International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-12 Issue-5, June 2023

Implementation Challenges and Opportunities in the Outcome-Based Education (OBE) for Teaching Engineering Courses: A Case Study

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Abstract: ***Outcome-based education is a closed-loop control system accepted globally for enhancing the teaching-learning processes. However, the success of the system is not prominently visible in fresh graduates. Hence detailed research and optimal process to implement OBE is necessary. This paper aims to investigate the challenges in implementing Outcome-based education and explores opportunities for improvement. Further, pedagogic planning for the analytical subjects has been proposed and the performance of the proposed method is analyzed using a case study. Performance improvement in Course Outcome attainments of the course Antennas and Wave Propagation, offered for undergraduate engineering (ECE) students have been investigated and evaluated in this paper. The investigation shows that dynamically adapting the teaching-learning and assessment methods during the course based on the assessments of the student's capabilities results in improved performance. The following changes in the system have been suggested for the optimal implementation of OBE. The CO targets for the current semester course should be fixed based on the CO attainment of the previous semester courses of the same batch instead of the traditional way of fixing CO attainment targets. The microanalysis of the end-semester marks and students' feedback at the ratio of 5:1 may be considered for overall CO attainment computation at the end of the course.***

Keywords**: *Outcome Based Education, Antenna and Wave Propagation, Course Outcomes, CO attainment.***

I. INTRODUCTION

In India, around 1.5 million students are enrolled in engineering programmes each year. Yet, the number of graduates lacks the fundamental abilities needed to compete on a global scale [1]. Due to a lack of crucial skills and industry-specific expertise, engineering graduates are frequently struggling to find and sustain employment. This necessitates a thorough investigation and analysis of the different factors that result in engineering graduates with inadequate skill sets [2]. Teaching students how to recall the lessons should be replaced by teaching them how to learn deeply. Given this, the UGC and NAAC have both said that OBE based on the Bloom-Anderson taxonomy of learning is a successful technique of curriculum design for high-quality teaching and learning processes [3]. OBE is a student-centered educational approach that emphasizes the desired results of learning rather than the content and methods of instruction. Unlike traditional education models that focus on delivering content through lectures and textbooks, OBE emphasizes the importance of defining measurable learning outcomes and designing instruction to achieve those outcomes. In technical education, OBE involves identifying the specific knowledge, skills, and abilities that students should be able to demonstrate upon completing a program or course of study [4]. The cornerstones of this learning system include contemporary curriculum content, a variety of teaching pedagogy and learning techniques, and suitable evaluation procedures [2]. This learning system makes teachers more creative and innovative in designing the curriculum, course content, teaching strategies and assessment evaluation. Further, it motivates the learners to take responsibility for their learning through feedback [5]. The main goals of OBE are to create methods for reverse instructional design that are output-oriented, to set training goals based on students' expected career development and future demands, and to implement ongoing improvement that is motivated by instructor assessment [6]. OBE approach places a greater emphasis on practical application and hands-on learning, intending to produce graduates who are well-prepared to enter the workforce and make meaningful contributions in their chosen fields. OBE has been widely adopted in technical education because it aligns closely with industry needs and ensures that graduates possess the skills and competencies that are most relevant to their future careers. OBE has gained popularity in recent years as it provides a clear framework for designing and delivering technical education programs that meet the needs of both students and employers. [7] discusses the implementation of OBE in the accounting programme at a higher education institution in Malaysia. The paper highlights the importance of OBE in the context of higher education and the need for higher education institutions to adopt this approach to ensure that graduates are equipped with the necessary skills and competencies to meet the demands of the job market. A survey has been conducted among students and faculty members to evaluate the effectiveness of the OBE approach.

Manuscript received on 18 April 2023 | Revised Manuscript received on 05 May 2023 | Manuscript Accepted on 15 June 2023 | Manuscript published on 30 June 2023.

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The findings of the study indicate that the OBE approach is effective in enhancing the quality of education and producing graduates who are competent and capable of meeting the job needs. In [8], an extensive review of the literature on Outcome-Based Education (OBE) and the factors that affect student learning outcomes in tertiary education. An extensive overview of the benefits and challenges of the OBE approach and the importance of faculty members and assessment in promoting student learning outcomes are discussed. The authors have identified faculty members and assessment as key factors that influence student learning outcomes.

While Outcome-based education (OBE) has many advantages, implementing this approach also comes with certain challenges. Some of the most common challenges in OBE are listed as follows.

Designing Effective Assessment Tools: One of the biggest challenges of OBE is designing effective assessment tools that accurately measure student performance against the desired learning outcomes. Developing valid and reliable assessment tools that can measure the desired outcomes can be a complex and time-consuming process.

