Enriching Curriculum Through Laboratory Courses for Technology-Enhanced Learning

Arati S. Phadke
Department of Electronics Engineering,
K J Somaiya College of Engineering,
Mumbai, India
aratiphadke@somaiya.edu

Sangeeta S. Kulkarni
Department of Electronics & telecommunication Engineering,
K J Somaiya College of Engineering
Mumbai, India
sangeetakulkarni@somaiya.edu

Abstract—**Experiences in laboratory continue to be an important aspect of engineering education. Laboratory plays very vital role in acquiring technical skills which are most needed in professional career. Traditionally learning from theory courses are supplemented by laboratory for verification and conceptual understanding. However, the reduced focus on laboratory work in terms of credits assigned and the mundane nature of laboratory instruction in the curriculum result into dwindling level of student interest. Considering penetration of IT in all engineering branches, every engineer must be equipped with basic IT background which enhances employability and enables him to keep pace with technology. The purpose of this paper is to share experience of focused laboratory learning environment introduced in curriculum of an autonomous self-financed college. The curriculum for laboratory courses is designed for exposure to advanced technology and hands-on experience which can result into professional development of a graduate. One cycle of implementation and responses of stakeholders show encouraging results.**

Keywords—engineering education, learning outcomes, laboratory learning, curriculum design

I. Introduction

Since 1983 engineering laboratory courses is a concern of study for researchers and it is interesting to compare fundamental objectives to the "roles" defined by Edward Ernst in his paper [1]. In his opinion, laboratory can be a place for the student to learn new and developing subject matter and laboratory courses help the student to gain insight and understanding of the real world. Basically, the student should learn how to be an experimenter.

Engineering is a practice-oriented profession and for creating applications useful for mankind, it has been deemed essential to develop the physical world interface in the laboratory [2][3].

Generally, working in laboratory encourages students for creative learning and arouses curiosity in them [4]

Researchers have also worked on Project based learning with encouraging results [8]; however implementing PBL approach for large number of students would require infrastructure support and preparation of faculty members. Hence as a first step laboratory courses were introduced in curriculum.

Teaching and Learning in Laboratory motivates students to learn by relating theory to practice and deepen the understanding. It also gives an opportunity to work together in team for analysis and solution of engineering problem and develop attitude and skill for operating effectively in engineering workplace. [7]

Traditionally in engineering, often concepts taught through lectures are complemented by laboratory experiments which are critical to enable learners to further develop their knowledge and skills. Student participation, however, in these laboratory based courses has been largely disappointing, either due to their disinterest or due to lack of sufficient motivation [5] [6]. Root cause analysis traces to the lack of clarity of learning objectives as well as suitable facilitation in terms of appropriate pedagogy of laboratory instructions [5].

This paper discusses the process and experience of designing laboratory courses in curriculum of an autonomous self-financed college affiliated to University of Mumbai. The designed courses were implemented for two degree programs of Electronics Engineering (ETRX) and Electronics and Telecommunication Engineering (EXTC) with intake capacity of 140 students each. Section II discusses the motivation to add special laboratory courses in the curriculum to help students attain graduate attributes. Section III describes the steps followed for identification of laboratory objectives and curriculum design. Section IV presents the implementation of laboratory courses for first batch of students in semester III , IV, V, and VII, followed by students' responses and discussion in Section V.

II. Motivation

In University curriculum of Electronics Engineering theory courses are associated with laboratory component, but the weightage for assessment of laboratory work is very less as compared to theory. It also restricts the scope for experimentation and opportunity for self-learning. As a result, learner gives least importance to the laboratory part and is deprived from the experience of "learning by doing".

From our experience, it is felt that at least in some courses understanding by experimentation or practice is more important than writing theory examination. The inputs

978-1-7281-1143-8/18/$31.00 ©2018 IEEE
DOI 10.1109/T4E.2018.00032

from alumni and industry experts/ recruiters emphasizes on modern IT capabilities of graduating students for better employability.

Hence efforts are taken for inclusion of laboratory courses in curriculum wherein opportunity for hands-on experience, exposure to latest technology is created.

III. Curriculum Design for Laboratory Courses

A. Defining Laboratory Objectives (LO)

Following objectives are kept in mind while deciding the laboratory courses.

- LO1: Learning by doing: Students can experiment and verify concepts learnt in theory .The experiments can be hardware based or simulation experiments. This enables graduates to analyse given problem and develop experiments.

- LO2: Usage of appropriate Instrumentation: Students learn to apply appropriate sensors, instrumentation, and/or software tools to make measurements of physical quantities. The graduates get an insight of availability resources selection of appropriate one for the designed experiment.

- LO3: Usage of Modern Tools: Students learn to select, and apply appropriate techniques, resources, and modern engineering and IT tools with an understanding of the limitations.

- LO4: Design of Electronic System: Students learn to design, build, or assemble a part, or system; to use of specific methodologies, equipment, or materials; to develop system specifications from requirements; and to test and debug a system. This helps to gain insight to real world problems and enhances students' curiosity.

