Comparison of Hybrid Project Based Learning and Traditional Learning Techniques in Computer Science Courses

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Approval

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Abstract

In current educational system, traditional method of learning and Project Based Learning are two popular techniques which are widely used by technology focused institutes. Each technique has its own pros and cons. Traditional method has a positive aspect that it can be covered with in limited time and it also cover breadth of course but its negative aspect is that students cannot gets hands on experience in this methodology. On other hand, Project Based Learning gives student hands on experience by practical implementing each concept but the major drawback of PBL is that it goes into more depth which is very difficult to manage in limited semester time. To overcome these issues in both techniques, recently another technique which is called Hybrid Project Based learning (HPBL) is introduced. HPBL is modified form of PBL, along with course projects it also includes some short lectures which help students to give some background knowledge. In this thesis, a detailed comparison between HPBL and traditional method of learning is done. This comparison was done by applying both techniques side by side on Advance Operating Systems course of Masters of Computer Science class in National University of Science and Technology. This thesis also proposed comparison and evaluation methodology. At the end of course, results collected from student's feedback show that more than 80% of students declared HPBL as better approach. HPBL also improved student's grades by 30% as compared to previous class in which traditional learning was applied.

Certificate of Originality

I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any degree or diploma at National University of Sciences & Technology (NUST) School of Electrical Engineering & Computer Science (SEECS) or at any other educational institute, except where due acknowledgement has been made in the thesis. Any contribution made to the research by others, with whom I have worked at NUST SEECS or elsewhere, is explicitly acknowledged in the thesis.

I also declare that the intellectual content of this thesis is the product of my own work, except for the assistance from others in the project's design and conception or in style, presentation and linguistics which has been acknowledged.

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Acknowledgment

Up and above everything all glory to **ALMIGHTY ALLAH**. The Beneficent, The most Merciful and Most Compassionate. It's a great blessing from Almighty Allah that gives me the health and strength to do this research work.

I would like to special thank my supervisor **Dr. Zahid Anwar**, evaluation committee members **Dr. Aamir Shafi**, **Dr. Asad Waqar Malik** and **Mr. Mohsan Jameel** for their guidance. I would like to thank my father for his supportive prayers and my all friends specially **Asma Javaid** who supported me during this research work.

Junaid Riaz

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List of Abbreviations

Abbreviations	Descriptions
PBL	Project Based Learning
HPBL	Hybrid Project Based Learning
OS	Operating Systems
CS	Computer Science
SEEQ	Students Evaluations of Educational Quality

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Chapter 1

INTRODUCTION

A growing need in the Computer Science field for students to practically implement the concepts learned throughout their studies has put an emphasis on the universities to design their programs and courses accordingly. Institutes or schools based on technology are changing their teaching methods in order to help students learn both the theoretical aspects and their practical implementation in industry. In this regard the universities are focusing on designing a new innovative curriculum to make a strong link between teaching a concept and its relevance to industry. HPBL is one of the most effective teaching strategies applied on many engineering and computing courses for teaching high-level technical subjects. This section gives a detailed comparison between the different methods used for teaching students.

1.1 Teaching Methods

There are different teaching methods such as traditional, PBL and Hybrid PBL and each method has its own pros and cons.In this thesis we have done a brief comparison between the two most common methods and evaluated the results on the basis of feedback given by the students. However the results shows that Hybrid Project based learning is better in teaching students as compared to traditional style of learning.

1.1.1 Traditional Learning

Traditional learning has been widely adopted by all universities as it is one of the most common and effective method of teaching students. In this method students were given lectures about the course and then they are expected to solve problems based on the course already taught. Traditional lectures

are not considered as an optimal approach for complex fields where students need to apply their knowledge or practically implement the concepts studied during lectures. It actually does not create any link between the course and its relevance to industry. It limits self-directed learning through which students can gain hands-on experience during their professional life. However traditional method of learning is still being used by many universities because of its effectiveness and ease.

1.1.2 Project Based Learning

PBL refers to either project-based learning or problem-based learning, which is defined as a learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem" [9]. In project based learning the students are presented with the real world problem first and then they will search and solve it on their own. It involves self-directed learning, which helps students to practically implement and search for the problem and came up with a viable solution. It enhances students professional skills such as ability to search on their own, develop a solution, better communication skills, work in a team and self assessment. However instructors find it difficult for students as in this method students were given no lectures and they have very little technical knowledge about the problem given to them. So, the instructors main role is to provide students with required resources, encouraging and motivating.

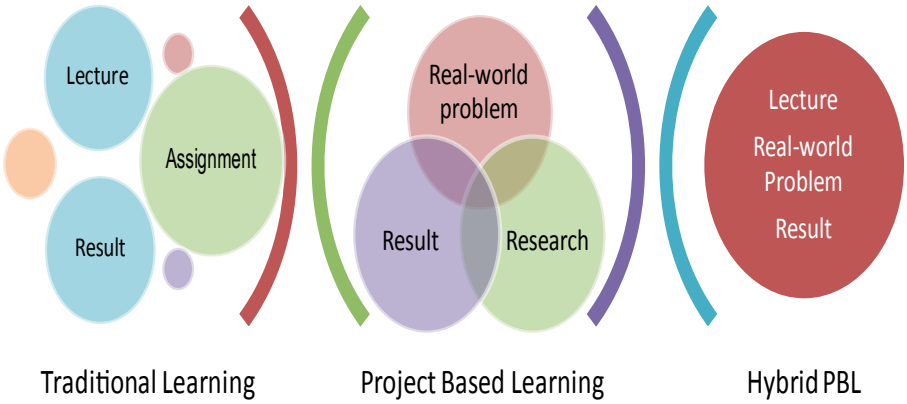

Figure 1.1: Traditional vs Project based learning

1.1.3 Hybrid Project Based Learning

Pure project based learning is an effective method of teaching but it has some disadvantages one is that students remain unaware of the technical knowledge about the topic and they need to search more about it. To overcome this problem a new technique hybrid project based learning has been introduced to provide students a comfortable environment for learning [9]. In this method the students were given some basic knowledge about the content and then they are expected to solve the real world problem. Although the lecture is not in much detail but at least covers the technical content involved in solving that problem. This involves self-directed knowledge as well as discussion with the lecturer. In this thesis we have compared hybrid project based learning to teach operating system course side by side with traditional method of learning. This project involves learning of the tool Valgrind and practical implementation of OS concepts using that tool.

