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Implementation of Course-Mini Project (CMP) in Core Laboratory Course for the Attainment of Program Outcomes in Outcome Based Education

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Abstract: In engineering education programs, students are expected to gain certain skill sets to address the global problems. Assessment of these skill sets by the instructor is one of the challenging task. This paper discusses the designed rubrics and the assessment tools used in order to attain graduate attributes to its best. The 'Automation and Control Laboratory' course of Final Year B. Tech Electrical under-graduate programme is selected for the attainment of Program Outcomes. The assessment of the course is done through Continuous Assessment (CA) and Course-Mini Projects (CMPs). Implementation of different methodologies to assess the student's skills are discussed in the paper. The correlation between assessment methods and CLOs and then POs is done. The attainment of POs is calculated after calculating Course Outcomes (COs) through direct and indirect methods.

Keywords: Outcome Based Education (OBE), Course-Mini Project (CMP), Continuous Assessment, Attainment

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1. Introduction

The education is a process of sharing instructions in a systematic manner. The motive of Education is to realize the truth. This can be experienced through design, create and experimentation. Time is one of the major constraints in teaching learning process for most of the programs. Course delivery in stipulated time is the major challenge for the course instructors and due to this reason, most of the faculties were habituated to conventional teaching methods where the process is monotonous. In monotonous teaching environment, instructor instructs and course takers are in passive mode through only listening and writing notes. According to the researchers' students may not pay attention after 15 minutes of continuous listening. In general, a class is the combination of heterogeneous groups with different sets of learning abilities. Such system does not ensure incorporation of all bloom's taxonomy levels in the students. Therefore, involving these different set of intelligence students in monotonous teaching process is difficult. The evaluation process in conventional system is mostly memory based through descriptive exams for theory courses. Even in conventional system, also there is a practice to involve students in experiments and team work through laboratory courses. The most of the experiments involved in lab courses are pre-defined by the course instructor and on same basis students are evaluated through only experimentation, vivo voce and manuals. These practices may not give an opportunity for student to think creatively.

OBE is a process that involves the restructuring of curriculum, assessment and reporting practices in education to reflect the achievement of high order learning and mastery rather than the accumulation of course credits (Tucker, 2004). Outcome based system provide the instructor to be facilitator who facilitates his/her students with appropriate inputs. The role of the facilitator is to ensure attainment of graduate attributes and fulfilling the needs of the students in order to prepare them to be industry ready. So, ensuring attainment of the graduate attributes through course attainment is the major challenge for the course instructor in OBE system. Measuring outcomes is difficult with conventional assessment methods of theory and laboratory courses. Laboratory courses provides a room for the course instructors to develop and assess various graduate attributes like analytical and design skills, team building, communication abilities. So, the autonomy is required for the course instructor to implement various appropriate tools and techniques for the assessment of students for measuring outcomes of the course. We have adopted OBE system in our curriculum delivery at Rajarambapu Institute of Technology (An autonomous Institute), Sakharale. The methods and techniques discussed in this paper have implemented for the Automation and Control (EE458) laboratory course.

The second session deals with literature review, the methodology and implementation of proposed work is discussed in third session followed by results and discussions fourth session and finally conclusions are given.

2. Literature Survey

The implementation of a well-designed continuous improvement process and applying the educational plan, curricular content, facilities, activities, teaching methodologies, and assessment practices, evaluation results to develop the program. The direct measures for outcomes attainment through exams and rubric analysis of various projects and laboratory courses are very effective tools for program assessment and evaluation [1]. The process of continuous assessment is effective in improving teaching learning in the engineering programme [2].

The continuous evaluation of the students during semester has shown improvement in technical knowledge and problem solving skills of the courses. Teaching and facilitating a student or a group with ethics about outcome based education helps students to comprehend the course in a better way [3].

For project phases, developed assessment rubrics helps in improved learning by students and enhanced participation of both instructor and students [4].

Along with internal exams, the additional assessment tools used is seminar or presentation in the laboratory course, which emphasizes on various aspects of learner's abilities. Real-time case studies make students aware of current scenario and address the program outcomes such as safety, societal needs and environment.

