Tailor-made Educational Model realizing Intended Learning Outcome to enhance competencies among Engineering graduates

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Abstract: To refrain from the constant crisis on lack on competent engineer's, it is vital for the educators to evolve a tailor-made Educational Model that custom suits the aspirants and help attainment of Programme Educational Objective. Clear alignment begins with Identifying what a student will be able to do, Planning & Organizing the curriculum delivery, and Strategies towards Teaching-Learning & Assessment ensuring realization of intended skills. The basic principles that facilitate and drive the above starts with clear definition on intended learning outcomes guided with set performance standard towards engaging deep learning and strive for expanding opportunities. Custom-designed educational model is essential for creation of learning atmosphere that supports appropriate learning activities to attain the desired learning outcomes. By effectively identifying the learning outcome for each topic in a course with proper implementation help us to achieve Course outcome (CO) of a course. This paper is a micro level initiative towards the achievement of COs and thereby visualizing the learning skill as well as the cognitive skill of a student through each and every topic taught in the course. The proposed approach was practiced in third semester B.E (CSE) for Data Structures and Algorithm Course. The effectiveness of the above model is implemented and measured using standard tools.

Keywords: Effective Teaching, Interactive classroom practices, Learner Centric Approaches, Intended Learning Outcome

1. Introduction

Conventional way of designing programmes was to start from content of the course. Teachers decide on what they intended to teach on the programme, decide content, plan how to teach and then assess the content. This approach of teaching is commonly referred as Teacher-Centric approach. Trends now have changed from Teacher-centered to Student-centered. The alternative method focuses on what the learners are expected to do at the end of the programme, commonly called Outcome-Based Education. A statement that expresses what is expected at the end of the course is referred as Intended Learning Outcome (ILO), in short Learning outcome. Clear understanding and articulation of intended learning outcomes facilitate the design of an effective curriculum and appropriate assessments to measure achievement, and to plan the learning process for individual students [1].

Educator involved in designing a course or adopting a standard curriculum, need to begin course preparation by clearly defining what students will be able to do as a result of the learning activity. The learning outcomes for each course need to be measured and used for continual improvement in course quality [2]. Outcome Based Approach to Student Learning (OBASL) focuses on what the students are expected to learn, and do in terms of ILO. OBASL based courses inform students what and how they learn leading to quality learning outcome attainment shown in Fig.1.

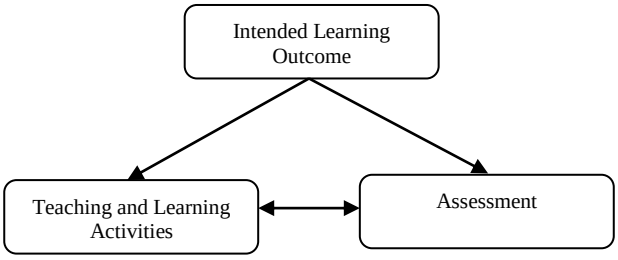

Fig. 1. OBASL Model

Learners aim to achieve learning outcomes by successfully completing a unit of learning [3]. Intended Learning Outcome articulates what the learner should able to know (cognitive), do (skills) and value (affective) upon

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completing the course. Hence, outcomes are usually expressed as Knowledge, Skill or Attitude. ILOs are the keys to determine course content, instructional strategies, student centric learning activities and assessment approach to ascertain attainment of ILO. Teaching learning activities are to be designed by the instructors to help learner achieve the stated ILO. Assessment as a continuous evaluation process is to be aimed at improving and understanding the achievement of ILO.

Intended learning outcomes is crucial that the teaching and learning activities (TLA) are designed in a way to help the students to achieve these outcomes [4]. When adopting the OBASL model, we need to ensure that all the learning outcomes have been addressed by the assessment tasks to some extent. The assessment procedures should be reliable and fair. Also, the assessment tasks should provide an adequate opportunity for learner's to express their individuality

This paper is organized as follows: Section 1 shows the motivation for designing the Learning outcomes for every course. Section 2 describes the way of identifying the learning outcomes whereas Section 3 discusses how to align Teaching, Learning & Assessment with ILO. In section 4, identification of ILOs for the case study is described and implementation as well as results are discussed in section 5 and finally concluded in section 6.