1.1.4 Learning Operating System using Valgrind

Course projects always serve as a powerful tool to solve real world problems. Operating system course helps students to learn thread management and synchronization, instruction handling, scheduling, signal handling, system call handling and vice versa. The main purpose of this project is to implement core concepts of operating system using Valgrind.Valgrind is a debugging and profiling tool that helps students to learn OS concepts as it has rich implementation of OS concepts. It supports more than 10 hardware architectures and is open source.

Valgrind is an instrumentation framework for building dynamic analysis tools. It comes with a set of tools each of which performs some kind of debugging, profiling, or similar task that helps you improve programs. Valgrind's architecture is modular, so new tools can be created easily and without disturbing the existing structure [1]. It can be used for testing memory leaks, multi-threaded application, cache simulation, heap analysis, signal handling, system call handling and scheduling. Valgrind takes control of program before it starts and work directly with the executable. The errors and output is then displayed according to the source code. As the program is controlled by the Valgrind core, it is then handed over to the selected tool for error checking. The tool add its instrumentation and send back the result to the core. Valgrind writes a commentary about the errors which gives user a complete detail about the errors. When the program has errors, they are written to the commentary. Errors are reported before it actually happens. Valgrind can also suppress errors which user do not want to see. There can be more

than one suppression file and we can add or modify it by our own. It consists of following set of tools each of which is used for different kind of debugging (Source: www.valgrind.org [1]):

- Memcheck:It is used for detecting memory errors such as memory leaks, overrunning of heap and stack, overlapping of source and destination pointers, incorrect freeing and double freeing, uninitialized values. Memcheck is the default tool so we do not need to specify it while running.

- Cachegrind: is a cache and branch-prediction profiler. It helps to make programs run faster. Cachegrind simulates how a program interacts with the cache and it is presented for the entire program and for each function in the program.

- Helgrind: is a thread error detector. It helps to make multi-threaded programs more correct.It is used for detecting synchronization errors in threads such as threads creation, thread joining, mutexes (locks) etc.

- Callgrind: is a call-graph generating cache profiler. It has some overlap with Cachegrind, but also gathers some information that Cachegrind does not. It basically records the call history among each function specifying the number of instructions executed, caller/callee relationship, no. of such calls.

- Lackey: Lackey is a sample Valgrind tool that does various kinds of basic program measurement. It is a sample learning tool which can be used to build new tools.

- Massif: is a heap profiler. It helps to make programs use less memory. It measures how much heap memory is used by the program and measure the size of program's stack.

- Nullgrind: It is the simplest possible Valgrind tool. It performs no instrumentation or analysis of a program and is used for debugging and regression testing.

- DRD: is also a thread error detector. It is similar to Helgrind but uses different analysis techniques and so may find different problems.

Valgrind is used for teaching operating system course because of its relevance to OS. As it supports different architecture and is open source, users find it easier to implement the basic concepts of OS and learn through them. It has its own scheduler for scheduling threads, it does not schedule on its

own but ensures that only one thread run at a time. It has complete implementation of signals and is able to handle any POSIX compliant signal. It also helps in implementing different system calls, to handle a system call in Valgrind, developer has to write PRE () and POST () of that system call. The basic mechanism of instruction handling in Valgrind and operating system is same however for fetching and executing instructions special files are used in Valgrind.

1.2 Problem Statement

There are numerous methods of teaching exists including project based learning, traditional learning, e-learning and game based learning which are used by different institutes. Most widely used methods are PBL, HPBL and Traditional. Each of these has its own pros and cons, so a there is a need for a detailed comparison between these which will help institutions to choose most appropriate methodology for teaching.

"Traditional Learning and Hybrid Project Based Learning are two most commonly used methods for teaching and each has its own negative and positive aspects, so there is need of a detailed comparison between these which helps instructors to choose most effective technique for teaching "

1.3 Thesis Contribution

Our research work contributes in evaluation of different teaching methodologies to find out best practices which should be adopted for learning technical courses, teaching using open source projects/tools in higher education and improving educational quality.

All contributions of thesis are summarizing as follows:

- Traditional learning produces large gap of knowledge between students learning and required industrial skill set
- Project Based Learning is a time taking strategy which is not appropriate semester system model of study.
- Hybrid Project based learning is a better alternative for teaching technical courses with respect to time constraints and building up industrial skills set.
- By using of appropriate open source projects students understanding about computer science concepts can be improved.

- Grouped based tasks in HPBL makes students a better Team player and enhance their communication skills.

1.4 Thesis Organization

The rest of the thesis is organized as follows:

Chapter 2 discusses the state of the art related to the current research, and reviews the relevant literature aimed at finding Application of Hybrid Project Based learning or Project Based learning in field of computer science and other engineering disciplines

In Chapter 3, design and architecture including lab handout structure and topic flow of both methodologies are compared and bird eye view of HPBL implementation is also explained.

In Chapter 4, implementation of both methodologies are discussed. This chapter includes tools and technologies used during project is explained. The comparison methodology and side by side comparison of HPBL and Traditional methodology tasks for each topic is also discussed in detail.

In Chapter 5, the students performance and project evaluation feedback results are given along with detailed discussions about grading criteria, students comments and challenges faced during this project.

In Chapter 6, the conclusion and future work is presented.

Chapter 2

LITERATURE REVIEW

Operating system is a core course in advance computer science. It contains very core concepts for basic computational problems. As modern operating systems are becoming more complex, theoretical lectures and theoretical study does not provide sufficient base with respect to implementation of real operating systems. There is a large difference between studying theory of an OS concept and practical implementing it. So, there is need for students that they get hands on practice with implementing learned concepts. There are some instructional Operating systems like Nachos[7], PintOS[16], GeekOS[10], PortOS[3], NachOS based OS System/161[8] has been developed for educational purpose.

