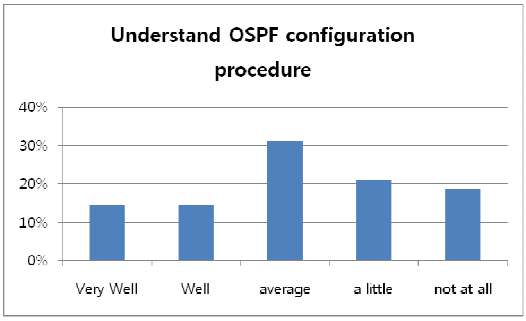
(e) Knowledge of EIGRP configuration procedure



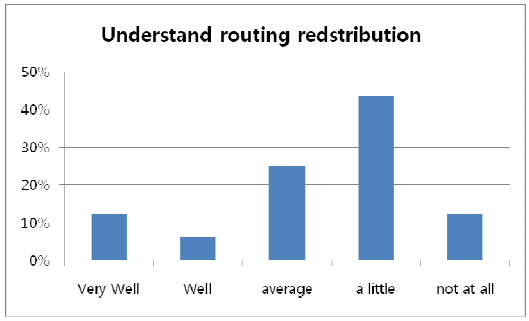
(f) Understand EIGRP configuration statements



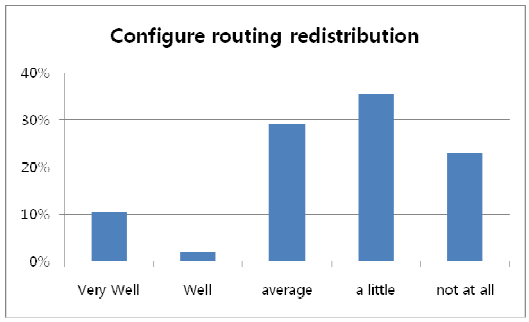
(g) Knowledge of OSPF configuration procedure



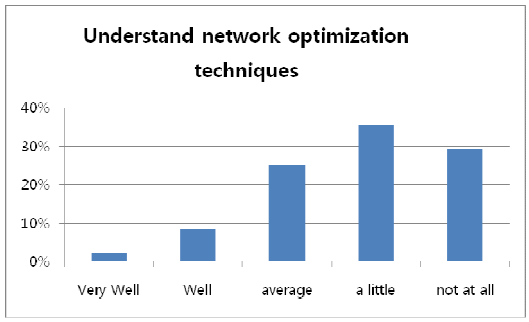
(h) Understand OSPF configuration procedure



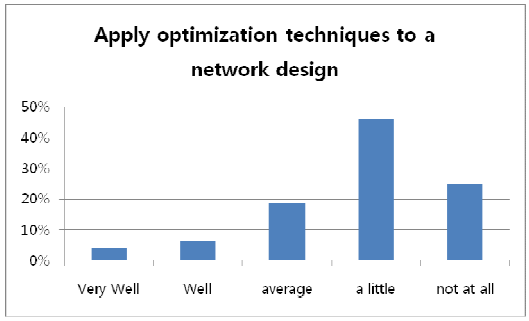
(i) Understand routing redistribution



(j) Configure routing redistribution



(k) Understand network optimization techniques



(l) Apply optimization techniques to a network design

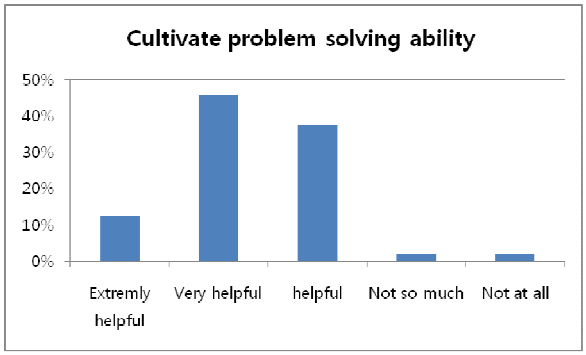
Figure 1 The results of survey at the end of the course.

