A Case Study: Efforts for Improvement in Attainment of Course Outcomes in Control System Engineering

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Abstract: In Outcome Based Education, defining Course Outcomes, content delivery and evaluation methods complement each other resulting in effective learning. Study of Control systems is vital in Electronics Engineering so that the graduate develops ability to design a system, component, or process to meet desired stability needs. However, in Electrical Networks and Control System Engineering it is experienced that students find it difficult to understand concepts of frequency domain analysis. and control system components. The related course outcomes attainment is less than the expected level. This paper focusses on detailing the methods used to attain the course outcomes by linking the two courses viz. Electrical Networks and Control System Engineering. It also discusses the effect on performance of students in Control System Engineering course after improvisations in content delivery and assessment tools.The feedback of students shows that students are motivated to learn better with this approach.

Keywords: Course Outcomes, Outcome Based Education, assessment tools, control system

1. Introduction

Outcome based Education approach is introduced to engineering institutes by National Board of Accreditation (NBA) which serves as a means to specify the process, identify and certify technical institutes on Outcome Based Education. Outcome-Based Education (OBE) approach is one of the student-centric learning methods that focus on measuring student performance [1] [2].

Researchers have found some of the effects and advantages of an OBE approach as a) quality of the graduates produced, b) development of more systematic, innovative and flexible teaching methods, and c) increase in student exposure to professional practices through internships and projects [3].

Every graduate is supposed to acquire attributes in three domains viz. knowledge, skill and attitude. Each program defines program outcomes (POs) which are assessed and evaluated at the end of four years of graduation. These attributes are acquired through Course outcomes (COs) defined in every course and evaluated every semester. Hence attainment of COs is the focus of teaching learning process in OBE approach [4].

Course outcomes, content delivery and evaluation methods complement each other resulting in effective learning. Course outcomes should map with program outcomes which are directly associated with Graduate Attributes (GA). Course outcomes are acquired through participation in a unit of learning, and evaluated through different assessment tools throughout the semester [3] [7].

OBE approach means a commitment not only to provide an opportunity of education, promotion to the next level and a commitment that all students will ultimately reach the same minimum standards as defined by GAs. Hence methods to deliver the contents and assessment tools should be thoughtfully developed [5].

The main purpose of this study is to investigate and present an analysis that combines the findings from two courses namely Electrical Networks (EN) and Control System Engineering (CSE), the linkage between their course outcomes and methods adapted for improvement in attainment of the same.

The impact on students' performance is observed after undergoing the courses in semester III and IV of Electronics Engineering in a self-financed autonomous engineering college affiliated to University of Mumbai, India. The goal is to improve understanding of students in the area of time and frequency domain analysis, and control system components.

Section II discusses the experience which motivated the facilitator to improve pedagogical methods and develop assessment tools. Section III describes the research questions leading to steps taken in content delivery, tools developed and data collection. Section IV presents the results of continuous assessment during the semester, student feedback and end semester examination, followed by conclusion in Section V.

2. Motivation

The most important technical skill of an engineer is the ability to design a system, component, or process to meet the desired needs. In control systems the formulation of control problems and the determination of control algorithms are based on the exact and precise knowledge of the deterministic control plant. This knowledge is usually presented in the form of

mathematical formulas, first and second order circuit or two port networks. During the graduation, students study Electrical Networks and Mathematics in semester III and Control System Engineering in semester IV. Hence they are expected to have prerequisite knowledge of Laplace transform, first order and second order circuits, circuits modelled by differential equations whose solutions describe the total response and behaviour of the circuit when they study Control System Engineering (CSE).

In 2014-15, it was observed while teaching CSE that students are not very clear with the concepts of transient analysis and control system component. Faculty had to take efforts to clear students' concepts of time domain and frequency domain analysis. Due to this the time allotted in curriculum was insufficient. Also for analysis of first and second order system with different type of inputs and different switching conditions, students were weak in concept of Laplace transform. So while studying CSE they found it difficult to study stability analysis and accuracy measurement topics.

So, they were needed to improve in the above mentioned fundamentals which were also indicated by the CO assessment (poor attainment).