PintOS [16] is an instructional Operating System that has been recently developed. It covers following topics:

- multi-threaded programming
- virtual memory
- memory mapped files
- on-demand paging
- simple priority scheduler
- multi-level feedback queue scheduler
- swapping file system
- hierarchy based file system

PintOS kernel runs on bare hardware as well as in simulated environment. Students can develop code on simulated environment and then test that on

bare hardware. In a user study conducted, the assignments were designed in such a way that students were required to study enough amount of PintOS code before writing the code related to tasks. The tasks were group based and designed for groups of 2-4 students. Test cases suite was given to students to intensively check their code. They were encouraged to write their own test cases also. Documentation provided for instructors and teacher assistants was very well detailed. The major drawback of this study is following:

- authors did not compare this approach with traditional learning.
- The low level details of PintOS were also hidden from students.
- There were no lectures given to students to understand background of problem
- they had to understand it on their own.

GeekOS [10] was developed in University of Maryland. It was originally developed as simple bootstrap program for x86 based PC. Students had to select one topic for the whole semester. Following topics were proposed in GeekOS:

- memory allocation
- multi-level scheduling algorithms
- priority scheduler
- implementing a system calls like exec() or fork()
- Inter-process communication using PIPEs and adaptive mutex

This OS executes on bare hardware and low level implementation was exposed to students. Along with proposed topics, students were also encouraged to choose their own topics for example some students developed device drivers for IDE and Ethernet. PBL using GeekOS was applied on Fall 2001 undergraduate class in University of Maryland. Evaluation of this approach and tools used was done by conducting a survey on class of 25 students about complexity of working directly with low level hardware implementations and understanding of concepts. The implementation strategy adopted by authors has following drawbacks:

- Each student has understanding of only one topic
- They do not have understanding about all the topics covered by other students during the semester.

- insufficient breadth of course.

The Raspberry Pi [6] is UK based charity organization founded in 2008 which aims to enhance the education and teaching methodology of adults as well as children particularly in the field of computer science. They have developed a low cost computer around 35$ which provides an environment to learn programming and electronics using PBL. Using this Raspberry Pi small credit cards size computer, Alex Chadwick *et al.* have developed an educational operating system named *"Baking Pi"* [5] based on Raspberry Pi hardware architecture. They also have developed a course [2] about learning and developing a Raspberry Pi basic operating system. The course has 11 lessons which are divided into three categories; OK LED Series, Screen Series and Input Series. In the first series students learn about dealing with OK and ACT LEDS. This includes changing its colors, turning in and off repeatedly and using timers to turn them on/off. Next series focused on graphics aspect of an OS which are line drawing, text drawing and text manipulation using graphics. Input series teaches students about device drivers, receiving input from keyboard and linking programs. These concepts are used to print out input characters on the screen. Students also learn a basic command line interface for an OS. Major drawback of this project is:

- it does not cover advanced concepts (file-system, multi-threading, signals, scheduling) of an OS.

Another research was conducted by David Santos-Martin *et al.* [18] on applying PBL on wind energy course of Master's degree in Electrical, Electronics, and Control Engineering at the University Carlos III of Madrid, Spain. Students were given a project to *find the response of a wind turbine to a grid fault.* Students worked in groups of three for one 15-weeks semester. The topics covered during this semester course were:

- technology overview
- wind resource
- wind farms
- grid codes
- control systems

Students defined their own problem and proposed the solution. The tasks given to students were related to electrical, mechanical, or aerodynamic. They also had to submit a written report and oral presentation at the end of

semester. Assessment of students had been conducted by their performance in labs, written reports and oral presentations. Feedback taken from students showed their experience and interest in PBL applied to wind energy course. The results proved PBL a better approach as compared to old traditional method of teaching this course.

Cappelleri *et al.* [4] applied PBL on robotics course in Mechanical Engineering Department at Stevens Institute of Technology, Hoboken, NJ. The topics covered during this course were the fundamental knowledge and related practical applications of:

- robot manipulator kinematics
- robot manipulator trajectory planning
- motion control
- mobile robot kinematics
- localization
- path planning
- navigation
- hardware/software control architectures
- robot control algorithms.

The course was divided into 10 projects and each project was completed by a team of two students. These projects include:

- Drawing a National Flag
- Build and Light the Torch
- Autonomous Clean and Jerk
- Repetition Challenge
- Sensor-Based Locomotion
- Vision-Based Navigation
- Localization
- Path Planning

- Tele-operation

Final year project include Synchronized Swimming, Robotic Archery and Robo-Soccer Shootout modules. Evaluation was done through a survey which consist of questions and average score(on a scale of 1 to 5)

Mishra *et al.* [13] applied project based learning in Distributed Operating System course in Computer Engineering at the Bhilai Institute of Technology of the University of CSVTU (India). They have used an open source distributed OS name AMOEBA for teaching PBL. The topics covered during the course were:

- Overview of distributed operating system
- Introduction of Omoeba distributed operating system
- The Amoeba System Architecture
- The Amoeba Micro-kernel
- Communication In Amoeba
- Process Management In Amoeba
- Objects And Capabilities In Amoeba

Total 36 Students were divided into 4 to 5 teams and given three tasks to complete in whole semester. First and second task was group based but third one was needed to be completed individually. First task was to write a review paper which given brief introduction about distributed operating systems. Task 2 was to gather software (AMOEBA Mirco Kernel, X-Termnal) and hardware (5 computers with 64MB RAM and 500 MB storage and Ethernet support) required to setup AMOEBA OS. Next task was to setup AMOEBA according to Tanenbaum (1990) on computers of 5 five different CPU architecture which include 68010, NS 32016, 8088, VAX, and PDP-ll. Students performance evaluation was done by two methods. First, students were evaluated on basis of their scientific designs ,reports submitted and quality of overview paper. Second, behavior of while working team and during teaching session was observed. Project evaluation was done by getting feedback from students about their perception toward this type of learning through anonymous questioners.

