AN OUTCOME BASED CURRICULUM DESIGN IN ENGINEERING - CASE STUDY APPROACH

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Abstract— **An Engineering curriculum is a continuously improving framework where the assessment of outcomes set path for further modifications to achieve the ideal result. The curriculum design is based on sound educational principles for giving students necessary fitness to solve the real world problems. For Outcome Based Education (OBE) to be a success in true measures, both the students and instructors must understand that higher education is not a unilateral mode where the textbook language is the only way to learn. Education in tertiary institutions should be more engaging and bilateral where the students develop the understanding on their own. Curriculum design plays a vital role in achieving such result. This paper proposes one such approach of curriculum design elaborating the design procedure with a case study. The paper brings out some of the interesting statistics about the outcomes achieved by implementing the proposed method. The case study discussed involves the exclusive set of rubrics developed as a measure of outcomes achieved and the computations of course outcomes providing weighted measures for different stake holders.**

Keywords-OBE, Curriculum Design, COs, POs

I. INTRODUCTION

OBE is an approach to education in which decisions about the curriculum are given by the exit learning outcomes that the students achieve at the end of the course. By taking a look at the traditional undergraduate education system present as on today, it is found that the system is not effective as students are not industry ready and lack in professional skills, soft skills, personality and leadership skills. Keeping the performance of the students in focus, colleges and universities around the world are moving towards adopting OBE.

One of the major issues in OBE is the effective curriculum design that provides experiential learning. Effectiveness of any curriculum can be measured by the process of teaching-learning and assessment of what students can actually do (i.e., learning outcomes), after they are taught. The OBE mainly attempts to adopt learning outcomes of the students in terms of knowledge, skills, attitudes and values that match the immediate social, economic and cultural environment of society. According literature survey made, there are three broad types of OBE:

- Traditional OBE which measures the learning outcomes in terms of students' mastery of the established curriculum.
- Transitional OBE which measures the learning outcomes of students in terms of generic or higher-order competencies such as critical thinking, problem solving, communication skills and teamwork.
- Transformational OBE which measures the learning outcomes of students in terms of broad category of disciplinary knowledge and skills (i.e., multi-disciplined), generic competencies, attitudes and values required by the industry or society.

Here is a table showing the differences between the Traditional Content based system to Outcomes Based System [1]

Table 1 Comparison of outcome based with content based education

Learning System Characteristics	Content Based (Traditional/Transactional)	Outcomes Based (Transformational)
Framework	Predefined curriculum, assessment & credentialing in place Structures "ends", no defined learners' outcomes	❖ Curriculum, instructional strategies, assessment & performed standards ❖ Structures support outcomes, flexible & a means to define "learning ends"
Time	❖ Inflexible constraint for educator & learner schedule controls learning & success	❖ Used alterable source – match needs of educator & learners
Performance standards	❖ Comparative & competitive approach ❖ Linked to predetermined "curve" or quota of possible successes	❖ Learners potentially able receive credit for achieving performance standards ❖ No quotas & standards pursued
Learning assessments	❖ Continuous testing & permanent grading ❖ Mistakes on permanent record: best grades & records fast & consistent performers; slower learners never catch up ❖ Never assess/ document what learners can ultimately do successfully	❖ Macro view learning & achievement ❖ Mistakes inevitable steps in development, internalizing & demonstrating high level of performance capabilities ❖ Ultimate achievement what able to do

The Table 1 indicates that the factors with which outcome based education method has its own advantage over the traditional content based education method. There have been quite a number of efforts that have been carried out to bring in the transformations in engineering education.

There are various educational strategies developed under OBE by researchers at different levels of education. The State Board of Education, Pennsylvania, in 1992 implemented performance based education In the US the General Professional Education of the Physician (GPEP) Report, published by the Association of American Medical Colleges (AAMC) in 1985, invited medical schools to give each student the knowledge, skills, values, and attitudes that all physicians should have [1, 2] .In the UK in 1993 the General Medical Council (GMC) published its recommendations for undergraduate medical education [2]. In recent years with the developments in semiconductor technology and computing technology the same need has been sensed in the field of Engineering also in different nations [3].

This paper presents the method followed for OBE based curriculum design with a case study where Instrumentation Technology program for under graduate study has been taken up. While designing the curriculum, an approach of forming course streams has been followed to cover the essential courses to be included under the specific program. Further, study includes analysis of designed POs in terms of their achievements through the attainments of course outcomes included in each stream. To compute the course attainments, both direct and indirect attainment tools have been developed.