2. Identification of Learning Outcome

Course Instructor can be effective in the role by identifying appropriate teaching, learning, assessment strategies with timeline and thereby, supporting progression in learner's potential. By realistic consideration on what students can accomplish, ILO for the courses can be determined. ILO should include minimum acceptable state / level a student to reach in examining course completion. Thus, stated ILO aid student to recognize what is expected and help teacher to precisely realize what student has to achieve.

A. Demonstration of ILO using Bloom's Taxonomy

The task of devising learning outcomes is made easier with Bloom's taxonomy. The taxonomy consists of a hierarchy of six increasingly complex thinking processes, starts with the simple recall of facts to evaluation at the highest level. Bloom's taxonomy is commonly used by course instructors for writing learning outcomes as it provides a readymade structure and list of verbs.

Course Instructor considering the topics and level of the course shall examine the following to identify ILO

1. Facts and core competency the student is expected to gain
2. Basic concepts students should understand
3. Skill that is expected to be gained by the students upon course completion.

Six successive level arranged in the hierarchy are Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation.

B. Measurable and Observable ILO

Learning outcome must specify the essential learning for every unit / module. Curriculum for the Programme offered must essentially have the component of ILO for every unit / module. Learning outcomes must be simple, clearly described and must be capable of being validly assessed. Greater the synergy between Teaching, Learning and Assessment strategies, the greater precision on the attainment of ILO.

Measurable and observable learning outcome with acceptable standard to facilitate attainment of intended skill / knowledge / attitude with a suitable assessment ascertains the attainment of Course Objective. Learning outcomes specifies the behaviour of the learner in any of the three domains viz cognitive, affective, psychomotor. Cognitive involves thought processes, Affective includes attitude, feelings, values and Psychomotor involves physical skills.

3. Aligning Teaching, Learning and Assessment with ILO

Aligning Teaching- Learning strategies, Assessment technique and criteria with ILO are the challenging phases for the course instructor. The correlation between Teaching-Learning and Assessment results in more transparent and meaningful overall educational experience.

A. Enhancing Student Learning through Teaching

1) *Effective Teaching Methodology:* Opportunities to plan and organize, monitor work, directs self- learning, and to self-reflect along the way amidst the learners. It also increases the ownership and self-awareness drives towards objective. It is the role of the instructor to create such opportunities in the process.

Methodology for Teaching should encourage learner's attitude towards accomplishing the objective of the course. It is ideal to present models or examples, real-world analogies, appropriate application of the concept and facilitate the entire class to involve in discussion. It is essential for the instructor to provide individual feedback and group feedback on patterns that they see in the collective class' response. Learner also need to be given opportunities to provide feedback to the instructor to adjust the learning process, materials, and instruction accordingly.

Content beyond the Syllabus (CBS) covering applications / latest technology / case study for theory and laboratory courses gives more insight into the courses. Mandate component on CBS helps in knowledge expansion and help learner being updated.

Tutorial sessions provides individual support for learners, a scheduled activity for problem-based subjects provides one-to-one attention in which instructor speaks less time than the students. Tutorial sheets are to be planned in prior to the schedule and circulated to the students well ahead to tutorial sessions. Learning can be greatly enhanced if the student is motivated to do prior work on the planned tutorial topic.

To enhance skills and knowledge in students, Case-studies are effective form of teaching. Case studies for the courses promotes active learning and shall be presented at the end of the course by the learners. Case studies demonstrating theoretical concepts to application provoke student-centric learning.

2) *Interactive Classroom Practices:* It is recommended for instructors to give equal priority for formative and summative assessment practices. To measure student's learning / understanding during the instructional phase, formative assessment is a great way to measure and to happen throughout the process. Instructor can adapt suitable approaches in teaching based on learner response to formative assessment and do modification, improvements to reflect on student learning. It gives evidence to progression resulting in active process. Interaction based lecture sessions includes activities like recapping sessions by students, questionnaire, quiz, role play, mind-mapping etc.