Perez *et al.* [15] have done comparison between cooperative learning and project based learning by applying these on Operating Systems course of Technical Engineering in Computer Systems degree in *Universidad Politcnica de Madrid*. In cooperative learning, total 60 students worked in small groups

to enhance their own and other's learning. The topics covered during 15 weeks semester were:

- Introduction
- Process and Threads
- Memory Management
- Input/Output
- File Systems

In project based learning students were divided in teams of 4 to 5 students and given a project to compared Windows nd Linux Operating Systems in detail. On other hand in cooperative learning 15 sessions were conducted and in each session a homework was given to teams of 4 students. Homework consisted of following sections:

- learning objectives and skills to be acquired with the homework
- information to be studied
- solving basic problems, developing a simple program or answering some questions

The results of both methodologies were compared by three aspects, one is academic performance of students, students dropout rate and opinion survey.

Chapter 3

DESIGN AND ARCHITECTURE

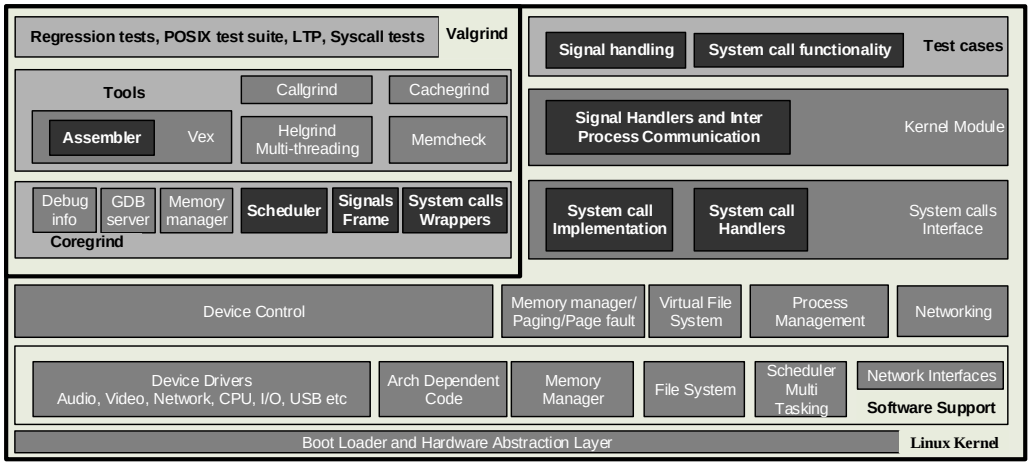

Figure 3.1: Architecture of project

In this section we discuss the design and over all architecture of the project with respect to tools. Basically we have used two major open source tools (x86 based Linux kernel and a dynamic instrumentation tool Valgrind) to apply Hybrid project based learning in Advance Operating Systems course. Figure 3.1 shows the bird eye view of overall sections and architecture. During the entire semester for each lab students read and understand (to some extent) already available support code such as Linux macros, APIs for kernel programming, Valgrind support code for system calls wrappers, similar assembly instructions implementation and signal handling mechanism in Valgrind. After reading sufficient amount of support code and developing a good

understanding of concepts, students attempt to solve the question.

Figure 3.1 explains architecture of project which is split in already implemented support code e.g. device drivers, hardware interface, file system and thread management, test cases, and components created in assignments. Overlapping components indicate when students have to replace parts of the support code.

3.1 HPBL and Traditional Learning flow comparison

3.1.1 HPBL Flow

Figure 3.2 show a typical flow of a topic which is taught through Hybrid Project Based Learning methodology. Once a topic is started instructor gives a brief lecture about topic it can also be in form of class activity which gives students background knowledge. Then students are given with project based lab task. Students have to understand it by example given in handout then do some research on problem. After that students have to implement the main task by using background knowledge and research results. Once implementation is completed two types of evaluation is done. First is by using test case to check the proposed solution. Second, is done by instructor who grade assignment on the bases of functionality of solution, code quality, code efficiency and document quality.

3.1.2 Traditional learning flow

Figure 3.3 shows flow of a topic which is taught through traditional method of learning. In Traditional method teacher gives a detailed lecture on concept of topic which covers all theoretical concepts. All major details are covered in lecture which include in depth theory. Then teacher gives assignment to student which has some question needed be answered related to lecture or a small practical task. Student are required to answer question and submit it to teacher. Then teacher grade on it bases of correctness of answers.

3.1.3 Comparison

A discussed above, HPBL gives background knowledge prior to task which reduce the time needed to understand that task. In contrast, traditional learning provided whole lecture about a bigger concept which may not specific to task. Students have to understand by their own. An other difference

