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Effectiveness of Laboratory Categorization for Attaining Program Outcomes at Undergraduate Level

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Abstract: The effectiveness of engineering education depends on the teaching and learning process adapted by the faculty and students. Lot of research is going on to effectively educate the undergraduate students, among that one of the methodology which we have followed is to categorize lab experiments as Exercise, Enquiry based and Open Ended learning. In the proposed paper a background study is carried out on how to develop problem solving, thinking and analysis skills among students and more importantly most of the students face difficulty in applying the concepts for developing applications or projects. Hence considering the above facts we carried out a study to bridge this gap with a novel approach of categorization. This practice was carried out on Distributed and cloud computing lab (DCC) as a case study for Information science and Engineering students of final year. A new technique to measure the effectiveness of students learning in DCC lab based on program outcome attainment for engineering laboratory education and affordances of the pedagogical features of the lab. The results interpret that the novel approach adopted has improved performance of students as compared to the traditional learning methods.

Keywords: DCC, Categorization, Cloud lab, PO, PI attainment

1. Introduction

Engineering is a practicing profession, a profession devoted to harnessing and modifying the three fundamental resources that humankind has available for the creation of all technology: energy, materials, and information. The overall goal of engineering education is to prepare students to practice engineering principles. Thus, the conventional engineering education focuses more on theoretical aspects rather than allowing students to practice the studied concept which enhances their learning skill. Earlier it was difficult to measure the learning outcome of students as the written exams were the only way to measure students performance and it was difficult to measure the learning skills of students as major focus is on Blooms Level 1, 2(L1 and L2) so to attain higher Blooms Level more attention has been paid to redesign curriculum and teaching methodology. A survey was carried out on

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courses which has associated laboratories so that it's easy to distinguish among any engineering laboratories into development, research, and educational [2]. Considering these facts in mind, mapping of lab experiments with the associated laboratories to program educational outcomes (PEO). To address these PEO's a criterion was framed which evaluates each program using both qualitative and quantitative approach [7].

Emphasis on learning outcomes:

Outcome Based Education (OBE) is a system that emphasis on outcomes measurement rather than inputs of curriculum covered. Outcomes may include a range of knowledge, skills and attitudes. In order to obtain the desired outcomes, teaching components and activities should be well organized, planned and continuously improved. To achieve these outcomes the course should map to the defined program educational objectives (PEO) w.r.t our department, the below table 1 illustrates the PEO's and the mapping of these PEO's to PO's.

In order to evolve from a conventional approach to further improve the education, Learning outcomes are the means to measure the learnability of the students. So the main objective of this paper is to enhance their learning skills through the use of effective learning techniques in the design of this DCC lab course [1].

2. Process and Planning

The Following are the defined PEO's for Information Science and Engineering department

Program Educational Objectives (PEO):

1. Have a strong foundation and ability to apply the knowledge of mathematics, computer and information science, engineering, modern tools and humanities to successfully design, develop and maintain computer based systems and processes dynamically to meet customer business objectives.
2. Have a broad based background to practice information science engineering in the fields of data engineering, system engineering, network engineering and software engineering.
3. Have an understanding of the professional, ethical and legal responsibilities of the engineer with awareness of contemporary issues, impact of technology on society and the need for lifelong learning.
4. Have an ability to participate in team oriented, open-ended activities that prepare them to work in integrated engineering environment and communicate effectively using modern tools.
5. Pursue successful career path in higher education, research development and add value to the organization.

Table 1: Mapping of PEO to PO

Program Outcomes (PO)	PEO 1	PEO 2	PEO 3	PEO 4	PEO 5
Engineering knowledge: Apply the knowledge of mathematics, science and engineering fundamentals for the solution of complex engineering problems.	√				
Problem Analysis: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.		√			
Design / Development of Solutions: Design/development of solutions: Design solutions for complex engineering problems and design system compo nents or processes that meet the specified needs with appropriate consideration for public health and cultural, societal, and environmental considerations.				√	
Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern en gineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.				√	
Communication: Communicate effectively on complex engineering activities with the engineering community and with t he society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions			√		

Students enrolled for information science and engineering stream, are expected to acquire these PEO's at the end of their four year of studies through registering various courses offered in each semester. Hence to achieve these PEO a laboratory course was redesigned and the experiments were categorized into four categories Demonstration, Exercise, Structured Enquiry and Open Ended Experiment [5]. With this

Distributed and cloud computing laboratory was framed to address the PEO's as shown in above table 1. The main objective of designing the lab was to enhance problem solving, thinking and analysis skills of students. We had found that most of the students are good at theoretical knowledge but they lack in implementation so to overcome this lab experiments were categorized. A common guidelines were designed to conduct the experiments planned at department level and are illustrated as shown in table 2.