To show case the method adopted in OBE, the results of attainment of POs pertaining to two courses have been considered. The same procedure may be followed for other courses structured in the curriculum. Both direct and indirect assessment methods have been taken up to measure the level of PO attainment and intern the success rate of the curriculum design

The paper is organised as follows. Section II gives the details about the steps followed while arriving at POs using the Graduate Attributes (GAs) pertaining to the curriculum structure under study. Section III provides the curriculum streams designed for the programme keeping attainment of the POs in focus. The procedure adopted for PO attainment through computation of course attainments is the subject matter of section IV. It gives the case study examples with the POs attained. The impact of PO attainment is discussed in section V as conclusion.

II. DEFINING THE PROGRAM OUTCOMES

Defining the Program Outcomes mainly involves the following steps:

1. Defining Program Educational Objectives
2. Adhering to Graduate Attributes Objectives
3. Discussion with Various Stakeholders
4. Summarizing Views to suit the requirement

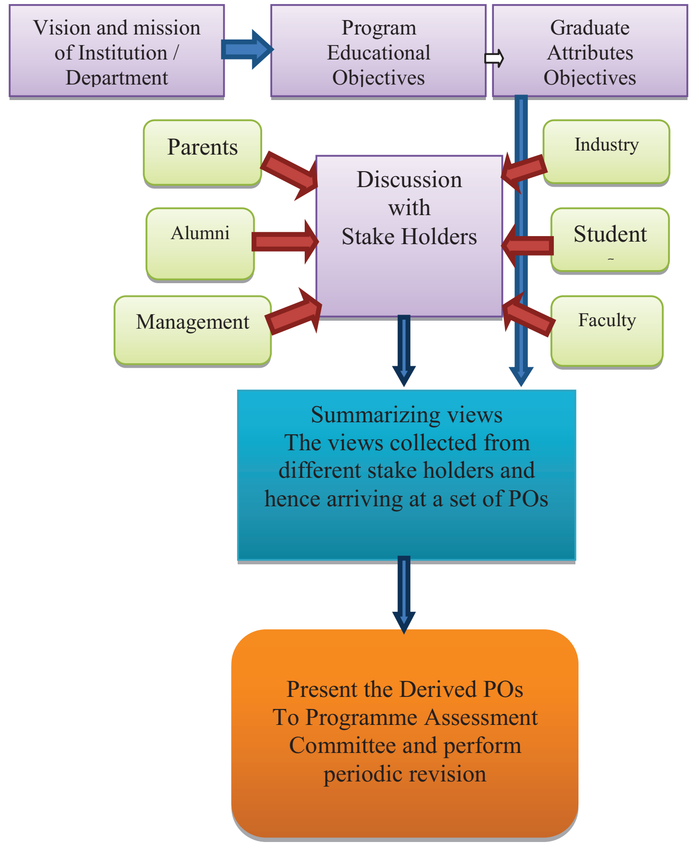


Fig 1 Procedure to define POs

Fig 1 indicates the contribution of various stake holders and the general steps followed in arriving at the POs while designing the curriculum in the current case study. With respect to OBE, Programme Outcomes (POs) become the resultant of the steps followed. POs for any programme are set of abilities which the student shall accomplish from the entire programme and are derived from the industry requirements and the society as the major focus. The defined POs are also aligned to the Graduate Attributes standards specific to the Engineering curriculum and as listed in Table 2 . The POs are grouped together to substantiate the PEOs. The correlation between the PEOs and POs are shown as the levels of agreements. The POs are designed based on the Graduate attributes, PEOs and inputs from Professional bodies. The correlation between the PEOs and POs are shown as the levels of agreements. As the POs are expected to attain by the graduates and PEOs are expected to attain few years after graduation, they have as many contributions. Each Program Outcome is contributing to one or more PEOs.