In reference [5] the authors have proposed a RUBRIC based evaluation method through innovative evaluation sheets to evaluate the student's project work. This work clearly provided the students on what are expected to do during their project work and introspect their levels of understanding. The evaluation method also promoted the students to participate in several technical events providing them a greater exposure and gain internship and sponsorship opportunities. It also could evaluate students considering the team's and individual member's contribution, which we found to be innovative. Difficulty rubrics facilitate the instructors of engineering courses to identify difficulty level while assessing an item and attain the right level of outcomes. Difficulty rubrics are learner independent, course non-specific and score independent will make them easier to use and implement.

The direct method of achieving the program outcomes of all the courses is discussed. A simple and very effective method for attainment of outcomes of courses using Microsoft Excel is discussed [6].

Attainment of program outcomes (POs) is one of the key aspects of outcome based education (OBE) system, which includes direct and indirect assessment methods. The Selection of relevant courses and its contribution in attaining the POs, and identification of the suitable delivery and assessment method and setting up of the desired targets for same [7].

For successful implementation of OBE, the assessment of POs plays an important role and analysis of course outcomes (COs) and is one of the direct tool for the assessment of the same [8].

3. Methodology and Implementation

Automation and Control (EE458) is a two-credit laboratory course in the curriculum for final year B. Tech electrical engineering under-graduate program. A course mini project is one learning opportunity to develop students in various aspects. Here the course delivery is divided in to two categories. In category one teaching learning process deals with instructions and case studies related to automation problems whereas the later includes implementation of various concepts learned during earlier category in real time applications. This proposed work deals with the designing assessment methods and development of rubrics and effective implementation of methods for the assessment of course learning outcomes.

The structure and evaluation scheme of laboratory course - Automation and Control laboratory (EE458) is given in Table 1.

Table 1

Automation & Control Laboratory (EE458)						
Teaching Scheme				Evaluation Scheme (100 Marks)		
L	T	P	Credits	Scheme	Practical (Marks)	
					Max	Min for Passing
--	--	4	2	ISE	50	25
				ESE	50	25

The program outcomes (POs) of Electrical Engineering undergraduate programme are mentioned in Table 2.

Table 2

Sr. No.	Department of Electrical Engineering Program Outcomes (POs)
PO1	Apply knowledge of mathematics, science, and electrical engineering.
PO2	Design and conduct experiments, as well as to analyse and interpret data.
PO3	Design a system, components or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
PO4	Function on multidisciplinary teams.
PO5	Identify, formulate, and solve e lectrical engineering problems.
PO6	Demonstrate professional and ethical responsibility.
PO7	Communicate effectively at work.
PO8	Understand the impact of electrical engineering solutions in global, economic, environmental, and societal context.
PO9	Engage in life-long learning.
PO10	Use the techniques, skills, and modern engineering tools necessary for engineering practice.
PO11	Apply the knowledge to evaluate contemporary issues with project and finance management skills.
PO12	Participate and succeed in competitive exams.

Table 3

Sr. No.	Automation and Control Lab Course Learning Outcomes (CLOs)
CLO1	Develop small programs using various PLC functions
CLO2	Designing wiring diagram for given system
CLO3	Develop RLL diagram for given system
CLO4	Demonstrate PLC based control for given system or process
CLO5	Identify, communicate and summarize related to PLC based applications

The list of COs of course EE458 are given in Table 3. Table 4 gives the mapping of CLOs and POs. The contribution of CLOs to the POs is mentioned where 1 depicts correlation.

Table 4

Correlation between POs and CLOs												
PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CLO1	1	1								1		
CLO2	1								1			
CLO3	1	1		1	1			1		1	1	
CLO4	1	1	1	1	1				1	1	1	
CLO5	1				1	1	1					

The delivery of this course is divided into two categories; one is dealing with instructional activities and another with implementation of the course learning for real time applications. This course is delivered by using cooperative teaching method. Two faculties delivered the course through cooperation. The instructional activities included face-to-face interactive sessions using Programmable Logic Controller (PLC) hardware. This module deals with basic programming instructions and development of Relay Logic Ladder (RLL) diagrams of small programs using PLC based instructions. As a part of teaching learning activity, various case studies of real-time applications were provided as assignments for the better understanding. Students are expected to develop RLL diagrams for the case studies, verify them and implement using PLC along with submission of technical reports within stipulated time. The role of the instructor is to mentor students and guide them to develop RLL diagrams through continuous assessment. The web based Virtual lab provided students to work on PLC based environment during off time. In second category, students are expected to identify, analyze, solve, design and implement a PLC based real time application in teams.