Table 2: Categorization of Laboratory

Types of laboratory work	Given or open			
	Aim	Material	Method	Answer
Demonstration	Given	Given	Given	Given
Exercise	Given	Given	Given	Open
Structured Enquiry The	Given	Given	Open	Open
Open Ended Enquiry	Given	Open	Open	Open

table 2 describes the categorization process where all the lab experiments will fall under one of these categories, with this approach of categorization students problem solving and thinking skills will enhance. By conducting structured enquiry process there is scope for students to think and analyze different methods to solve a given problem. It also integrates the study of engineering analysis, design, and engineering systems for a professional background to stimulate creative thinking in basic sciences. The Categorization of experiments was introduced to develop the real time social problems and to serve the needs of the society and for integration of work and ideas in humanities into engineering programs [7].

3. Laboratory Teaching and Learning Model

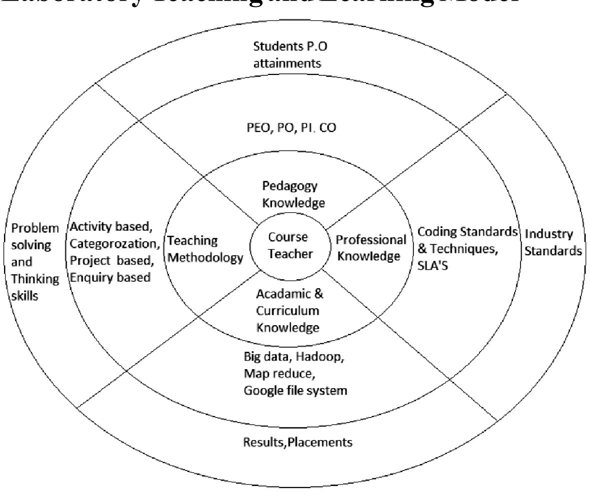

Fig. 1 Spiral Model for Teaching and Learning Process

Spiral model for teaching and learning process involves interactive teaching methodologies with different steps and goals. There are many modern theories for teaching and learning, they generally include cognitive styles and strategies, multi-intelligence, critical and creative thinking, cooperative learning, interactive learning. New circumstances create new learning experience which is more student-active, self-conscious and creative. According to the study, using active teaching models is considered as teachers' skill and ability [6]. It is the teacher's ability to perform these models and change instruction to growing setting. The spiral learning model, as an active instructional model, intends to promote teaching and learning method, to achieve better learning and enhance student's problem solving skills.

DCC Lab Experiment Categorization:

The table 3 describes the categorization of experiments which we followed for the Distributed and cloud computing lab [12].

Table 3: Categorization of Lab Experiments

Experiment Type	Learning Outcome	BL	PI
Demonstration			
Hypervisors(Type 1 & Type 2)	Demonstrate the ability to create, customize and run guest machines on hypervisor.	L3	1.4.1
Virtual Machines with Para and Full virtualization	Create and Run guest machines on para and full virtulization environment	L3	1.4.1 2.2.4
Exercise			
Instance building using IaaS, PaaS, SaaS	Analyze the design and architecture of cloud deployment models.	L4	1.4.1 2.1.1 2.1.2 5.2.1
Private Cloud setup	Configure the operations/procedures required to setup private cloud environment	L4	1.4.1 2.1.1 2.1.2 2.2.4
Structured Enquiry			
Aneka Ma nagement Studio	Developing Task Model, thread model and MapReduce Applications using Aneka Management studio	L4	1.4.1 2.1.2 2.2.4 5.2.1 10.3.1
Aneka Management Studio	Implement data and compute intensive applications on infrastructure using various programming models.	L4	1.4.1 2.1.1 2.1.2 2.2.4 5.2.1
VMware online Hands-on Lab (HOL)	Conduct various experiments in a tested and documented lab environment using HOL	L3	1.4.1 2.1.2 2.2.4
Open Ended Enquiry			
Development of Secure Cloud Based Application	Design and develop secure applications best suited for various cloud delivery models.	L4	1.4.1 2.1.1 2.1.2 2.3.1 5.2.1 10.3.1

Conventional teaching practice focuses on predefined set of experiments with the defined procedure to carry out the given task, all the students use to get the same set of problem statements and the method of solving those problems will also be fixed, due to this only few students use to solve the given problem and remaining students copy the solutions. Hence plagiarism was found in the submitted report and there was less scope for enhancing student learning, thinking and analysis skills. The lab categorization practice enhances the student's problem solving skills and it eliminates plagiarism. Thus Students will be able to identify different methods to solve the given problem with varied input and outputs [3].