Balancing Competing Interests: Another challenge in OBE is balancing the competing interests of various stakeholders, such as students, employers, and regulatory bodies. Students may want to focus on achieving good grades, while employers may prioritize specific competencies that are essential for job performance.

Ensuring Faculty Buy-In: For OBE to be successful, faculty members need to buy into the approach and be committed to implementing it effectively. However, some faculty members may be resistant to change or may lack the necessary skills to implement OBE effectively.

Addressing Resource Constraints: Implementing OBE requires significant resources, including time, expertise, and funding. Institutions may face resource constraints that limit their ability to develop and implement effective OBE programs.

Managing Data: OBE generates a significant amount of data, and managing this data can be challenging. Institutions need to have effective systems in place for collecting, storing, and analyzing data to ensure that they are making informed decisions based on accurate information.

Overall, addressing these challenges requires careful planning, effective communication, and a commitment to continuous improvement and evaluation. In this paper, OBE processes implemented for the conduction of the course Antenna and Wave Propagation offered to the group of 64 third-year BE (ECE) students have been evaluated. The organization of the paper is as follows: Session II elaborates on the OBE process implemented for the course and the CO attainment computation and the course under the case study given in Session III. Session IV concludes with suggestions for improvement.

II. TEACHING LEARNING METHODOLOGY

The flow chart describes the teaching-learning process implemented and analyzed in this paper. It consists of 3 phases: The planning Phase, the Implementation Phase and Attainment Analysis Phase. The components included in the teaching-learning process are as below.

- Syllabus
- Course Plan
- Resources planning
- Instructor's perception of students' abilities and motivation
- Observations on Instruction
- Additional sessions are conducted by the instructor beyond the scheduled hours.
- Assessment tools
- Feedback to students after every assessment
- Report on Observations on Assessment Tools and Student Performance
- Student feedback during the course.

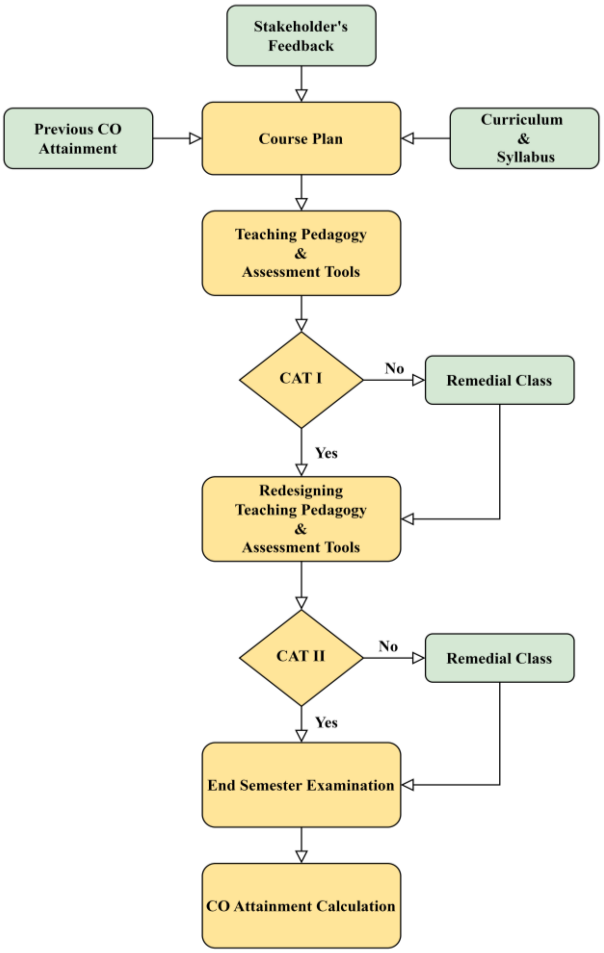

Fig. 1 Teaching Learning Process

The course plan is a critical part of OBE, and it should be prepared well ahead of the start of the course. The Feedback from the students/faculty who have studied in the previous year is taken as the main input for the course plan. The CO attainment analysis for the previous batch and suggestions reported, and the course-end survey from faculty and students are the components to be considered. Understand the Implement Phase's sub-processes including Syllabus, Planning for resources and Instructor's perception of students' abilities and motivation.

The teaching-learning process for the course should be designed by considering the nature of the course, the number of hours/credits given in the curriculum, and the student's competencies and motivations. The success of the process also depends on the instructor's perceptions of the students and ability. In recent years, the teaching-learning process uses various methods to engage the students effectively such as; experiential learning, participative learning, and e-resources using Learning Management Systems (LMS). It should be students friendly and encouraging by incorporating flexibility and proper communication.