Table 2 POs for the specific program

Graduate Attributes	POS set for Instrumentation Technology
Engineering Knowledge	An ability to apply knowledge of Mathematics, Science & Engineering fundamentals for the solution of Engineering problems
Problem analysis	Capability to identify, formulate & Analyze design requirements for an appropriate solution.
Design/ development of solutions	An ability to design, implement & Evaluate an Instrumentation System to meet desired needs with appropriate Considerations for public health and safety, cultural societal and Environmental Considerations
Conduct investigations of complex problems	Capability to design & Conduct Experiments as well as analyze and derive inferences.
Modern tool usage	An ability to use current techniques skills & modern tools necessary for advanced instrumentation systems.
The engineer and society	Capability to analyze and design applications based on the Contextual knowledge to give solutions relevant to Engineering Practice.
Environment and sustainability	Understanding the impact of Contemporary issues.
Ethics	Understanding of Professional, ethical, legal, security and social issues and responsibility.
Individual and team work	An ability to function effectively as an individual and as team member in multidisciplinary environment.
Communication	Capability to communicate effectively on engineering activities with Engineering Community.
Project management and finance	Understanding of Engineering and management principles and apply to one's own work.
Lifelong learning	An ability to engage in continuing professional development

III STRUCTURING THE CURRICULUM DESIGN

Once POs have been clearly defined, a system level design has been developed in which course stream formation; content delivery and evaluation are considered to be main aspects. The POs are achieved through curriculum which offers a number of courses as well as elective courses. The courses offered could be broadly classified as Basic Sciences, Engineering Sciences, Core Engineering, Humanity and Social sciences, Electives and Project work. The present case study considered involves the curriculum design in Instrumentation Technology. This curriculum has 30% weightage on basic and Engineering Sciences, 40% weightage for core engineering courses while 20% for electives and 10% weight for Humanities, Social sciences and project work. The designed curriculum is grouped mainly into six streams. Two examples of course streams have been depicted in Fig 2 and Fig 3. As seen in Fig2 it indicates one stream of curriculum where the courses mentioned indicate an upward flow for continuity in learning

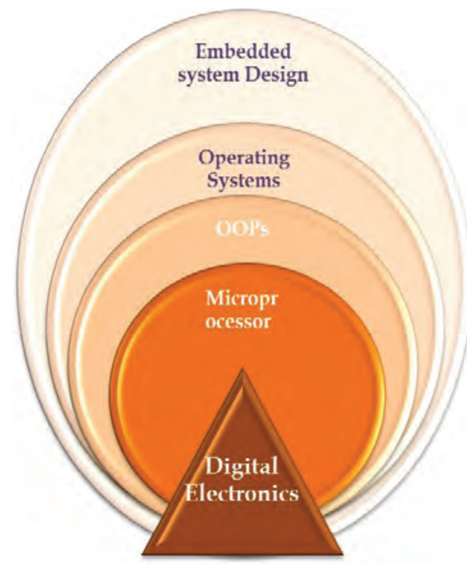


Fig 2.Course stream I

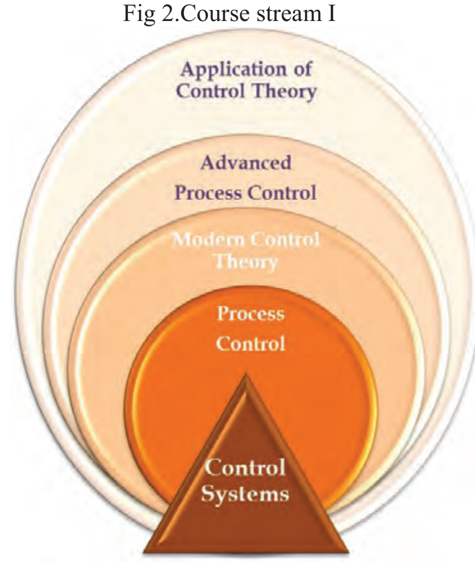


Fig 3.Course Stream II

A The curriculum implementation

Every course structured in the curriculum will have course outcomes (COs) which are priorly defined. Table 3 and Table 4 indicate the COs of two different courses defined in two streams. The COs are the outcomes that a student is expected to achieve after learning the course.

Table 3 COs of Field theory course

CO1: Apply the knowledge of electrostatic fields(PO1,PO2)
CO2:Apply the knowledge of Magneto-static fields.(PO1,PO2)
CO3: Combine the knowledge of electromagnet statics for time varying fields (PO1, PO2).