The table 3 illustrates the categorization of lab experiments, Blooms Level (BL) and Performance Indicator (PI). In the demonstration category the teacher's role is to explain and correlate the concepts and techniques related to cloud services and deployment models mapping to real world applications. Exercise involves given a problem statement, students need to identify the method/techniques to solve the problem in which the aim and methods of given problem is fixed and the answer is open. In structured enquiry approach the aim is fixed and the students need to choose appropriate technique to find the solution for problem. The solution varies from student to students depending on the technique which they choose to attain the required results [4]. Open ended experiment in a broader way problem statements are set, students will have the freedom to search the required material and identify the required technique to come up with optimized solution.

5. Case Study: Distributed and Cloud Computing Lab

Over the past three decades, distributed and cloud computing has emerged as a well-developed field in computer science and information technology. Cloud computing lab integrates computing theories and information technologies with the design, programming, and application of distributed and cloud systems. It covers programming, and the use of distributed or cloud systems in innovative Internet applications. With double-digit growth predicted in industry, our graduates need to learn distributed and cloud computing to successfully enter the workforce.

Lab Conduction Process:

The Lab Experiment and the conduction process were designed to bridge the gap of problem solving, thinking and analysis skills of students. The major focus was to make understand different paradigms of computing, hypervisor and service oriented architecture, programming environment, network based computing models. The lab experiments focused on implementation and hands on experience on cloud technologies and trends. And to overcome the plagiarism problem each batch of students were given with a set of problem statement and expected to come up with multiple approach of finding the solution to the given problems.

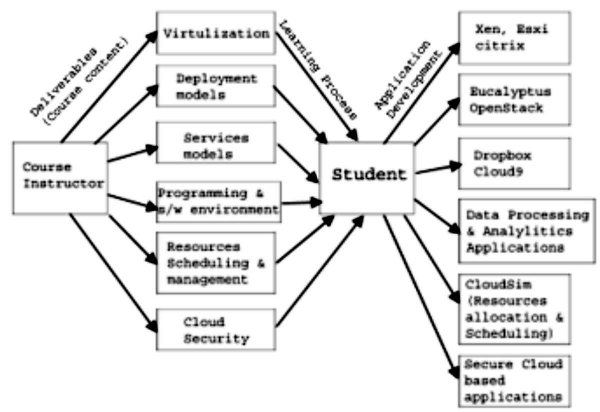

Fig. 2 DCC Lab Conduction Process

The lab conduction process is illustrated in figure 2. According to that the following course outcomes were defined:

i. Demonstrate the ability to create, customize and run guest machines on hypervisor
ii. Analyze the design and architecture of cloud deployment models
iii. Implement data and compute intensive applications on infrastructure using various programming models.
iv. Design and develop secure applications best suited for various cloud delivery models.

Lab Evaluation Rubrics:

The table 4 describes the evaluation parameters where each experiment is mapped to specific Program Outcome (PO) and Performance Indicator (PI). CIE was conducted for 80 Marks and SEE exam for 20 Marks.

Table 4: Lab Evaluation Parameters

Categorization	Rubric Parameters	Marks	PO	PI
Demonstration	Hypervisor :Type I & Type II	Nil	1	1.4.1
	Para and Full Virtulization	Nil	1	1.4.1
Exercise	IaaS: Instance selection & Deployment	10	1 2	1.4.1 2.2.4
	PaaS: Platform Selection & Deployment	10	1 2	1.4.1 2.2.4
	SaaS: Sub version & QoS Parameters.	10	1 2	1.4.1 2.2.4
Structured Enquiry	Design, Impleme nt & Execute multi -threaded ,MapReduce Programs on Aneka Management studio	30	1 2 5 10	1.4.1 2.1.2 2.2.4 5.2.1 10.3.1
Open Ended Experiment	Integrated with theory course of cloud computing Categorization	20	1 2 10	1.4.1 2.1.2 2.2.4 10.3.1

5. Results and Discussions

The figure 3 shows the PI attainment analysis graph, the lab categorization approach helped us to attain the program outcomes in efficient way. Attainment of PI confirms that students learning, problem solving and analysis skills have enhanced.

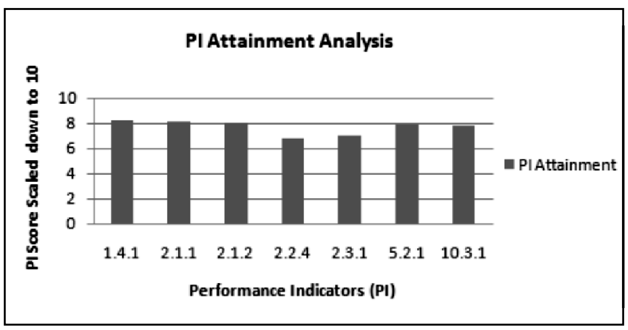

Fig. 3 PI Attainment

Result Analysis:

The CIE was conducted for 80 marks and result analysis is carried out to measure the students learning and outcome attainment. The figure 4 interprets the CIE result analysis for the academic year 2014-15 and 2015-16. From the results analysis it clearly depicts that there is improvement in student's performance from grade A to S 15%, from B to A 8%, from C to B 20%.