Feedback from the students to the teacher and the teacher to the students plays a major role in the stable feedback system. The observations of the instruction classes, assignment performance and surveys from the students will be the main components of the feedback system. In this proposed method the system parameters were dynamically changed during the course based on the observations from the performance in the continuous Assessment Tests conducted during the middle of the semester and surveys from the students.

III. CASE STUDY

The method proposed in this paper is implemented and analyzed in this session for the course Antenna and wave propagation (AWP) offered to the students studying the third year undergraduate BE programme, Electronics and Communication Engineering at Kumaraguru College of Technology. The number of students in the group is 64 and it is a mixture of students with different levels of competencies and mathematics/Science knowledge.

A. About the Course

Antennas and Wave propagation is an analytical course that is always considered a tough course from students' point of view. It is hard to visualize the propagation of the waves unless one deeply understands the basic physics behind the content. Also, to solve problems and understand the derivations the students should have deep knowledge of vector calculus and electromagnetic theory. If one could crack the secret behind electromagnetics, then this is a wonderful subject and people will start admiring the course. The challenge in teaching antenna theory is motivating the students to learn the basics along with analytical discussions. The course outcomes of the Antenna and Wave Propagation course are listed below: On Successful completion of this course, students should be able to

1. Describe different antenna parameters [K2]
2. Design and analyze various wire antennas. [K4]
3. Compare different antenna arrays [K2].
4. Illustrate techniques used for antenna parameter measurements [K3].
5. Analyze the performance of aperture antennas [K4].
6. Identify the different types of propagation of radio waves at various frequencies [K2].

B. Course Outcome Attainment Calculation

The pass percentage is considered a direct measure to understand the student's knowledge level. Also, the course outcome attainments were computed based on the performance in the CAT Tests and ESE marks. In this case, student the Continuous Assessment Test I mark is considered as direct feedback about the students to understand the attainment of their learning objectives. 3 COs were considered in the CAT1, and the questions are coined to assess the learning outcomes of the students. The pass percentage was below 50% in CAT I. The CO attainments were well below the targets fixed. It was observed from their performance on the test, they were not able to answer the problems correctly, however, many of the students attempted to solve the problem. It shows the students struggled to understand and relate mathematics and physics involved in the content. After the end-semester examination, the student's feedback about the CO attainment was obtained on a three-point scale and used as an indirect assessment tool. The average value of the feedback collected is shown in the Figure.

C. Course Outcome Attainment Calculation

The Course Outcome attainment should be quantified to do a scientific analysis of the teaching-learning process. The attainment is calculated based on the scores in the following assessment components:

1. Continuous Assessment Test I (CAT I),
2. Continuous Assessment Test II (CAT II),
3. Assignments,
4. End Semester Exam marks and Student feedback about the CO attainments.

The scores of all the components were taken out of 100. The CO score (in %) of the individual student was computed by a weighted average of these components.

$$\begin{aligned} &CO\ Score\ in\ \% = 0.5 \times \\ &(CAT\ I\ and\ CAT\ II\ marks\ scored\ by\ the\ student) + \\ &0.2 \times (marks\ scored\ through\ Assignments) + \\ &0.2 \times (End\ Semester\ marks) + 0.1 \times \\ &(Student's\ Feedback) \end{aligned}$$

The overall attainment of the COs was computed as,

$$CO\ attainment = \%\ Number\ of\ students\ obtained\ CO\ score\ above\ 60\%$$

The overall CO attainment of the sample batch of 64 students for the course Antenna and Wave Propagation is compared with the feedback given by the students in Figure 3. The students' feedback shows that they gained good confidence at the end of the course. However, the attainments of CO1 and CO2 are less than 50% in the CAT I. However, the attainments of CO3, CO4 and CO5 were improved comparatively. This improvement shows that the knowledge of the fundamentals had improved; since Antenna parameters and the idea of the radiation pattern of a basic antenna (dipole antenna) are necessary to understand the concepts dealt with in the other COs. The teacher's feedback about their score in the CAT I and the remedial classes conducted for the students helps them to understand the basic concepts.

IV. RESULT AND DISCUSSION

The CO attainment for all 6 COs was computed based on the methodology described in the previous session and the results are plotted in Fig.2 and Fig. 3.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Fig. 2 reveals that the CO attainments of CAT II are better than CAT I. The first two COs address the fundamental concepts. Even though the students struggled during the CAT I period to follow the concepts, they should be able to pick up during the CAT II duration. This is due to the feedback given to the students based on their CAT I performance and fine-tuning the teaching-learning process according to the student's level of learning and expectations.