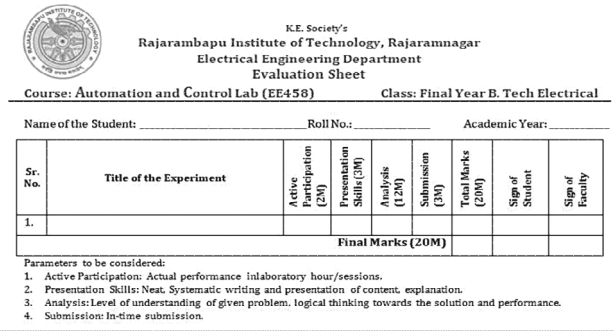
This course is assessed through In-Semester-Evaluation (ISE) and End Semester Evaluation (ESE) for maximum 100 marks. ISE and ESE are assigned 50 marks each. In ESE students will be given an

application and are expected to develop logic and implement on PLC hardware in given time. The learning of student is evaluated through demonstration and viva-voce by both internal and external examiners. To evaluate students, an Industry expert is invited as an external examiner along with internal examiner who is working in same domain. The evaluation of ESE is subdivided into two modules one is experimentation (E1) and vivo-voce (E2) weighted 20% and 30% respectively of total. The elements of evaluation of ESE are shown in Table 5.

Table 5

ESE Mode of Evaluation schemes				
Sr. No.	**Modes of ESE**	**Marks (%)**	**Topic to be tested**	**Examiner**
1	Experimentation	20 (20 %)	Develop RLL and Demonstrate given application using available hardware	Internal and External
2	Viva-voce	30 (30 %)	Logical, conceptual and communication abilities related to automation and control	Internal and External
	Total	50		

The evaluation of ISE is included two modes of evaluation schemes one is continuous assessment (CA) of LAB performance and the other is course mini project (CMP). The evaluation of CA is done for 20% which includes active participation through face-to-face interactions, presentation skills, analytical abilities and punctuality. The Continuous Assessment Sheet (CAS) is shown in Fig. 1.



K.E. Society's
Rajarambapu Institute of Technology, Rajaramnagar
Electrical Engineering Department
Evaluation Sheet

Course: Automation and Control Lab (EE458) Class: Final Year B. Tech Electrical

Name of the Student: _____ Roll No.: _____ Academic Year: _____

Sr. No.	Title of the Experiment	Active Participation (2M)	Presentation Skills (3M)	Analysis (12M)	Submission (3M)	Total Marks (20M)	Sign of Student	Sign of Faculty
1.								
				Final Marks (20M)				

Parameters to be considered:
1. Active Participation: Actual performance inlaboratory hour/sessions.
2. Presentation Skills: Neat, Systematic writing and presentation of content, explanation.
3. Analysis: Level of understanding of given problem, logical thinking towards the solution and performance.
4. Submission: In-time submission.

Fig. 1: Continuous assessment sheet of Laboratory Course Automation and Control EE458

The CMP (group activity) is evaluated for 30% of total marks that includes various components mentioned in Fig. 2. The details of mode of evaluation involved in ISE are shown in Table 6.

The attributes of students that are to be assessed are shown in Fig.2. The correlation between individual components of modes of assessment techniques and

Table 6

ISE Mode of Evaluation schemes			
Sr. No.	**Modes of ISE**	**Marks (%)**	**Topic to be tested**
1	**Class performance** (oral examination, attentiveness, performance, regularity)	20 (20%)	Basics of PLC, wiring and circuit designing , applications , installation processes, execution process, Development of RLL diagram for given application (report generation)
2	**Group activity** Course-Mini Project (CMP):	30 (30%)	Covers all the syllabus **Note:** simulations and mini projects will be given on PLC based applications.
	Total	**50 (100%)**	

the CLOs are mentioned in Table 7. The existence of correlation is represented with bit 1. So, the attainment of POs can be obtained from the attainment of CLOs where CLOs can be achieved from the key areas of various modes of assessments mentioned in Fig. 2 and Table 5 and Table 6.

