Continuous Improvements in Teaching-Learning-Process in Outcomes Based Education

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***Abstract*— There has been an attempt to effectively implement Outcomes Based Education (OBE), to ensure quality of engineering graduates. For effective implementation, we need to introduce small changes in the teaching learning process, and significant changes in the assessment tools. The accreditation norms emphasize the need to: (i) develop the ability to apply knowledge of sciences and engineering to solve, design, develop, implement, test, analyze systems/sub-systems related to the engineering domain, (ii) develop the ability to perform in diverse teams through effective communication, and (iii) demonstrate professional behavior through concern for society, environment, safety and health. The focus of this paper is to present the complete activities of a faculty in a semester in the OBE framework. We present a typical example of a course in this model. The suggested model can be included in any of the courses and when successfully implemented in most courses, leads to enhanced attributes acquired by the graduating engineer.**

***Keywords*— Graduate Attributes, Outcomes Based Education, Program Outcomes, Course Outcomes, Assessment Tools,**

I. Introduction

Outcome Based Education (OBE), is penetrating the Engineering Education system at an increasing pace. Today, every activity, every course, is measured by the Outcomes being addressed. The outcomes of a program are the set of competencies acquired by the student at the time of completion of the program. The broad guidelines for desired competencies are defined by the accreditation bodies [1-4]. The National Board of Accreditation (NBA), the accreditation body for India, has defined the desirable competencies through the twelve Graduate Attributes (GAs) [1]. The first four Graduate Attributes develops the application of basic science/engineering concepts to solve, design, and analyze systems/sub-systems in the core engineering domain. These attributes are usually addressed by a significant number of courses in a curriculum. GA5 deals with the competency to use a modern engineering tool, and this component is usually addressed by the laboratory component of the curriculum. GA6 and GA7 develop the awareness, concern and responsibility towards health, society and environment. GA8 emphasizes the importance of abiding by professional ethics, and the student is introduced to the norms of professional practice. GA9, measures the ability to perform as an individual/as a member of a diverse team. This attribute helps develop the competency to respect diverse cultures and perform in diverse teams, and thus prepares the skills necessary to pursue a professional career. GA10 emphasizes the need for effective communication, both with the engineering community and non-engineering community. GA11 takes the student through the norms of planning and implementing a project. GA12 attempts to measure the ability to engage in independent learning and the desire to continuously upgrade the knowledge. Hence

it can be seen that the Graduate Attributes emphasize ability to apply knowledge, and have the professional skill and attitude. The Graduate Attributes are addressed through the Program Outcomes (POs), which are addressed through the Course Outcomes (COs). The contribution by every course leads to the overall development of the necessary skill set in the graduating engineer [5-8].

In an Outcome Based Education (OBE) system of education, every course in the curriculum has a list of Course Outcomes (COs). Every course has a set of COs and every CO addresses one or more Program Outcomes (POs), which are aligned to the Graduate Attributes. COs, represent the student learning outcomes at the end of the course, and hence sometimes they are known as Student Outcomes (SOs). The COs needs to be assessable and measurable and they describe knowledge, skills, abilities or attitudes that a student attains at the end of the course. Given the content for a course, it is possible to design the COs, the delivery methods and assessment tools for each of the COs, so that a larger number of POs are addressed [7-9]. Hence, it can be stated the COs constitute the basic building blocks of an outcome based education system. For a given course content, it is possible to define the COs addressing different POs [1-5]. .

In this work, we present the different activities associated in a semester, by the faculty for a given course. We assume the course content is available and the faculty is assigned a course to deliver. The first major responsibility of the faculty is to define the Course Outcomes [1-6]. Having defined the course outcomes, the faculty then plans the delivery methods, the assessment tools, and finally at the end of the semester arrives as the attainment of the COs. The semester then concludes with a self-assessment/review by the faculty. In India, the engineering colleges fall under three major types: (i) affiliated to an University, (ii) guided autonomy, where in the colleges have academic autonomy and (iii) completely autonomous. While most colleges are of the first type, there are few Institutions in the second and third type. Irrespective of the type of the Institution, in all colleges, we have faculty to deliver the course and the faculty has a course to deliver. Autonomous Institutions have the freedom to change the course content, while the affiliated Institutions can change the course content through a guided process. In this work, the model we propose can be implemented irrespective of the type of affiliation, and the discussed procedures lead to an effective implementation of Outcomes Based Education. The methods proposed can be suitably implemented by any faculty, and when successfully implemented by all teachers in all the courses, shall lead to an overall development of the graduating engineer.