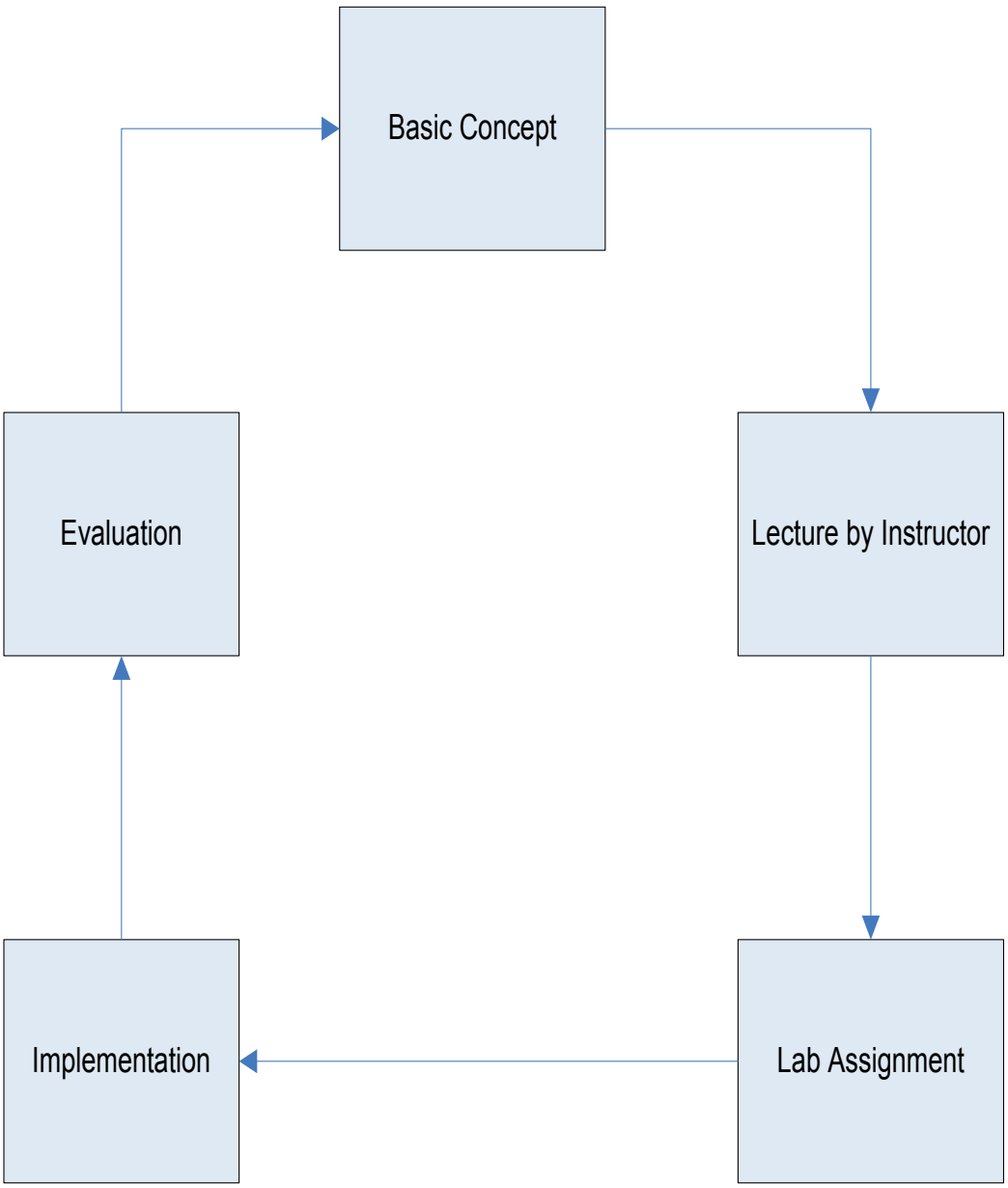

Figure 3.2: HPBL Lab Flow Diagram

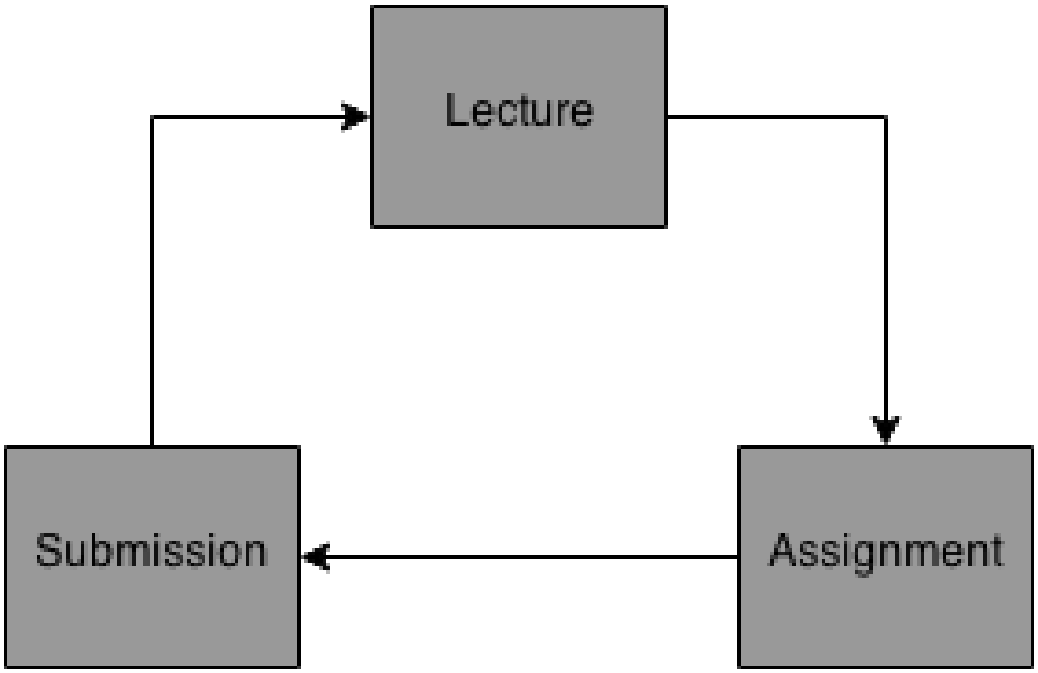

Figure 3.3: Traditional Assignment Flow Diagram

between flows of these two approaches is that in HPBL two types of evaluation is done, one by test cases and other by instructor, on other hand, in traditional learning there are no test cases derived for testing and evaluation by instructor is also limited to checking answers of questions.

3.2 HPBL and Traditional Learning Assignment Structure comparison

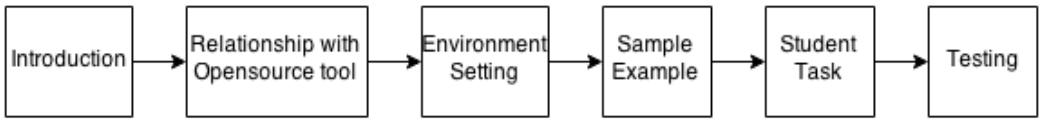

Figure 3.4: HPBL Lab Handout structure

3.2.1 HPBL Lab structure

In hybrid project based learning, the lab handout provided to students extensively guides them to setup the development environment and elaborate with example cases how the support code actually works. Figure 3.4 shows different sections of every HPBL lab handout. First of introduction and basic idea of topic is described then next section explains relation and relevance of topic with the tool in which students are going to implement task. Then next section guide student step by step to setup environment for completing task. Then student task is elaborated with example so that student can understand requirements of task. After that the actual task or problem statement which needed to complete is described and it can be the combination of small tasks. Next section gives details about writing test case to check the implementation.