Effective Formative assessment practices

- Doodle – Challenge learners to draw picture to explain the concept
- Caption images – Learner to caption the image depicting the concept
- Metacognition table – Learner to answer the questions presented to them on index cards:
    - What is taught?
    - Why it is essential?
    - What did I learn today?
    - How can I apply it?
    - What questions do I have about it?
- Twitter Board – Learner to summarize what was learnt in a lesson.
- Roll the die - At the end of class, each student rolls and briefly answers aloud a question based on the number rolled:
    - I want to remember …
    - Something I learned today
    - One word to sum up what I learned
    - Something I already knew
    - I'm still confused about …
    - An "aha" moment that I had today
- Viva-Voce for every laboratory experiments.

3) *ICT enabled Approaches in Teaching:* An ICT-enabled pedagogy entails that the teachers take on newer and challenging roles to facilitate an effective teaching-learning process. ICT enabled teaching has the potential to impact quality education for all.

ICTs implementation approaches

- ICT for course delivery through synchronous distance-mode video-conferencing like EDUSAT, A-View Classes
- Embedding ICT components in course contents like usage of Virtual Labs, simulation tools etc.
- ICT for learning process, like packages (Commercial / custom-built) for tracking student learning processes.

B. Learner-Centric Approaches

Learning approaches are guided by curriculum content, pedagogy & assessment, and supported by course instructor and the learning environment. Learner should play an active role in their learning experience – either on their own, or in collaboration with peers.

1) Independent Learning: Nurturing, creating opportunities and experiences that encourage learner's motivation, curiosity, self-confidence are essential Teaching-Learning components. Course instructor formulates the component that fosters independent learning that includes skills and attitude. Course wise Problem-Solving Tutorial Sessions, Computer Based Tutorial sessions, Library hours shall be integrated in regular class time-table. Appropriate appraisal on the learning element with suitable reviews ensures the objective of the learning.

2) Collaborative and Cooperative Learning: Educational experience that are active, contextual, engaging and student-centric leads to in-depth learning. Scheduled activities resulting in development of higher-level thinking, promotion of student-faculty interaction, increase in student self-esteem & responsibility, understanding on diverse perspectives should be incorporated in the learning process.

- Course wise Application based group assignments to be made as an integrated component for passing the course. Suitable development of proto-type model / simulation works is to be encouraged
- Industrial exposure through In-House training scheme / In-Plant Training / Industrial Visits to be made as an integral component of learning.
- Mini project and Mega project Expo to strengthen practical skills. Encouragement on Mini-Project work before regular final year project work inculcates team learning abilities among learners and explores technical skills in a cooperative manner.
- Technical activities involving Student Association, Professional Societies, Clubs etc. helps participant attain Technical, Communication, Organizational skills.

C. Designing assessment to demonstrate achievement of ILO

Effective assessment is inseparable from good teaching and learning. Assessment determines student approach to learning. It is the role of the assessor (Teacher) to define, prioritize what is expected to learn. It is essential to upfront learning outcome for the courses at the course plan. Learners are made to be active partners with shared responsibilities for their own learning and achievement. This strategy recognizes the need to develop progressively self-directed and confident learners with the knowledge, skills, attitudes and values, which enhance their employability and progression opportunities. It acknowledges that students learn most effectively if they are supported as individuals to achieve personal development.

Learning outcome for the courses must be stated in course plan and learner must be made aware. Course outcome cumulatively meet the Programme Outcomes which in turn achieve Programme Educational Objective. Attainment of Intended Learning Outcome confides with assessment blueprint and question paper. Weightages to Professional and career enhancement skills augments the overall grooming of the learner.

4. Case Study on identification of ILO attainment for the courses

The ILO attainment for every course can be measured by the following.

Table 1. Test Blue Print

Intended Learning Outcome	% of Exam points
University Exams	50%
Internal Assessments and Activities	50%

Table 2. Weightage for Student-Centric learning activities

Academic Skills (40)	
Formative Assessment based evaluation	10
Independent Learning based evaluation	15
Collaborative learning based evaluation	15
Professional skills & Career enhancements (10)-PCE	
Curricular activities (Labs / Presentation/Seminars etc.)	10
Co-Curricular (Mini-Project, Contest etc.)	
Extra-curricular activities reflecting Behavioral traits (if Applicable)	

Table 3. Standardization of Internal Assessment Question Paper using Bloom's Taxonomy

S.No	Intended Learning Outcome	% of exam points
1.	Define, State, List	10%
2.	Describe, Distinguish	10%
3.	Solve, Illustrate, Sketch	20%
4.	Compare, Analyze	20%
5.	Estimate, Assess	20%
6.	Design, Construct, Develop	20%