The rest of the paper is structured in the following manner. Section II deals with the various activities in a semester by the faculty for a given course, Section III presents the activities by the faculty and the course over successive semesters. Section IV has a specific example of one course in a semester, while and our concluding remarks are in Section V.

II. The Activities Associated With A Course In One Semester

We now commence our discussion with the significant activities associated in one semester span of the faculty and the assigned course. The major activities are listed in Figure 1. As it can be observed, there are three major stages: (i) the commencement of the semester, (ii) the semester and (iii) the end of the semester. We now discuss each of these in some detail.

At the start of the semester, for the given course content, the faculty needs to define the Course Outcomes (COs), which are the set of competencies the student acquires at the end of the semester. For example, the course outcome may develop the ability to apply knowledge of mathematics/ science/ engineering, or develop the ability to solve engineering problems, or develop the ability to design/analyze systems/sub-systems. The course outcome may include ability to use a modern tool, include a self-study/component. The course outcome may develop communication

skills, ability to perform as an individual or in a team. The course outcome may include formulating, designing, implementing, demonstrating a project that addresses needs of society, has concern for environment and abides by professional ethics. It is essential that the Course Outcomes are aligned to the Program Outcomes (POs), which are aligned to the Graduate Attributes (GAs). In addition to being aligned to the POs, the COs need to be measurable. Defining the Course Outcome, constitutes the most significant component of an effective implementation of Outcomes Based Education (OBE). Having defined the COs, we then need to establish the mapping of each CO to the PO, in addition we need to include the targets for the attainment of each of the CO-PO mapping. The set targets may be different for each CO. These three activities needs to be completed before the commencement of the semester (or during the initial weeks). Associated with each of the COs, is the process of defining the assessment tools. As it is preferred the student is aware of the various assessment he/she needs to take during the course.

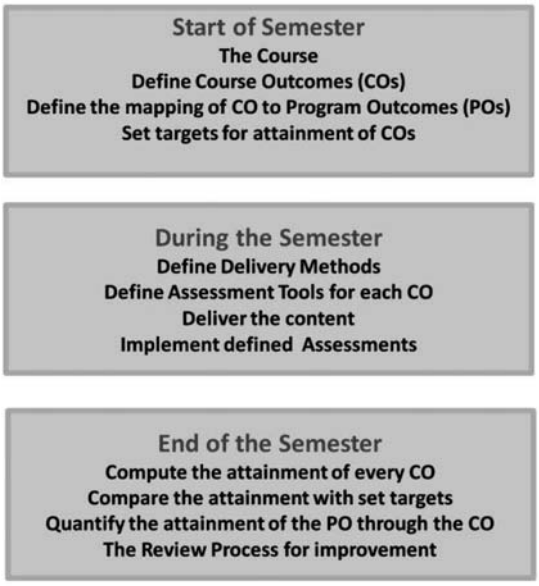

Figure 1: The significant activities in ONE semester of the faculty and the Course

We now proceed to the next phase in the cycle of the faculty-course in a semester. This second phase includes all activities during the semester. The attempt is to deliver the content, to ensure student learning. Hence, along with delivery of the content, the faculty may include different assessments to measure and quantify the learning process. The teaching process may include conventional lectures, tutorials, lab demos, watching videos, listening to lectures by industry experts, listening to on-line lectures, an industrial or conducting an experiment. These teaching processes need to be accompanied by suitable assessment tools, to ensure the attainment of the defined Course Outcomes. Assessment tools may include written examinations, quiz, oral examination, demonstration of an experiment, demonstration of a project, presentation of a seminar, submission of a report, etc. The teaching –learning process during the semester needs to structures such that the students develop a passion for the course, develop a desire to engage in further independent study, and have the ability to apply the knowledge gained in other courses if required. Hence this is the major phase of the faculty-course cycle. Here the faculty has scope of introducing innovations in the teaching learning process.

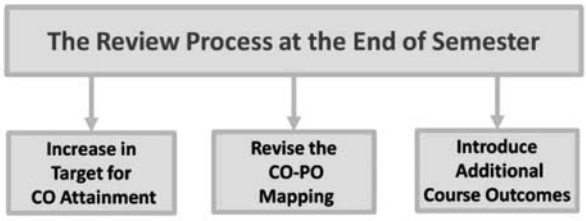

Figure 2: Some possible review measures at the end of the semester

The third phase in the faculty-course cycle of the semester is towards the end of the semester. Here we need to compute the attainment of every Course Outcome, and hence the corresponding Program Outcome. The attainment usually is a measure of the percentage of students who have attained above a set threshold. From the attainment figures, there is the

need for a review process. This is a self-assessment of the overall performance by the faculty of the course delivered and the attainments achieved. Some possible review measures are listed in Figure 2. The activities that are likely in the review process are: (i) increase the targets for the CO attainment, (ii) enhance the POs addressed by the COs, (iii) define additional COs. All these three measures, are focused on enhancing the attributes addressed by the course, and hence on improving the competencies gained by the student at the end of the semester. In purely autonomous Institutions, the review process shall include revision in content.