Hence for better CO attainment of CSE, it was felt that fundamentals of EN should be strengthened.

It is also found that the MATLAB simulation of experiments gives students the opportunity to solve control problems and integrate theoretical knowledge obtained in lectures with practical experience, where the role and relevance of each concept becomes evident. The simulations aim at reproducing, as closely as possible, the typical "look and feel" of real-world process control situations [6].

Hence, it was felt that simulation based experiments on Bode plot, Nyquist plot, polar plots and controller design could be added during tutorials.

3. Methodology

Following methods were evolved from previous experience

- Strengthening fundamentals of EN
- Improving content delivery methods and assessment tools of CSE

In order to study the effectiveness of these methods following research questions are formed.

RQ1: Do the students perform better in areas of frequency domain analysis and control system components and fulfill the course outcomes?

RQ2: Do the students perceive that learning through problem solving and simulations is useful for design and analysis of control systems?

These methods were implemented on 150 students of second year of Electronics Engineering in Autonomous curriculum of a self-financed autonomous institute affiliated to University of Mumbai, India. The sampling is convenience sampling as the researchers are the faculties conducting the courses of CSE. The groups of students used for observations are students in 2014-15 and 2015-16 of second year level.

By keeping in mind observations of CSE in previous year (2014-15) following corrective measures were taken in subsequent year (2015-16)

A. Corrective Measures taken in EN (in Semester III):

1) To strengthen the fundamentals in Laplace transform more assignments were given in tutorial sessions. Guidance for solving the problems was given by faculty members from Electronics as well as Mathematics background.

2) MATLAB simulation of first order and second order system was introduced for study of transient response. Students were given clear idea that they would require this knowledge in stability study of control system.

3) Open Book test for Network Synthesis was conducted.

B. Corrective Measures in CSE(in Semester IV):

1) In autonomy curriculum was modified for CSE in 2015-16 and tutorial was added so as to support teaching with problem solving.

2) Some topics which are studied earlier, like stepper motors, application of control system in Industry, were given to students for self-study and presentation. During their presentations in the class discussions were held where all could learn collaboratively.

3) Some topics like bode plot, root locus, compensators and polar plot were implemented and simulated in MATLAB which helped students to understand theoretical concepts. The simulation based teaching also provides skills essential for control professionals.

4) Learning Management System (LMS) was introduced with the purpose of study at convenience and pace. Course material which can be used for learning offline and for revising classroom teaching was shared on LMS. Assignments and quizzes were conducted on LMS for which enough study material was made available.

5) In autonomy weightage is given to in-semester activities like open book test and assignments. This helps students to prepare individual topic in curriculum and clear their concepts.

C. System of Evaluation and Assessment

1) Course Outcomes

Following are the course outcomes of CSE defined by faculty in the year 2014-15 and 2015-16 which cover the curriculum and set the objectives.

Target is set at 60% with the understanding that every learner should be gaining at least 60% marks to have attained the course outcome.

Table 1: Course Outcomes of CSE

Course Outcome	After successful completion of the course students should be able to
CO1	Derive simplified mathematical model of systems in different domains (electrical, mechanical systems) by applying first principles.
CO2	Measure and improve performance parameters of the systems in time domain using classical control techniques.
CO3	Measure and improve performance parameters of the systems in frequency domain using classical control techniques.
CO4	Apply modern control techniques to obtain performance parameters of nonlinear control systems.

2) Direst Assessment Tools

Various Assessment tools are developed by carefully mapping them with course outcomes. The schedule and the syllabus was declared well in advance. The scheme of assessment was given to students. In assessment of COs the weightage of direct assessment tools was 80%.

- **In semester tests:** Two tests were conducted covering topics like mathematical modelling in different domains, time domain and frequency domain analysis using classical control techniques. These were conducted in both academic years 2014-15, 2015-16.
- **Internal Assessment:** Additional assessments like multiple choice quizzes, Open book test and homework assignment were conducted on topics focussing on system reduction techniques, response of first and second order systems and application of control system in industry. This assessment tool was introduced in 2015-16.
- **Tutorials:** In tutorial students cleared their concepts of time and frequency domain analysis using classical control approach by solving number of problems, and they also simulated bode plot , root locus and Nyquist plot in MATLAB hence they were able to compare practical and theoretical results. This assessment tool was introduced in 2015-16.
- **End semester Examination:** At the end of the semester all the students had to appear in examination covering complete syllabus. These were conducted in both academic years 2014-15, 2015-16.