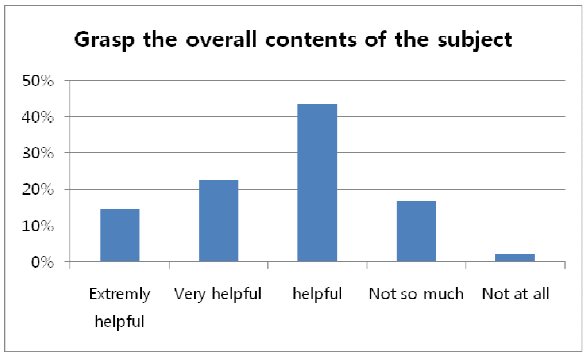
Analysis: For question 1 to 8, 71%, 60%, 69%, 67%, 58%, 58%, 56%, and 60% of the students answered positively (above the average level) which means that they acquired the basic networking skills. For question 9 to 12, 44%, 42%, 35%, and 29% of the students answered positively. Question 9 to 12 is about advanced networking skills. From this survey, we can realize that the achievement level of the basic networking skill is good but that of the advanced skill is very low. Considering the results of the pre-survey, we can say that the students acquired some networking knowledge through this class.

At the end of the curse, we also conducted a survey to evaluate the effectiveness of PBL. The survey questions at the end of the course are as follows;

(1) Was PBL helpful for cultivating problem solving ability?
(2) Was PBL helpful to understand the total contents of the subject by integrating individual knowledge learned weekly into a comprehensive problem?
(3) Was PBL helpful to recognize the importance of teamwork through team project activity?

Figure 2 shows results of the survey. According to the survey, even though the level of the course achievement was a little bit low, students answered that the effectiveness of PBL was good. 97% of the students thought that the course was helpful to identify the problems to study by themselves and to develop the problem solving ability, also 82% of the students thought that the course was helpful to understand the global picture of the subject by integrating knowledge of each chapter into a project. The survey shows that 86% of the students recognized the importance of the team-work throughout the project activity.





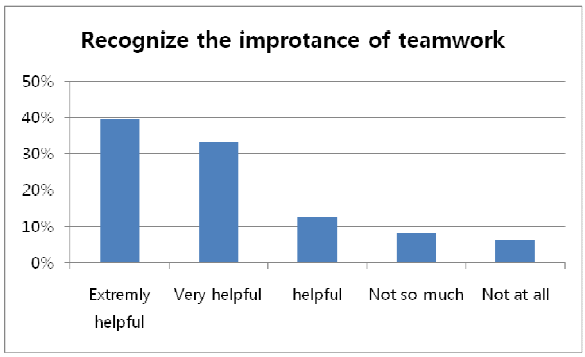


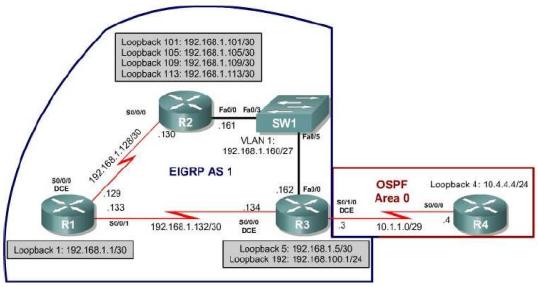
Figure 2 Results of the survey to evaluate the effectiveness of PBL.

IV. CONCLUSION

We implemented problem based learning for a course in “Network application and lab 1” course. At the end of the curse, we conducted two kinds of survey to evaluate the achievement level of the course and the effectiveness of the PBL. In terms of the achievements level of the course, it was a little bit low. But, in terms of the effectiveness, the result was very good. According to the end of course surveys, 97% of the students replied that the course was helpful to identify the problems to study by themselves and to develop the problem solving ability, also 82% of the students replied that the course was helpful to understand the global picture of the subject by integrating knowledge of each chapter into a project. The survey shows that 86% of the students recognized the importance of the team-work skill throughout the project activity. We also suggested a cheap solution to setup network lab environment.

APPENDIX : NETWORK DESIGN PROJECT [8]

1. Topology Diagram



2. Instructions

- Plan, design, and implement the complex International Travel Agency (ITA) EIGRP network based on the above diagram and following specifications.
- Implement the design on the Dynamips/Dynagen Network Emulation Environments.
- Verify that all configurations are operational and functioning according to the guidelines.

3. Scenario and design specifications

The ITA needs its core network set up with EIGRP with the following specifications. It has also recently acquired Local Travel Agency, which was running OSPF. Use the addressing scheme shown in the diagram.

- The ITA core network is running EIGRP in AS 1.
- Summarize the loopback interfaces on R2 with the best possible summary to the other EIGRP routers
- Loopback 192 on R3 represents a connection to the Internet. Originate a default route into EIGRP from R3.
- The Local Travel Agency router, R4, needs to communicate with the ITA core via OSPF area 0.
- Redistribute OSPF into EIGRP.
- Originate a default route into the OSPF process from R3.
- Configure R2 to act as a DHCP server on the Ethernet subnet between R2 and R3.

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