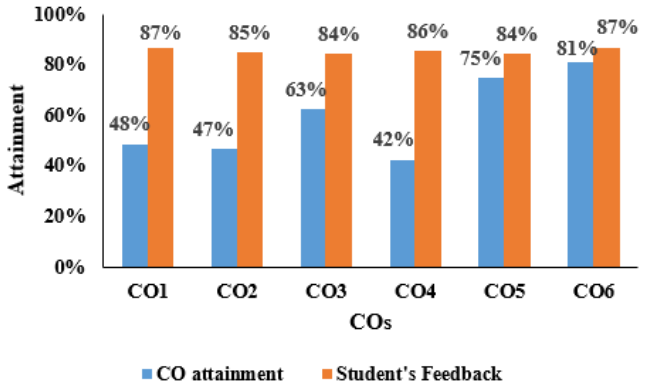

Fig. 2. Comparison of overall CO attainment and student Feedback.

The student's feedback about the course outcomes is above 80% for all the COs. This shows that at the end of the course, their fundamental knowledge also increased and they could understand better the concepts thought during CAT II.

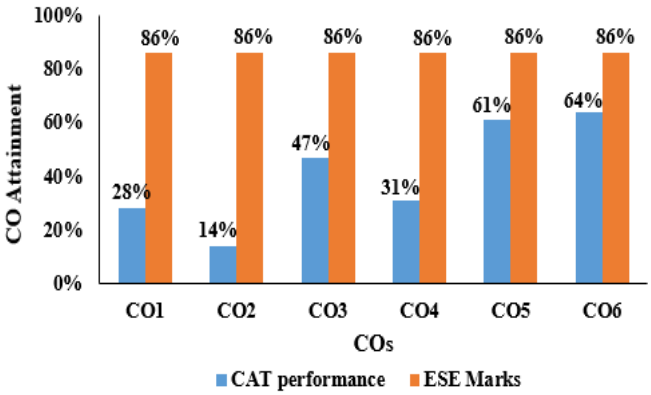

Fig. 3. Comparison of CO attainment in the CAT and ESE.

In Fig. 3 the CO attainments computed using only CAT performance are compared with the average value of the end-semester marks. This figure shows that the attainments of all the COs were significantly improved in the end-semester examination. The results reveal that the feedback system proposed works well and improves the overall end-semester exam performance of the target group.

A. Observations:

Many of the references suggest the targets for CO attainment should be fixed based on the performance of the previous batches based on the assumption that the students opting for Engineering would have similar knowledge levels and motivations. The fact is that the student's expectations and learning abilities are different and seek individual attention. Hence, the CO attainments of the previous batch will not be appropriate for fixing the CO attainment target for the current batch. Hence, it is suggested to consider this CO attainment to fix the targets for the COs of the courses offered in the next semester for the same batch. These concepts are still to be researched to improve processes to achieve overall performance which would have been quantified through Programme Outcome attainments.

The implemented CO calculation gives equal weightage to the CAT I and CAT II performance. However, the CAT II performance got improved after the remedial classes and giving special attention to the subject concepts on which students lagged during CAT I. It shows that the overall knowledge of the fundamentals increased. Hence, it is suggested to have only the microanalysis of the end-semester marks and the overall feedback from the students collected at the end of the course. This would be an optimal and unbiased estimate of CO attainment.

V. CONCLUSION

The attainment of programme outcomes (POs) is the main objective of the curriculum design and the teaching-learning process adapted. The main source of PO attainment is CO attainment. The targets for the CO attainments are fixed based on the performance comparison with the previous batches. This paper analyzed the teaching-learning and assessment process implemented for the course Antenna and Wave Propagation offered for third-year BE (ECE) students. Based on the results and analysis, suggestions were given for a stable feedback system to achieve improvement in students' performance.

The results show that adapting the teaching-learning / assessment process more dynamically during the course based on the CAT and Assignment performance will help the students to achieve the learning outcomes. Based on the analysis, it is suggested to fix the CO targets based on the CO attainments obtained in the previous semesters of the same batch to get meaningful results. Further, it is observed that the microanalysis of the end semester marks and the student's feedback alone is sufficient for the overall CO attainment computations.

DECLARATION

Funding/ Grants/ Financial Support	No, I did not receive.
Conflicts of Interest/ Competing Interests	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	All authors have equal participation in this article

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