Table 7

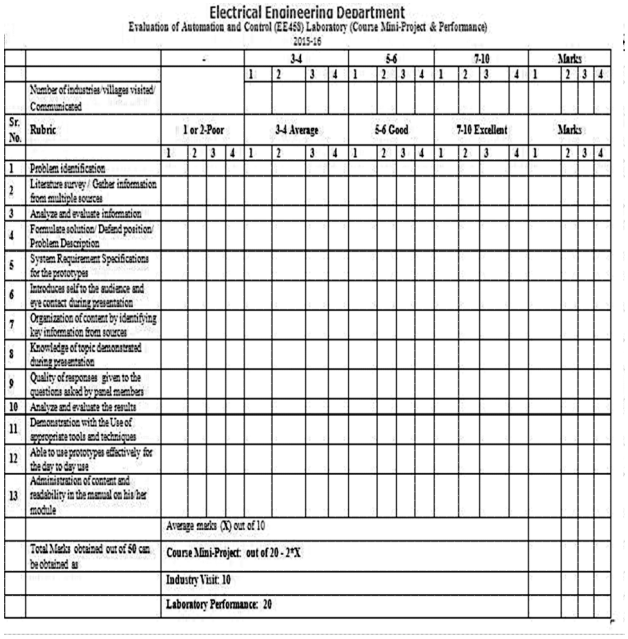
Correlation between Evaluation parameters and CLOs						
Sr. No.	**Rubric**	**CLO1**	**CLO2**	**CLO3**	**CLO4**	**CLO5**
1	Number of industries/villages visited/ Communicated					1
2	Problem identification					1
3	Literature survey / Gather information from multiple sources					1
4	Analyze and evaluate information	1				1
5	Formulate solution/ Defend position / Problem Description	1	1	1	1	1
6	System Requirement Specifications for the prototypes	1	1		1	
7	Introduces self to the audience and eye contact during presentation					1
8	Organization of content by identifying key information from sources					1
9	Knowledge of topic demonstrated during presentation				1	
10	Quality of responses given to the questions asked by panel members				1	1
11	Analyse and evaluate the results	1	1	1		
12	Demonstration with the Use of appropriate tools and techniques				1	
13	Able to use prototypes effectively for the day to day use	1		1	1	
14	Administration of content and readability in the manual on his/her module					1
15	Active participation-2M	1				1
16	Presentation Skills-3M					1
17	Analysis-12M		1	1	1	
18	Punctuality-3M				1	
19	E1-20M		1	1	1	
20	E2-30M	1				1

In this proposed work total 20 components were assessed during the laboratory course which includes ESE, CA, individual and group performances of the students during CMP mentioned in Table 8.

Table 8

Number of modules involved in evaluation schemes			
Mode of assessment	ESE (E1 & E2)	CA	CMP
Number of components assessed	2	4	14

The organization of CMP is as follows. Group formation, leader ship model, understanding concepts and identification of problem related to real time applications, analysis, design implementation and report generation.



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		-				3-4				5-6				7-10				Marks			
						1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	Number of industries/villages visited/ Communicated																				
Sr. No.	Rubric	1 or 2-Poor				3-4 Average				5-6 Good				7-10 Excellent				Marks			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	Problem identification																				
2	Literature survey / Gather information from multiple sources																				
3	Analyze and evaluate information																				
4	Formulate solution/ Defend position/ Problem Description																				
5	System Requirement Specifications for the prototypes																				
6	Introduces self to the audience and eye contact during presentation																				
7	Organization of content by identifying key information from sources																				
8	Knowledge of topic demonstrated during presentation																				
9	Quality of responses given to the questions asked by panel members																				
10	Analyze and evaluate the results																				
11	Demonstration with the Use of appropriate tools and techniques																				
12	Able to use prototypes effectively for the day to day use																				
13	Administration of content and readability in the manual on his/her module																				
		Average marks (X) out of 10																			
	Total Marks obtained out of 60 can be obtained as	Course Mini-Project: out of 20 - 2*X																			
		Industry Visit: 10																			
		Laboratory Performance: 20																			

Fig. 2: Individual and group evaluation sheet of Course mini project

In Course Mini Project, likeminded students have formed as groups with strength 3-4. All students are leaders and are equally responsible for the project work. To ensure the contribution of each student in his or her work the responsibility of reporting to the instructor is rotated time-to-time. EE458 is a two-credit course so, by considering contact hours and weight age of marks, in CMP students were expected to develop prototypes of various real time applications related to the field of Automation and Control. In CMP total 14 components are involved and are mentioned in evaluation sheet of course mini project shown in Fig.2.