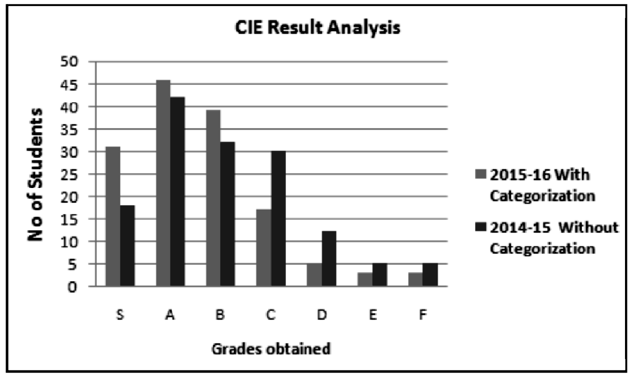

Fig. 4 CIE Result Analysis

The SEE was conducted for 20 marks, The figure 5 interprets the SEE result analysis, different types of problems with higher blooms level encouraged more number of students involvement and can be measured in student's result performance from grade D to C 15%, from C to B 24%, from B to A 46% and from A to S 20%.

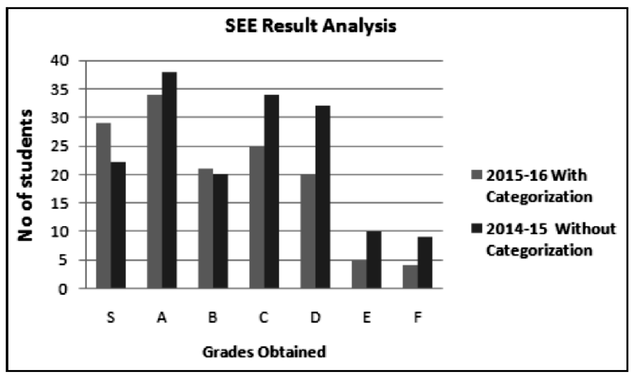

Fig. 5 SEE Result Analysis

Performance and Achievements:

Student's extents of achievement for achieving the outcomes were measured by their performance in CIE and SEE exams. The figure 4 & 5 shows clearly shows the improvements in student learning which we can confirm by the effective attainment of performance indicators [13].

The following are the advantages of lab categorization:

1. During CIE student's evaluation was transparent for each batch and different set of problem statement were given to avoid plagiarism.
2. Evaluation was carried out in detailed which led to better performance of the students.

3. Students problem solving and enquiry based learning skills were enhanced which led in shifting of grades from A to S and from B to A.
4. This approach helped them to perform better in their placements and capstone project.
5. By practicing this approach students gained lifelong learning skills.

Feedback Analysis:

A feedback survey was conducted with a following set of questions the figure 4 illustrates the feedback analysis this will help us to effectively design the course and plan for improvements.

Feedback Questionnaires:

1. Do you find course content is in-line with the current trends and technologies?
2. Did the course instructor stimulate you to think beyond the syllabus and you were able to explore new technologies?
3. Did Lab experiments brought awareness of different cloud service and deployment models which are used by industries?
4. Did lab categorization approach helped in understanding the concepts in better way?
5. Do you feel structured enquiry and open ended experiments helped to enhance your problem solving and analysis skills?

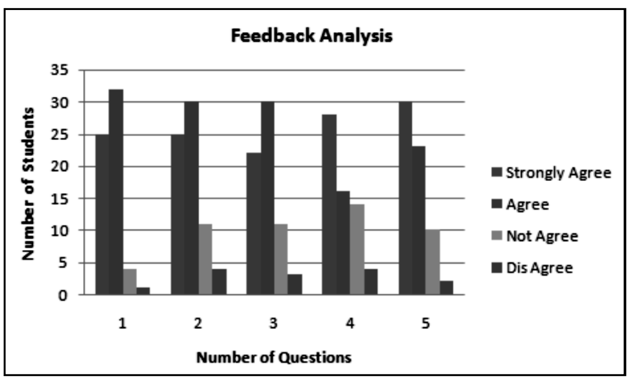

Fig. 5 Feedback Analysis

6. Conclusion

Lab categorization approach helped in attaining the program outcomes and enhanced student performance which we can confirm through CIE and SEE result analysis. The overall conduction of the lab was clearly appreciated by the students which can be interpreted through feedback analysis. This categorization approach enhanced problem solving, thinking and analysis skills of students and in turn helped to perform better in their placements, Capstone project and engaged in lifelong learning skills. This approach resulted in better performance and it stimulated course instructor to design lab experiments mapping to the current IT Industry needs.

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