3) Indirect Assessment Tools

At the end of semester; survey questionnaire was administered through Learning Management System. The students were given two week duration for completion of the survey. They completed the survey individually without any influence of peer or faculty. These were conducted in both academic years 2014-15, 2015-16.

In assessment of COs the weightage of indirect assessment tools is 20%.

4. Data gathered:

The following data was gathered for analysis at the completion of the study.

A. The marks obtained by students of EN in 2015-16 in semester evaluation of tutorials and multiple choice question test related to transient and steady state analysis of first and second order circuits.
B. The marks obtained by students of CSE during 2015-16 in semester assignments and evaluation of tutorials.
C. CO assessment of CSE in 2014-15and 2015-16.
D. The marks obtained by students in End Semester Examination of CSE during 2014-15 (control group) and 2015-16 (experimental group)
E. Student responses to the survey questions.

5. Results

A. Marks of EN(2015-16)

The impact of quizzes and tutorial on performance of students to improve the attainment of CO2 and CO3 (to transient and steady state analysis of first and second order circuits) of EN is shown in fig. 1 and fig. 2.

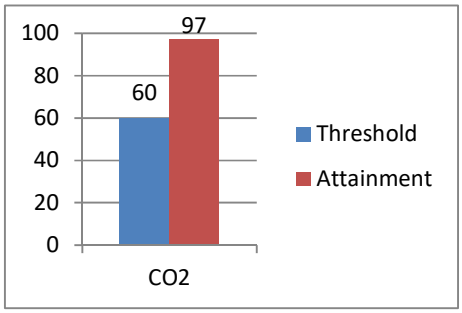

Fig.1 Performance of students in EN Quiz

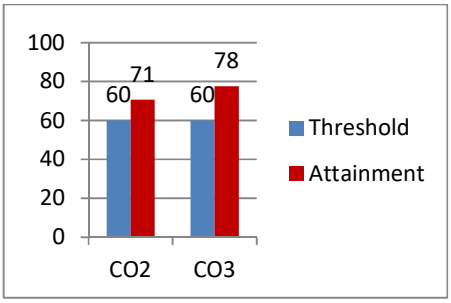

Fig.2 Performance of students in EN Tutorial

B. Performance of students of CSE (2015-16) in in-semester evaluation of tutorials

Assignments were also given related to CO3 and CO4, as a part of in-semester evaluation. It was observed that the performance in the assignment was above 80% as seen in fig. 3 and it directly affected the final performance of students and helped in the CO attainment.

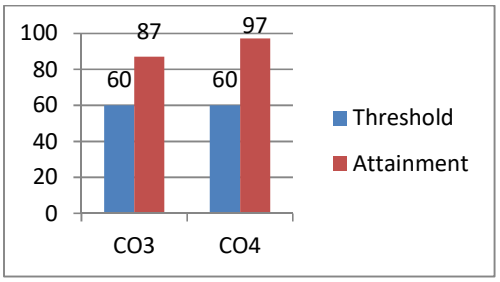

Fig.3 Performance of students in CSE Assignments

Students' performance was quite good in tutorials as compared to target set in the year 2015-16.

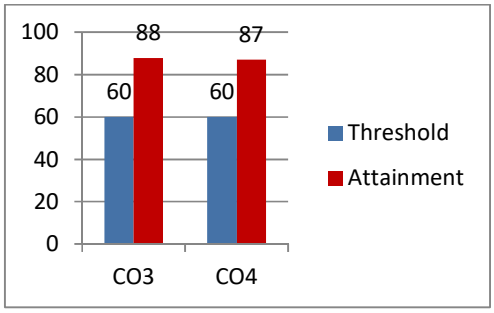

Fig.4 Performance of students in CSE Tutorials (2015-16)

C. CO attainment of CSE in 2014-15and 2015-16

The focus was on the improvement of the attainment of CO3 and CO4 in the year 2015-16. The results of the continuous improvement during the term indicate the effect of efforts taken in 2015-16.