III. The Activities Associated By The Faculty With A Course In Successive Semesters

Having discussed the various activities of the faculty and a course during one semester, we now consider the case where the faculty may have the opportunity to handle the same course over successive semesters. In this case, the self-assessment and review process by the faculty leads to gradual improvement in the attributes acquired by the student, as depicted through a possible mapping of the CO-PO in Figure 3. It can be observed that during the first attempt of handling the course, the number of attributes addressed is relatively less. With each successive attempt, there is an increase in the set target, an increase in the attributes addressed and introduction of new course outcomes. Hence it gradually leads to enhanced skills acquired by the student through the course. This improvement in the teaching learning process is purely based on the self-review process by the faculty, and is not dependent on any external monitoring process.

Handling the Course for the First Time

	PO 1	PO 2	PO 3	PO 4	PO 6	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	60%	60%										
CO2	60%											
CO3	60%	60%										
CO4	60%											

Handling the Course for the Second Time

	PO 1	PO 2	PO 3	PO 4	PO 6	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	60%	60%	60%									
CO2	60%	60%										
CO3	60%	60%	60%	60%								
CO4	60%				60%							

Handling the Course for the Third Time

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	60%	60%	60%									
CO2	60%	60%										
CO3	60%	60%	60%	60%								
CO4	60%		60%		60%							
CO5	60%	60%										
CO6	60%			60%		60%			60%	60%		60%

Figure 3: The possible CO- PO mapping for successive semesters for the same course handled by the same faculty

We now proceed to the situation where the faculty has the opportunity to deliver the course for a significantly large number of times (more than ten for example). What do we expect in this case? Probably the CO-PO mapping has reached a limit, and further improvement is not possible. In this case, some of the possible contributions by the faculty is listed in Figure 4.

After having taught the course a large number of times

Most COs attain set targets
The course addresses a large number of POs
Leverage technology in the teaching-learning-process
Industry Association in the teaching-learning-process
Publish innovative teaching practices of the course
Develop new algorithms/applications in the domain of the course
The course content developed and is available on-line/ published as a book
The course is offered as a MOOC
Global recognition of students and faculty of the said course

Figure 4: The list of possible academic activities related to the course when handled by the same faculty a large number of times

It can be observed that we now expect innovations in the teaching-learning process, publications in the innovation introduced in the teaching-learning process, an association with an industry, development of new algorithms/new applications of a concept. The faculty is now expected to have most of the teaching content in digital form, and makes available to the registered students. The digital content then may likely get published as a book. The faculty may now plan to reach beyond the boundaries of the class room, and may plan to offer a MOOC. The attributes, the competencies acquired by the student in the case now shall be truly of Global standards. Probably the association with the industry may lead to student internships, and executing funded projects. Hence, the outcomes of this situation have no boundaries, and it is at the hands of a dedicated teacher.

TABLE-I: COURSE OUTCOMES FOR DIGITAL COMMUNICATION COURSE DEFINED AT THE COMMENCEMENT OF THE SEMESTER

Course Outcomes
CO1: Ability to apply mathematical concepts of convolution and Fourier analysis to develop to time-domain and frequency domain representation of digital communication modules
CO2: Ability to apply concepts of 'Analog Signal Processing', 'Discrete time signal processing' and 'Analog Communication', to develop base-band and band-pass transmission of digital data
CO3: Ability to represent a finite set of energy signals using orthonormal basis functions through the Gram-Schmidt procedure, and extend to digital modulation schemes, and obtain the corresponding BER
CO4: Ability to apply the PRBS sequence to spread-spectrum modulation techniques
CO5: Ability to work as an individual to conduct experiments to design and implement electronics circuits for generation of digital communication modulated waveforms (ASK, BPSK, FSK, QPSK,OFDM)
CO6: Ability to work as an individual to conduct experiments using LABVIEW software Engineering tool for generation of digital communication modulated schemes (ASK, BPSK, FSK, QPSK,OFDM), generation of PRBS sequence, Linear Block Codes
CO7: Ability to engage in independent learning, submit a report and use ICT for effective presentation of the study to design, formulate, implement and analyze digital communication systems/sub-systems through conduction of an Open-Ended experiment using electronic discrete components/LABVIEW software/MATLAB software

The CO-PO Mapping at beginning of semester

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	60%	60%	60%									
CO2	60%	60%	60%									
CO3	60%	60%		60%								
CO4	60%		60%									
CO5					60%				60%			
CO6					60%				60%			
CO7		60%	60%					60%	60%	60%		60%

Figure 5 The mapping of the COs with POs, with set targets

IV. An Example: Digital Communications

We now present the results of a VI semester core course in Telecommunication Engineering, 'Digital Communication', handled during the academic year 2013-14. The course outcomes are listed in **Table-I**, and the course content is available in the college website [9].