- LO5: Developing self-learning skills: Students learn concepts by using study material on their own while experimenting. Students are free to discover relevant literature and choose appropriate methods of completing the task in the laboratory.

- LO6: Teamwork: Students learn to work as a team for exploring relevant literature and methodology, completing the task in the laboratory, and development of mini projects.

- LO7: Communication: Students learn to communicate orally and in writing about interpretation of laboratory results, to write reports effectively.

B. Identification of suitable laboratory courses

Curriculum design was based on fundamental, core and thrust areas of Electronics Engineering. In the process, when a survey was conducted for the purpose of curriculum design, faculty members, alumni and students suggested that some courses can be introduced only as laboratory courses wherein the focus will be on learning through experimentation. Some of the laboratory courses are introduced to make the learner employable in areas where opportunities are available presently due to penetration of IT in all branches of Engineering. Some other courses in which students will get breadth of knowledge in technology or tools which are useful for project development. Theoretical treatment of such courses fails to cover the aspect of development of an application.

The curriculum also contains traditional laboratories based on theory courses.

Table I gives a list of special laboratory courses introduced in KJSCE syllabus.

C. Conduction and Evaluation

The laboratory course is conducted batch wise and allotted time duration of 2 hours per week Students work is evaluated continuously with the help of rubrics developed which may include parameters like understanding, contribution, skills developed, report writing. Case study / Mini Projects are also included as part of laboratory work.

For some courses there is one hour theory session for familiarization with technology or design methodology etc. In all laboratory courses manuals and study material are made available for reference.

Some of the laboratories have in semester practice test to ensure that they are learning the concepts. End semester examination is based on practical which is conducted by pair of faculty members in the subject area.

D. Feedback

At the end of every laboratory course feedback is taken from all students. The questionnaire is with focus of assessing outcomes defined for the course and suggestions in content delivery. The questionnaire is administered through Google form. The students are given two week duration for completion of the survey. They complete the survey individually without any bias of peer or faculty. The inputs from students help to identify gaps and improvise the course in next cycle.

A Feedback from final year students who have completed all courses is taken at the end of their graduation.

Also feedback from recruiter is taken at the time of placements after their aptitude test and interviews.

IV. Experience Gathered

The designed curriculum is implemented from 2015-16 for second year and progressively for the same batch of students.

A. Experience of faculty members

The opinion of faculty members who have conducted such laboratory courses is collected through interviews,

- Students devote more time to assigned work and concepts are better understood in laboratory courses.
- Each student learns at least to some extent in regular laboratory sessions; as against in theory course.
- Skills learnt through laboratory courses are found to be useful while working on projects in higher semesters

TABLE I. LIST OF LABORATORY COURSES IDENTIFIED.

Laboratory Course Name	Semester / Branch	Description	Laboratory Objectives
Object Oriented Programming (OOPM)	III ETRX, III EXTC	This course is basically enabling students to use basic object oriented approach and C++/ Java constructs. This would help them in thinking of Object Oriented Methodology and equip them for Industry needs. Experiments are conducted which include concepts of class, object, constructor, functions, inheritance, overloading, polymorphism, virtual function, file handling etc.	LO3, LO4, LO5,LO6, LO7
Hardware Description Language (HDL)	IV ETRX, IV EXTC	In this course students use power and features of HDL for writing codes for combinational and sequential circuits. They debug, Test and simulate their codes and also implement the design on CPLD/FPGA to create small applications.	LO1, LO3, LO4, LO5, LO6, LO7
Software Simulation Workshop (SSL)	IV EXTC	Students are introduced to simulation software like MATLAB, TARGET etc. to simulate Analog Circuits, to visualize concepts in Signals and Systems, Control System and Wave Theory.	LO1,LO3, LO5,LO6, LO7
Electronic Instrumentation(EIL)	IV EXTC	This course enables students to use various electronic instruments for measurement of electronic parameters; use appropriate transducer and do error analysis; and develop application using sensor and signal conditioning methods.	LO1, LO2, LO4, LO5, LO6, LO7
Data Structures And Algorithms (DSA)	IV ETRX, V EXTC	Students use their programming skills to learn and select different data structures for the given application; analyze the performance, space and time complexity, of basic algorithms using various notations.	LO3, LO4, LO5,LO6, LO7
Micro-controllers Laboratory (MCL)	V ETRX VI EXTC	This course enables students to program microcontrollers to meet the requirements of a system. They learn to use features like I/O interfacing, Timers, ADC/DAC etc. which are essential for development of application. Students use variety of platforms like 8051, PIC, ARM family. To design, and implement systems.	LO1, LO3, LO4, LO5, LO6, LO7
Mini Project (MP)	V ETRX VI ETRX VI EXTC	This helps students to identify/define the real world problem; apply the technical knowledge and skills gained from courses learned or learn new techniques; implement the design on prototype.	LO1,LO2, LO3, LO5, LO6, LO7
Signal Processing Laboratory (SPL)	VII ETRX	This course is basically enabling students to design, analyze and implement DSP systems, including digital IIR/FIR filters, Multi-rate systems. It also exposes students to develop an application using TMS320C6713	LO1, LO3, LO4,LO5, LO6,LO7

One observation from a project examiner who regularly examines the project from the college is very encouraging.