Table 4 COs of Microprocessors

CO1:Apply knowledge of digital Electronics, identify various functional blocks of ,microprocessor and its interconnection to peripherals in forming a microcomputer based system(PO1,PO2)
CO2:Using standard programming structures, develop assembly language programs to solve reasonably complex problems and implement the same on a standard assembler(PO3,PO4,PO6)
CO3: Design memory interface for different system requirements using typical memory chips(PO3.PO4,PO5)
CO4: Using Input/ Output data transfer techniques and interfacing chips, design hardware and software for different applications(PO3,PO4,PO5)

For example, this paper takes up two case studies of Field Theory and Microprocessors. Under the transformational or rigorous OBE, curriculum, teaching and assessment are developed jointly by all stakeholders – students, employers, faculty staff, alumni and community. Each student's needs and learning outcome are accommodated in this approach through multiple instructional strategies and assessment tools including assignments, projects, oral presentation, traditional tests and the totality or portfolio of the student's work. Common teaching and learning methods include interactive lecture, case-based learning, problem-based learning, simulation, role play; online tutorials, self-directed learning, experiential learning, laboratory work, fieldwork, peer tutoring; together with a choice or combination of different assessment methods such as objective tests, case studies, essay questions, projects, end-of-chapter type problems, reflective journals, seminar presentation, portfolio, examinations, and peer and self-assessment. Students will undergo rigorous training on selected set of courses and will be taking up continuous internal evaluation (CIE) tests given by the course instructor and semester end examination (SEE) conducted at institution level comprising of both internal and external evaluators. The following section indicates the attainment of POs through COs

IV ATTAINMENT OF POs

One of the parameters to measure the attainment of POs is through evaluation of attainment of a pre-defined set of COs. Each course has defined set of COs that are mapped to the POs and they are used to provide quantitative measurement of how well course outcomes are achieved. The correlation between POs and COs for two courses is shown Table 3 and Table 4. The CO mapping is done quantitatively and mapping matrix is made available in the course syllabi. Meeting the COs by the process of evaluation through examination system is a clear benchmark for attainment of POs. Indirect measurement involves the course-end survey, project based learning assessments, conducting open ended experiments, taking up competitive examination for higher education etc

The attainment procedure has been elaborated in the following sub-section.

A. CO Attainment

COs are evaluated based on Continuous Internal Evaluation (CIE) as a direct measure and Course End Survey (CES) as an indirect measure. To explain the procedure adopted for attainment calculation, two courses examples have been considered. The total attainment in terms of the students' performance towards achieving the COs is measured using both direct and indirect assessment tools. The direct assessment involves his performance measures in CIE and SEE.

B. CIE Calculation

(i) Case Study Examples

A course work named 'Field Theory' as a core Engineering course in Instrumentation Technology at 2nd year (4th Semester) is considered for CO attainment has a set of COs as indicated earlier in Table 3. To compute the CIE performance of the student in this course-work, a weightage of 20% has been assigned for each question in each CIE test conducted in a semester. The percentage of students attempted a particular

Table 5: CIE Contribution for CO attainment

Field Theory11ES4GCFTH			
ATTAINMENT	CO1	CO2	CO3
>40%	0.68	0.68	0.42
>60%	0.31	0	0
>75%	0.24	0	0

question in a CIE and scoring of number of students who are able to score above 40%, above 60% and above 75% have been considered as scales of measures for attainment (See Appendix 1, 1.2). As seen from Table 3 there is an average attainment of 0.68 on scale of 1 as more than pass percentage contributing towards CO1 and a contribution of 0.3 and 0.24 for greater than 60% and 75% respectively. Since CO1 and CO2 both have contribution for PO1 and PO2 this course outcome computation through CIE has directly affected the PO attainment

Table 6: CIE Contribution for CO attainment

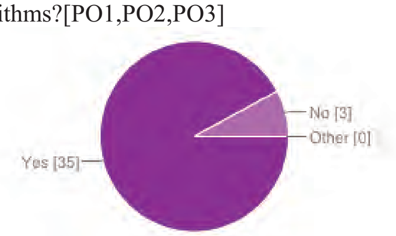
CO Attainment (Direct) for Microprocessor				
ATTAINMENT	CO1	CO2	CO3	CO4
>40%	0.847	0.90	0.85	1
>60%	0.76	0.81	3) 0.70	0.98
>75%	0.63	0.76	0.62	0.87

The Table 6 shows the attainment of COs in another course-work Microcontrollers taken up by the students in the 2nd year of their course. As seen in Table 6, the rubric developed for direct attainment considers test performance of the students where scoring of 60% of the marks in every question set in the question paper is given a weightage of 50%. Above 75% of the scoring is given weightage of 25%. Below 60% and above 40% is given weightage of another 25%. From the table it is seen that this course contributes with four outcomes to POs where 4 POs have been addressed by these COs (Appendix 1, 1.1). The results represented clearly indicate that the CO computation of different courses and intern their impact on PO attainment using direct method.