To expose students to community based services and industrial related real time applications they were encouraged to visit various villages and industries. Marks given to individual students based on number of villages and industries visited on the scale of 10. Here, students are expected to communicate with authorities of various industries and various communities and the role of the instructor is to provide motivation and supporting documents. Fig. 2 explains the marking scheme of industry visit and other components like problem identification, team work, analysis, design and demonstration related to CMP. Also Communication skills which are related to oral and written also assessed through presentations and technical report. Students are encouraged to follow ethics while producing technical report on their own. The average of all components is considered to assign total marks for the CMP mentioned in Equation 1. The total marks earned by individual student for this course are obtained from marks earned through CAS of laboratory performance and CMP which is given by Equation 2. The flow chart of overall execution of course plan is shown in Fig.6.

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$$CMP_{total} = Marks_{industry\_visits} + 2 * Average\_Marks_{all\_componets} \quad .1$$

$$Total\_Marks = CMP_{total} + CA_{total} \quad .2$$

The next session discusses results of CLO and PO attainment of the course EE458 and conclusions.

4. Results and Discussions

The attainment of CLOs done through two modes, i.e. direct attainment of the course which achieved through the average of individual marks obtained by the students. The other one is indirect attainment which is calculated from course end survey. The total attainment of CLOs is obtained from 80% of direct and 20% of indirect attainment. The results are depicted in Table 9 and in Fig. 3. The contribution of CLOs to POs mentioned in Table 10 and in Fig. 4.

Table 9

CLOs Attainment					
Attainment/COs	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Direct	84.88	80.89	81.87	83.67	82.03
Indirect	73.33	66.67	60.00	73.33	86.67
Direct (80%) + Indirect(20%)	**82.57**	**78.05**	**77.49**	**81.60**	**82.96**

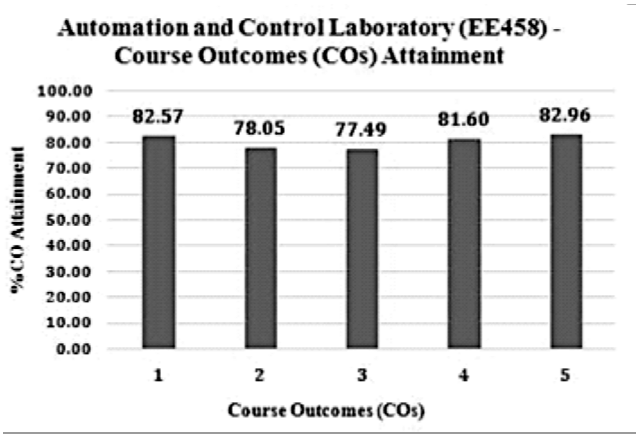

Fig. 3: CLOs Attainment of course EE458

Table 10	
Attainment of Program Outcomes	
POs	**% POs Attainment**
PO1	**80.53**
PO2	**80.55**
PO3	**81.60**
PO4	**79.55**
PO5	**80.68**
PO6	**82.03**
PO7	**82.96**
PO8	**77.49**
PO9	**79.82**
PO10	**80.55**
PO11	**79.55**
PO12	--

Fig. 6: Flow chart of course plan and its execution.