"I have been involved for UG project examinations for quite some time now - I could see a perceptible difference in the students this year."

B. Assessment in Examination

Table II shows grades of one class of students in these laboratory courses from which it is evident that majority of the students earned grade 7 and above.

TABLE II. SAMPLE RESULTS OF ONE BATCH

Sem	Year	Course	AA	AB	BB	BC	% of Students above BC
III	2015-16	OOPM	12	65	34	30	94
IV	2015-16	DSL	14	44	36	41	95.07
IV	2015-16	HDL	12	34	26	39	78.17
V	2016-17	MCL	4	26	23	58	84.09
VII	2017-18	SPL	0	33	61	36	100.00

C. Feedback from Graduating Students

Feedback from graduating students is taken at the end of academic year 2017-18 as a part of exit survey of our first autonomous batch. The questionnaire was designed by the concerned engineering faculty members. Majority of the students expressed that laboratory component in their curriculum was very useful. Average grade given for usefulness of laboratory courses in the curriculum was 3.75 on scale of 5.

Typical comments about features of curriculum are as "Inclusion of Latest technologies in syllabus", "Practical sessions are interactive which are useful for developing skills", "Added subjects like Data Structures and OOPM which give a basic idea for IT related jobs." etc. to name a few.

D. Feedback from recruiters

The feedback from recruiters was obtained during placements of 2017-18 for our first autonomous batch admitted in 2014. This feedback is obtained from more than ten regular recruiters representing software as well as core industries. Fig 1 shows comparison with previous batches on different aspects like basic and advanced technical skills, leadership qualities, team spirit, communication skills.

Figure 1. Feedback from Recruiters

V. Discussions

Addition of special laboratory courses in curriculum is an attempt to enhance learning experience and skills of graduates. This experience also helps students to develop further lifelong learning abilities.

From implementation results of this curriculum it is observed that almost more than 80% students are above grade 7 on scale of 10 and hence the laboratory objectives are satisfied. Since the assessment tools were completely based on laboratory practices, these courses contribute to skill development of a graduate which is an advantage over theory based laboratories. Such achievement of laboratory objectives has also resulted in the improvement in placement. The distinct improvement in technical skills and professional attributes of students has also seen from feedback obtained from recruiters.

From the responses of students it can be said that they are very enthusiastic about learning in laboratories. They also feel that they acquire skills like self-learning and working on project or electronic system design. Students gain more confidence in handling appropriate laboratory tools. In this process the students improve on their writing, presentation skills and teamwork.

Since the focus of laboratory courses is on learning by doing, it is essential that the laboratory resources are sufficient in number for each student getting opportunity to work. Also the inclusion of latest technologies and tools should be incorporated in the curriculum to keep pace with the trends in industry. This demands for upkeep and development of curriculum and laboratory infrastructure on a regular basis.

Looking at the whole experience, college is keen on inclusion of such technology driven experiential courses in each of its programme. We hope this feature will enrich the learning experience of students.

Acknowledgement

We would like to thank the faculty members, project examiners and Board of Studies members of both ETRX and EXTC departments who contributed in curriculum design and implementation of various laboratory courses.

We are grateful to our principal Dr. Shubha Pandit, for continuous encouragement and suggestions.

References

[1] Ernst, E W, "A New Role for the Undergraduate Engineering Laboratory", IEEE Transactions on Education, Vol. E-26, No. 2, May 1983, pp. 49-51.

[2] Feisel, L., Rosa A.J., "The Role of the Laboratory in Undergraduate Engineering Education", Journal of Engineering Education, January 2005.

[3] Feisel, L., and Peterson, G.D., "A Colloquy on Learning Objectives for Engineering Educational Laboratories," 2002 ASEE Annual Conference and Exposition, Montreal, Ontario, Canada, June 16–19, 2002.

[4] Claudius Terkowsky, Tobias Haertel, Emanuel Bielski, Dominik May," Bringing The Inquiring Mind Back Into The Labs : A Conceptual Framework to Foster the Creative Attitude in Higher Engineering Education"3-5 April 2014, Istanbul, Turkey , 2014 IEEE Global Engineering Education Conference (EDUCON)

[5] Dr. Sujatha J, Dr. Rajshri Jobanputra," Facilitating Group-Work: To Enhance Learning in Laboratory Based Courses of Engineering Education in India" ASEE Annual Conference, San Antonio, Texas

[6] Vijay Gupta ,"Aims of Laboratory Teaching", , Indian Institute of Technology, Kanpur (In Practical Work,February 2001, Vol.4 No. 1).

[7] Davies,C., 2008. Learning and teaching in laboratories. Loughborough: Higher Education Academy Engineering Subject Centre, Loughborough University.

[8] Dr Anita Shekar, "Project based Learning in Engineering Design Education: Sharing Best Practices",121st ASEE Annual Conference and Exposition, Indianapolis, IN, June 2014