Having defined the Course Outcomes at the beginning of the semester, we also define the mapping of the Course Outcomes to the Program Outcomes, as shown in Figure 5. The mapping may be YES/NO format, or may include the set targets. The targets need not be constant for all entries. It is for the faculty to decide the targets. Since we are in the initial stages of comprehending Outcomes Based Education, we have set a uniform target of 60%. In addition to the above mapping, during the commencement of the semester, we also list the various assessment tools, and make the student aware of the various components that he would be assessed. The assessment tools we used are: (i) written examination, (ii) Quiz, (iii) conduction of fixed guided experiments, (iv) demonstration of an open-ended experiment and (v) seminar/ presentation of the self-designed experiment. The assessments were spread over the entire semester through three written examination as specified by the college calendar, and in addition we included a number quizzes. The laboratory component included continuous evaluation, and a semester end exam. The various assessments helped in arrive at the attainment for each of the defined course outcome and is shown in Figure 6.

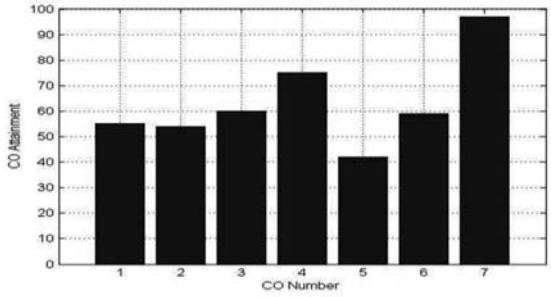

Figure 6: The attainment of the CO, computed at the end of the semester, and is based on the various assessment tools used.

In addition to arriving at the attainment of the course outcome, we also arrive at the attainment of the CO-PO components as shown in Figure 7. This is through mapping of every assessment tool to a CO and hence to a PO, and then computing the percentage of students who have secured greater than a set threshold.

The attainment of COs at the end of semester

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	63	39		63								
CO2		65	79	19								
CO3		66	79	35								
CO4	76	74										
CO5				37	44				44			
CO6				21	78				78			
C07		97	97		97			97	97	97		97

Figure 7: The actual attainment of the CO-P O through the course The contribution to various POs through the attainment of the CO, and is based on the mapping of the various assessment tools

The review process now requires comparing the attainment of Figure 7, with the initial set targets of Figure 5. Some of the positive aspects of the observation are:

- Though not in the CO-PO mapping, the assessment has addressed CO1-PO4, CO2-PO4, CO5-PO4 and CO6-PO4, and hence, during the next revision of CO-PO mapping, the addition will be incorporated
- This single integrated course has addressed relatively a large number of POs

The observations that cause concern are:

- It can be seen that we have achieved the set targets in most cases, however, there are some components not having met the target (CO1-PO2 for example).
- All the COs are well attained, however, CO5, is poorly attained and will be suitably be emphasized in the next semester
- The assessment did not address CO1-PO3, C02-PO1, CO3-PO1 and CO4-PO3, and shall be rectified, in the next semester
- The attainment of CO7, through the Open-Ended experiment is extremely high (97%), and hence the RUBRICS, and evaluation model needs to be looked into. This shall be addressed in the next semester
- PO6, PO7 and PO11 are not being addressed, and assessment tools to address them needs to be developed

The above observations will help during the teaching learning process for the next semester; there shall be a revision in the mapping of the CO-PO, small changes in the assessment tools.

V. Conclusions

In this work we have presented a typical semester cycle of a faculty handling a course. We have discussed possible improvements that are likely when the same faculty handles the course over successive semesters. It is expected that the self-assessment/review by the faculty at the end of the semester shall lead to a gradual improvement in the attributes addressed. When the faculty has an opportunity to handle the same course for significantly large number of times, then the outcomes are even higher and probably shall lead to the faculty presenting the course on a Global standards. The process improvement is a continuous one and can be improved forther through leveraging technology. The paper presents data for one typical course, as an example. The proposed process can

be introduced in any course, and if implemented in all courses, the competencies developed in the graduating engineering student will be able to meet the expectations and needs for his professional career.

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