This was also reflected in the final CO assessment when CO attainment of two academic years for CSE was compared. (Refer fig. 5)

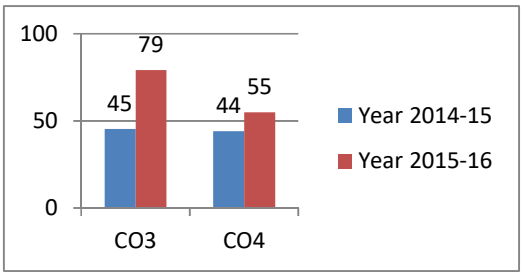

Fig.5: Comparison of CO attainment in 2014-15 and 2015-16

D. Analysis of End Semester Examination of CSE

The data analysis techniques used in the study are comparison of means using t-test for students' scores in the end semester examination of the control and experimental groups.

In order to ascertain the statistical significance of result of ESE, we formulated a hypothesis and performed paired sample t-test to prove or disprove our hypothesis. The null hypothesis can be stated as:

H0: $\mu 1 = \mu 2$: the improvisation efforts in CSE didn't cause any change in students' performance.

The alternate hypothesis is:

H1: $\mu 1 \neq \mu 2$: The improvisation efforts in CSE did cause a change in students' performance.

The result of t-test is tabulated in Table 2. From Table 2, we observe, that the test is statistically significant and hence, we can reject the null hypothesis. ($\rho<0.0001$)

Table 2: Result of T Test

	2014-15(CG)	2015-16(EG)
No of Students	149	142
Mean	49.61	57.64
Median	49.0	60.0
Standard deviation	14.6	17.6
Value of T	-4.25	
P	<0.0001	

E. Student responses to the survey questions

Table 3 gives the summary of responses collected from survey at the end of the course in 2015-16.

6. Discussions and Conclusion

Through this study the authors have tried to find answers to the following research questions

RQ1: Do the students perform better in areas of frequency domain analysis and control system components and fulfil the course outcomes?

From the evaluation of the work during the year, it is found that the learning experience is better with appropriate prerequisite knowledge, problem solving and simulations.

From the results obtained in assignments and tutorials it is seen that almost 80% students are able to perform in in-semester assessment tools. It was also observed in their presentations on self-study topics. Analysis of their end semester examinations shows that their scores have improved. The attainment of Course Outcomes has also improved.

RQ2: Do the students perceive that learning through problem solving and simulations is useful for design and analysis of control systems?

In the response of survey conducted, more than 90% of students feel that course contents are really useful in future for design and analysis of control systems. More than 80% students feel that they learnt the concepts of frequency domain better by problem solving and simulations. In the concepts of controller design around 70% students have confidence.

These corrective measures were taken in 2015-16 and the observations are based on our first experience.

It will not be appropriate to concretely put forth these observations as conclusions. They can be substantiated only after sufficient time. It is also felt that for better understanding of designing of controllers, simple applications can be given to students as mini project.

Table 3: Summary of Student Responses

Course Outcome	Question asked	% of Students with response as			
		Strongly Agree	Agree	Disagree	Neutral
CO3	Were you able to solve the problems on Bode Plot and Nyquist Plot given in tutorials?	41.18	48.53	2.21	8.82
	Are you able to analyze the control System in frequency domain?	46.32	48.53	0	5.15
CO4	Have you understood the concept of controllers?	38.97	44.85	2.21	13.97
	Are you able to design a controller?	27.21	46.32	8.82	17.65
Tutorials	Is this course contents really useful in future for design and analysis of control systems?	43.38	50	0.74	5.88
	Was Tutorial beneficial to solve the problems of Control Systems?	48.53	46.32	2.94	2.94
	Were you able to solve problems of transient analysis and steady state error given in tutorials?	43.80	47.45	1.46	6.57
	Were you able to solve problems on block diagram and Signal flow graph given in tutorials?	61.59	35.51	0.72	1.45

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