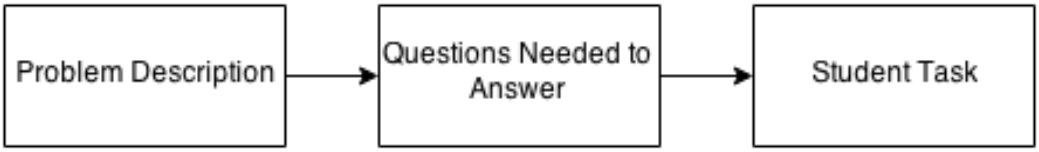

Figure 3.5: Traditional Assignment Structure

3.2.2 Traditional Assignment structure

Figure 3.5 shows the structure of an assignment given to students in traditional learning system. It consists of three part. First part contains some description of the problem. Second part contains some theocratical question which are needed to answered by student. Last part is optional, it contains if any topic specific task is needed to be done by students.

3.2.3 Comparison

When structures of HPBL lab hand out and traditional assignment is compared, there is a large difference between these. HPBL lab hand out is more detailed, self-explanatory, task oriented and guides students on even minor details. On other hand, traditional learning assignments are concise, to the point and gives limits details. The problem description part in traditional learning assignment covers only basic aspects of problem but in HPBL lab handout it gives more detailed background of problem and also relate with it concept with tool being used. In HPBL handout, students are also guided how to setup development environment to complete given task and it also

gives instructions to test implemented solution. Both these parts are missing in traditional assignments.

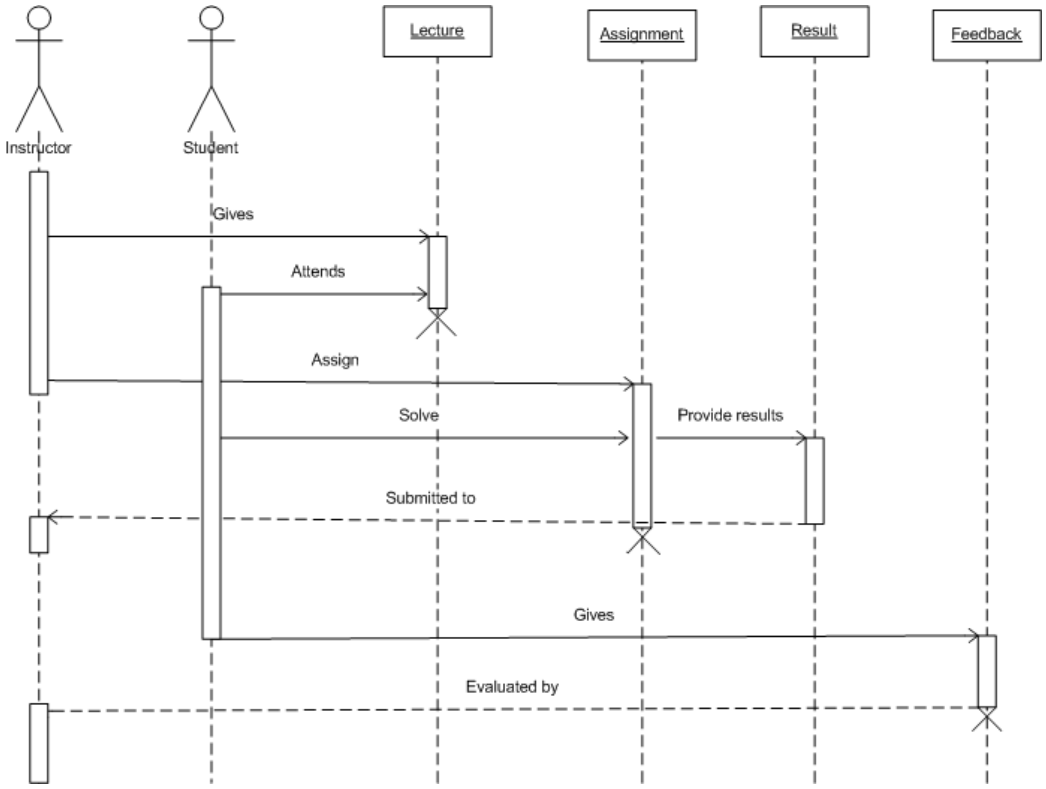

Figure 3.6: Sequence Diagram

Figure 3.6 shows the sequence diagram for the overall process. It clearly shows the role of instructor and student along with the sequence of events. The main components involved are the same as in process diagram but the main difference is that it shows from start to end the sequence in which each the instructor or the student is active. The dotted line denotes the lifeline for objects and actors.

Chapter 4

IMPLEMENTATION

This chapter gives the detail comparison of the lab tasks assigned to students for both the teaching methods. There were 27 students and the hybrid project based learning tasks were performed in groups and traditional learning tasks were individual based. The topics covered in hybrid project based learning and traditional learning are listed out in Table 4.1 and 4.2 respectively.

Table 4.1: Hybrid Project Based Learning Topics

Lab	**HPBL Task**
1	Memory management with Valgrind
2	MIPS Instruction handling in Valgrind
3	Implement a new system call
4	Build a kernel loadable module to implement chat server
5	Scheduling

4.1 Tools and Projects Used

In HPBL labs, we have used Valgrind and Linux Kernel as learning tools. Students have to code in these two projects to complete their lab tasks.

In traditional assignment students have used QTSpim [11] simulator for MIPS related assignments for example assignments related to Interrupts, Bit Manipulation. Spim is a self-contained simulator that runs MIPS32 programs. It reads and executes assembly language programs written for this

Table 4.2: Traditional Learning Topics

Lab	Traditional Task
1	Analysing memory management issues
2	Reverse Bits of decimal in MIPS
3	Using exec and fork to develop menu driven program
4	Use timer and KB interrupts to display text typed
5	Implementing a simple scheduler

processor. Spim also provides a simple debugger and minimal set of operating system services. Spim does not execute binary (compiled) programs.