Table 4. ILO Attainment based on marks

Marks	LO Attainment	Grading
91-100	1-6	Excellent
81-90	1-5	V.Good
71-80	1-4	Good
61-70	1-3	Fair
51-60	1-2	Satisfactory
21-50	1	Needs Improvement

As per ACM-Computer science curricula, Data Structures and Algorithms course is designed and it is currently offered in the third semester of BE CSE. The following learning outcomes for that course is as per ACM-CSE curriculum standard,

- Identify a practical example to which it would apply.
- Have facility mapping pseudocode to implementation, implementing examples of algorithmic strategies from scratch, and applying them to specific problems.
- Use a heuristic approach to solve an appropriate problem.

The above-mentioned learning outcomes can be implemented by the following ways either as a group assignment, mini project or as a recap session in the class room depending upon the course handler:

- Worst case quadratic sorting algorithms including selection and insertion. (Lab experiments / Seminars)
- Worst and average case analysis O (N log N) sorting algorithms such as quick sort, heap sort, merge sort (Lab experiments).
- Hash tables, including strategies for avoiding and resolving collisions (Lab experiments/ Tutorials).
- Common operations on binary search trees such as select min, max, insert, delete, iterate over binary search tree (Lab experiments / Mini Project).
- Representations of graphs (e.g) adjacency list, adjacency matrix (Class room discussion).
- Depth and breadth first traversals.

The runtime and memory efficiency of principal algorithms for sorting, searching and hashing in the classroom by recalling the concepts either by a single student or as a group using Roll the die or by Twitter board.

We can also discuss factors other than computational efficiency that influence the choice of algorithms such as programming time, maintainability and the use of application-specific patterns in the input data through Meta cognition table. The weightage shown in Table 2 will help us to identify ILO for every topic within the class hours itself. Table 5 shows the course outcomes for the respective course and Table 6 shows the intended learning outcomes for the specific topics like Binary search tree &its traversal techniques and solving recurrence relations.

Table 5. Course Outcomes of Data Structures and Algorithms

On successful completion of the course, the students will be able to		
CO1	Explain how arrays, stacks, queues, linked lists, trees, heaps, Graphs and Hash Tables are represented in the main memory and manipulated or used by different operations.	Understand
CO2	Solve any recurrence equations using divide and conquer strategies	Apply
CO3	Examine the behavior of different tree data structure after insertion, deletion and rotation operations.	Analyze
CO4	Illustrate how arrays, stacks, queues, linked lists, trees, heaps, Graphs and Hash Tables are used in various applications.	Understand
CO5	Analyze the computational efficiency of key searching, sorting and Hashing algorithms.	Analyze
C06	Evaluate the suitability of different data structures for solving computing problems	Evaluate

Table 6: Intended Learning Outcome for a unit of learning

Topic	No. of Lectures	Learning outcomes	Course Outcome
Binary search tree	3	LO1: Students can understand the basics of tree as well as tree traversals	CO3
		LO2: Students can recollect/ illustrate the types of traversals.	
Quick sort	2	LO1: Students are able to predict the outcome of a set of data after performing quick sort	CO5
		LO2: Students are able to identify and solve the problems based on their input using various	
		LO3: Students are able to analyze the nature of data as well as apply appropriate way of selecting pivot for sorting	

Table 3 is used in Continuous Assessment Test for effective measurement of ILO. By using Table 2 and Table 4, the attainment of every ILO designed for the respective course can be calculated.

5. Implementation and Results

Best Practices are implemented with Third Semester B.E students in the Department of Computer Science and Engineering, Thiagarajar College of Engineering, Madurai. Every CSE Students should have strong foundation in the core courses especially Data Structures and Algorithms. Due to the complexity of teaching and understanding of this course, we are focusing in measuring the student learning outcomes. The Different Active Learning Strategies are used in the respective Course, and it is described as follows:

A. Flipped Classroom

The topic given for the Flipped Classroom Activity is "Quicksort". For this activity, the students are asked to go through the video lectures available in YouTube as well as other educational links before two days of the actual lecture day.