C.Rubric for Indirect assessment

Rubrics are the tools used for assessing the course outcomes indirectly which would have an impact on PO attainment. Course end survey for every course designed under the curriculum structure and the analysis of the survey carried out in the form of a rubric gives the outcome of a course in terms of percentage achivements. Following few questions belong to course end survey questionaiers. The question sample indicated in this paper also indicate the POs addressed and quantitaive measurements can be computed using the response.

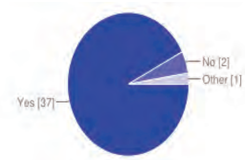
1) Q1: Will you be able to design, build, and debug simple microcontroller based systems by applying suitable algorithms?[PO1,PO2,PO3]



2) Q: Given an analog circuit using diodes, BJTs and FETs, would you be able to identify and describe models and transfer characteristics of the same?[PO1,PO2]

No. of responses:40

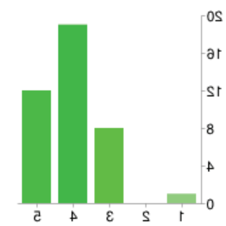
Yes	**37**	93%
No	**2**	5%
Other	**1**	3%



Q: How would you rate the relevance of the subject

No. of responses:40

1	**1**	3%
2	**0**	0%
3	**8**	20%
4	**19**	48%
5	**12**	30%



V CONCLUSION

It is observed in this study that by devising proper content delivery and assessment mechanisms it is possible to know the outcomes of an Engineering curriculum quantitatively and hence the success of a curriculum design. In this way it seen that the outcome based education provides an opportunity for a student to explore his interests in technical education. The OBE implementation enables him to be able to evolve himself to take up engineering problems addressing the contemporary issues and provide Engineering solution.

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Apendix 1

1.1 Example for Direct assessment of Field theory

Course Code	CO 1	CO2	CO 3	CO 4	CO 5	Average of COs	Attainment Level (High)
10ES4GCMCS	0.625 067	1	0.725166			0.78	
BMI		0.7				0.7	
DSPA		1		0.83606		0.9	
VHDL	0.89	0.95	0.950	0.927		0.92	
Fundamentals of HDL	0.828	0.82	0.93			0.86	
DEC	0.699	0.69	0.737			0.71	
AEC	0.624	0.667	0.9666	0.966		0.793	
Op-amps and Linear ICs		0.775	0.784	0.84		0.79	
DSP			0.7	0.98		0.84	
Process Control			0.54	0.85		0.7	
VLSI Design	0.70	0.86	0.90	0.88		0.83	
PROJECT WORK	NA					0.728	

1.2 CO Attainment through CIE Test

Total attained 75%	2	1	9	7	11	10	21	13	22	19	12	20	16	17	4	11	32
Total attained 60%	2	2	10	15	15	15	27	23	25	23	15	20	16	17	4	24	33
Total attained 40%	13	18	23	18	22	18	28	29	27	23	17	20	17	18	4	32	33
Total attempted	29	30	24	20	24	18	29	29	28	23	18	20	17	18	4	32	33
Attained for 1 (40%)	0.44828	0.6	0.95833	0.9	0.91667	1	0.96552	1	0.96429	1	0.94444	1	1	1	1	1	1
Attained for 1 (60%)	0.06897	0.06667	0.41667	0.75	0.625	0.83333	0.93103	0.7931	0.89286	1	0.83333	1	0.94118	0.94444	1	0.75	1
Attained for 1 (75%)	0.06897	0.03333	0.375	0.35	0.45833	0.55556	0.72414	0.44828	0.78571	0.82609	0.66667	1	0.94118	0.94444	1	0.34	0.9697

Attainment on 40%		Attainment on 60%		Attainment on 75%		Direct Attainment
CO1 Attainment	0.81897	CO1 Attainment	0.5944444	CO1 Attainment	0.4149806	0.8283523
CO2 Attainment	0.97837	CO2 Attainment	0.8252137	CO2 Attainment	0.6814701	0.8283523
CO3 Attainment	1	CO3 Attainment	0.9444444	CO3 Attainment	0.8674242	0.9372896
Direct Attainment	0.9324462	Direct Attainment	0.7880342	Direct Attainment	0.654625	

CO Attainment on 40%