For other assignments like system calls and scheduling students Linux based OS. All the assignments were needed to be completed by students individually. Students have to submit their assignment solution on student online portal on form of document. All gradings, uploading course material including lectures and lab handout, feedbacks to students were done using online portal [14]. It also provide plagiarism check, auto ranking of students according to obtained marks and discussion forum.

Students also use facebook[17] page for communication with other students and also with instructors in case of any confusion or issue related to assignments. That facebook page also provides a platform for students so that they can propose new ideas or suggestions and all group members and instructors contributed to update group with latest news related to OS.

4.2 Comparison Methodology

To compare our HBPL approach with already existing traditional style of learning we divided the 9 groups into two categories. For example, 4 groups are given HPBL task and 5 are given traditional assignment and these group are then switched on next lab task. By adopting this strategy, we collected feedback from students, about the better learning approach.

4.3 Instruction Handling

4.3.1 Lab Details

This lab is about instruction handling and it is given to 4 groups each having 3 members. The manual clearly explains in detail the instruction handling in OS and Valgrind. In this assignment the students have to access the MIPS Octeon board that is installed in the data centre. Each group has given the login and password to access the board through internet and they can access it from anywhere in the university only. Complete process of installation along with the tools were provided to the students. An example instruction is also implemented during the class activity to help student understand the process. Students were also given introduction about the Assembly language.

4.3.2 Comparison with Traditional Assignment Task

The traditional assignment given to students against *Instruction handling* of HPBL was reverse bits of decimal integer using MIPS assembly. A small program written into MIPS assembly language given to students. Students were required to modify the code so that it can reverse bits of input number then print it on screen. This assignment also introduces SPIM simulator of MIPS for Windows environment. Difficulty level of this assignment was medium according to many students. The learning objective achieved was that student learnt MIPS assembly language and operation on bits. Many aspects of how assembly instructions are handled by CPU and how an OS translate human understandable language into assembly language, was not covered by this assignment.

4.4 System Call Handling

4.4.1 Lab Details

This lab gives students an idea about system call handling. In this lab, student task was to implement a new system call in Linux Kernel which list out currently running processes in system. The lab manual describes the complete mechanism of system call in OS and Valgrind as well.In addition to that students were provided with the steps involved in adding a new system call to Linux kernel and kernel compilation. The assignment was assigned to 5 groups. For this assignment students should have Linux installed on their systems. An example with complete detail is also provided in the manual

for student ease and learning. Despite of that students should know about Linux kernel compilation.

4.4.2 Comparison with Traditional Assignment Task

In traditional assignment students have to write a program using existing *fork* and *exec* system calls to implement a menu driven program that will execute the commend given by user and after completion it asks again from user to input a new command. Learning objective of the assignment was to introduce students to systems calls usage and its working. If we compare this traditional assignment with PBL assignment, in which students have to implement their new system call into Linux using kernel programming skills, there is lack of learned concepts that how a system call is written and how an OS handles it using system call tables. In traditional assignment, student just used already implemented system calls which is not sufficient for grasping details of the whole concept. The difficulty level of this traditional assignment of system calls was low according to students, it was just like any normal programming task.

4.5 Signal Handling

4.5.1 Lab Details

This lab is describing signal/intrrupts handling mechanism in an operating system. In lab handout of this topic, explanation and introduction about types signals in OS and its handling mechanism in operating system and Valgrind is provided to the students. The task of students was to build a Loadable Kernel Module (LKM) which can be used to deliver signals between two processes. They were given instructions about writing a kernel module and its test case with the help of an example. This assignment is given to 4 groups of students and at the end of this lab they have to provide a complete document about their implementation.

4.5.2 Comparison with Traditional Assignment Task

Traditional assignment given in contrast of Signal Handling assignment of PBL, was that students have to interpret existing keyboard and timer interrupts and display the keys typed on screen. Timer was also involved so that it will check if no key is pressed within 15 sec program will halt and show error messages. All coding needs to be completed in MIPS assembly language.

Some support code for polling was given and students have to write code related to timer and keyboard interrupt. Learning objective of this assignment was to enable students to understand how hardware and user programs interact with each other using signals and interrupts. Difficulty level of this assignment was medium to most of students and was high to some students.

4.6 Scheduling

4.6.1 Lab Details

The last lab is about Scheduling in OS and scheduling in PThread library. Students were given brief introduction about Scheduling in OS and Valgrind. They were also given introduction about the tool helgrind that detect thread synchronising errors. The manual also consists of explanation about fair share scheduling and scheduling in Pthread libraries. This assignment is given to all the 9 groups of students.

Chapter 5

RESULTS AND DISCUSSION

This chapter describe students performance evaluation methodology and also discuss results collected from feedback given by students about these two approaches. Performance evaluation of students is done by following three methods:

- First, instructor evaluates the students performance and participation during the lectures
- Second, observations were made about the understanding of students during the teaching sessions on the basis of their assignments and quizzes
- Third, student's perceptions and attitudes towards this sort of learning strategy was gauged through anonymous questioners

5.1 Grading Criteria

In perspective of grading, each lab task was divided into 3 parts which are project report, presentation and class activity. Before assigning the lab task to groups, a class activity was performed to elaborate the purpose of the next assignment and we also take presentations randomly from groups to explain their findings in previous task. The class activity consist of surprise quiz, QA session regarding confusions in concept and feedback from students. Students have to submit their solution in the form of project report which includes implementation, test cases and results. Project report was evaluated on the basis of working code, valid test cases, well documented and well commented code.

Table 5.1: Students Grades

Teaching Method	**HPBL**	**Traditional**
Year	2013	2012
Number of students	27	42
Students scoring A grade	11	5
A grade percentage	41%	11%

5.2 Students Performance Evaluation

Table 5.1 compares the students grades which were scored by class of 2013 (in which HPBL was applied) and class of 2012 (in which traditional learning was applied). It explains the effect of teaching methods on students grade. When the traditional method was applied 11% of students scored A grade while when HPBL was applied 41% scored A. The results show 30% of improvement in the grades.