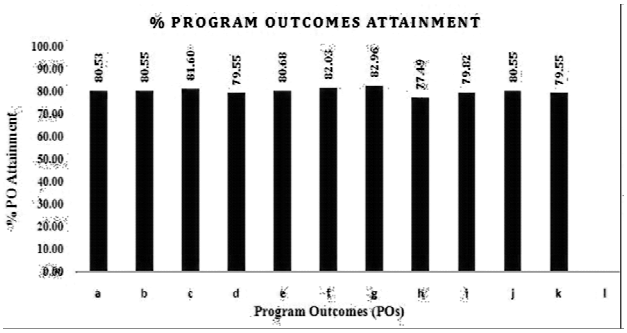

Fig. 4: POs attainment by course EE458

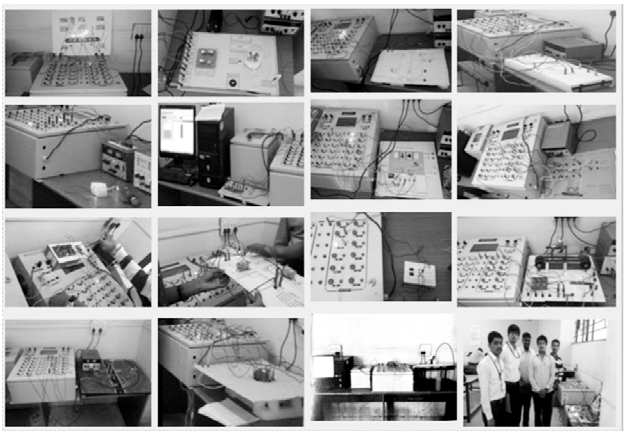

Fig. 5: Prototypes of Course mini Projects

List of course mini projects:

- A priority wise switching to fed available source to load
- SCADA based automatic water level control
- Draw bridge system using PLC
- Automatic tolling system
- Automatic railway signal crossing system
- Automatic boom barrier system at rail-road crossing
- Automatic traffic light control
- Automatic stamping system
- Automatic dam shutter
- Automatic car washing system
- PLC based elevator system for an apartment
- Automatic washing machine
- Automatic sugar cane crusher process
- Automatic solar panel guidance system
- Automatic car parking system
- Automatic tablet packing system with two conveyor model
- Automatic temperature control system using PLC
- On/Off control of load
- Home automation system for 1 BHK flat
- PLC based Automatic coal carrying/crushing unit
- PLC based bottle filling plant
- Automatic ice cutting process using PLC
- PLC based automatic chemical mixture process

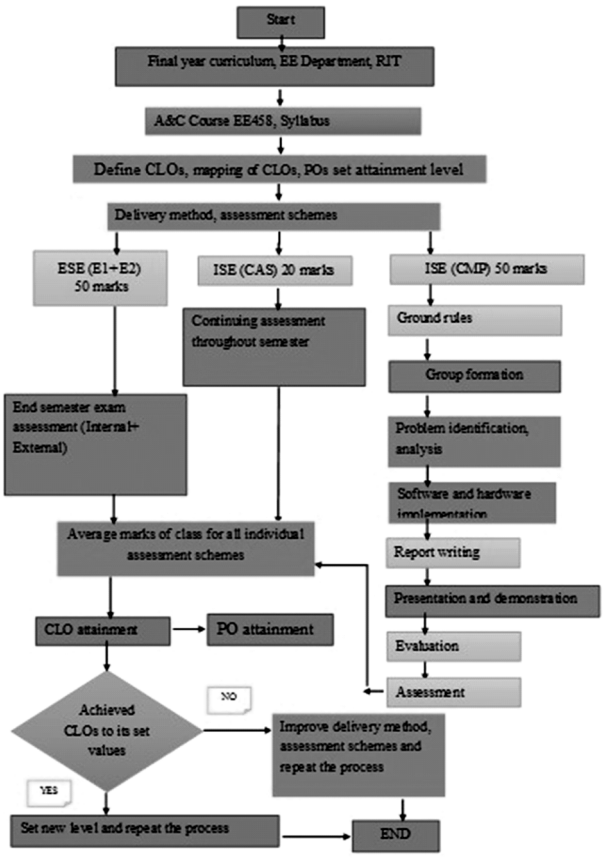

Fig. 6: Flow chart of course plan and its execution.

5. Conclusions

This proposed work provides the new dimensions of course delivery and assessment methods of student learning in core Laboratory course, attainment of CLOs and POs. These modules are implemented for EE458 course included in final year B. Tech. electrical engineering curriculum. It is observed that students are more interested to work on real time projects in groups. The results show that course delivery and learning are achieved through improvement in the CLOs attainment in the range of 77% to 83% and the attainment of POs are in the range of 77% to 83%. This work concludes that the students' skill-sets can be improved by involving students to work on community based or industry related real time CMP. The attainment of the COs and POs will be considered as the benchmark for further study.

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