5.3 Project Evaluation and Feedback

The project evaluation of these two approaches was done by getting feedback from students using anonymous survey questionnaire. The feedback questionnaire was adapted from Students Evaluations of Educational Quality (SEEQ) [12] which is used to asses the teaching-learning and evaluation process. The questionnaire is modification of famous evaluation method Student Evaluation of Educational Quality (SEEQ), proposed by Dr. Herbert W. Marsh. The evaluation questions are divided into following 8 categories:

1. Valgrind as an Educational Resource
2. Learning
3. Enthusiasm
4. Organization
5. Group Interaction
6. Assignments
7. Project Based Learning

8. Overall

Table 5.2: SEEQ Questions

Sr.	Question
1	Is Hybrid project based learning a better approach as compared to traditional method of learning?
2	Do you find project based learning technique practical?
3	Is feedback on examinations/graded materials valuable?
4	Does methods of evaluating student work are fair and appropriate?
5	How does this course compare with other courses you have had?

Figure 5.1 shows the results of feedback taken from students that which approach is more practical and helps to improve the learning experience. The results shows that almost 75% of the students accepted that HPBL was a better approach as compared to traditional learning in terms of learning. As far as practicality of the two approaches was concerned 90% of the students reported that HPBL was more practical as they can practically implement concepts of OS and understand them in comparison to just taking lectures.

5.4 Challenges

Teaching a highly technical subject like Advance Operating Systems, which has a key role in creating a solid understanding of concepts of computing, in a limited time of a semester is a challenging task for instructor. Each topic of OS from memory management to multi-tasking has deep level of details so it is impossible to cover every topic with all details. This is actually the major problem of applying PBL on such technical subject because it goes into more depth and overall breadth of course covered is not satisfactory. In Hybrid Project Based learning, it becomes more difficult for instructor to design labs in such a way which covers all necessary details of each topic that has to be completed by students into limited time and it should not be very difficult for students to grasp, without effecting breadth of overall course.

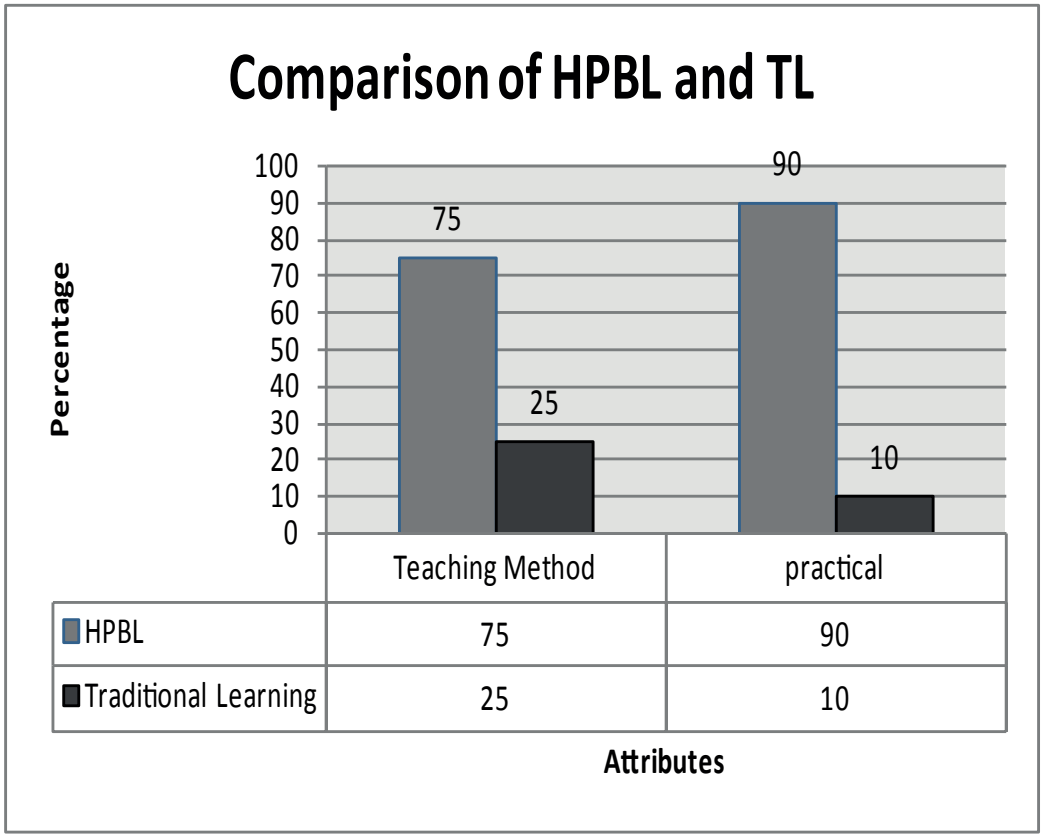

Figure 5.1: Graph shows the comparison of HPBL and Traditional Learning

Chapter 6

CONCLUSION AND FUTURE WORK

This chapter briefly explains conclusion of the over all thesis and it also discuss future directions to extend this work.

6.1 Conclusion

Two very well known techniques for teaching are traditional style of learning and hybrid project based learning. This these discuss the comparison between these two techniques in details by applying these on Operating Systems course for five different OS concepts. These were applied simultaneously and compared side by side. The project evaluation methodology adopted in this project includes students anonymous feedback survey and their performance evaluation.

The feedback from students was showed that hybrid project based learning is more effecting in terms of learning highly technical courses like operating systems. HPBL technique involves intensive practical work which boost up understanding of complex concepts. Students also get hands on experience with industry level projects which also increase their confidence level when they graduated and go to industry for jobs. HPBL has one draw back for instructor that it is challenging for instructor to design labs which maintain complexity and knowledge according to time factor. The students performance results showed 30% improvement in in their grades when HPBL was applied. The feedback taken from students showed that HPBL is better approach than traditional learning in terms of practicality and learning.

6.2 Future Work

There are some other methodologies exist like game based learning, e-learning, problem based learning, cooperative learning and project based learning. In future work, HPBL can be with these techniques to find out which is best technique to teach a technical course. Alternatively, HPBL can be extended to advance topics of OS like file systems, multi threading and device drivers then it can be compared with pure project based learning to find which one better technique.

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