B. In Classroom Activity

Followed by the Flipped Classroom activity, Peer Instruction is given as the first in-class activity to the students in the class. With the in-class activity all students are advised to think about the basic concepts of quick sort as well as related concepts about 5 minutes and then the objective type question paper is given to the students along with one question as "Predict the outcome for the given input after performing quick sort". As a mentor, teacher clarifies all the doubts regarding the activity at the end of the session. Most of the students come up with correct answers related to the flipped classroom activity.

Feedback is collected from all the students regarding the Flipped Classroom activity, from the feedback given by the students more than 95% of students really enjoyed the activity and their learning ability is increased in the in-class as well as out of class activity and independent learning is also improved during Peer Instruction as well as during predict the outcome activity.

C. Usage Scenario

In the pilot study, out of 70 students, 20 were identified as slow learners including lateral entry students and remaining 50 were fast learners. 5% of the students did not watch the videos. Out of 7 questions in Peer Instruction, 4 questions have multiple choices and one question is with choice but none of them are correct answer. All the questions are equally answered by the most of the students. Some of the students were struggled in answering the question no.3. As a result, 95% of the students attended

the test and above 89% of students got full marks in the test.

D. Independent Learning

Take home assignments as well as tutorials are given to the students in the topic solving recurrence as well as tree traversal.

Performance of the students is measured in the First Continuous Assessment Test (CAT1), the questions relevant to the above-mentioned topic are asked under higher order thinking skill category "Apply and Analyse". Students including slow learners attended the tree traversal question opting "C1" choice when compared to "C2" question as shown in Fig. 2. Similarly, "C4" is taken as option when compared to C3. Few of the fast learners attended C2 as well as C3.

PART- C (Apply & Analyze) (2 x 10 = 20)

Apply Type Questions: (1 x 10 =10)

C1) Build a binary search tree for the set of keys {1, 4, 5, 10, 16, 17, 21} and show the running time for finding the largest node in a tree.

(Or)

C2) Use Substitution method to solve the given recurrence equation: T (n) = 2 T (n-1) + 1 And T (1) =1

Analyze type Questions: (1 x 10 =10)

C3) Analyze the Linear search in best, worst and in average case with suitable input.

(Or)

C4) Examine the behavior of Quick sort when the array A contains distinct element and is sorted in decreasing order. Express its running time.

Fig. 2. CAT1 Question paper highlighting respective topics

Fig. 3 and 4 shows more students opted the C1 as well as C3 when compared to other choice because no. of active learning strategies was followed for the tree traversal as well as quick sort topic. This says that active learning strategies can be used in every topic level for intended learning outcomes.

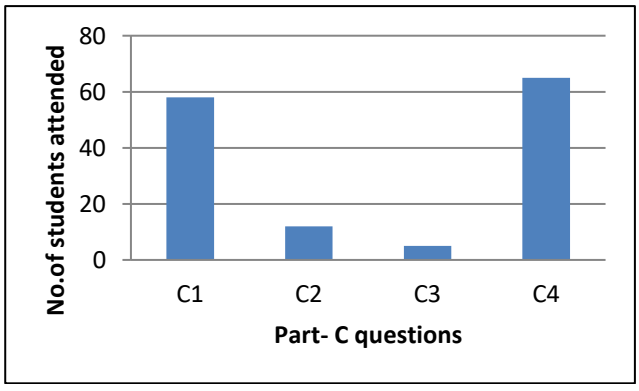

Fig. 3.Students Option in Continuous Assessment Test 1 for Analyze category

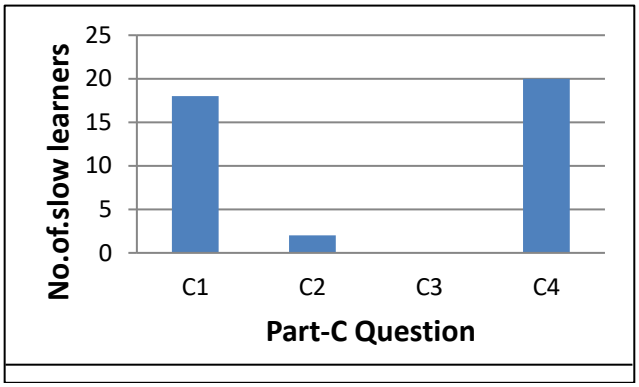

Fig. 4. Slow learners option in CAT1

Final Assignment 3 is Seminar Presentation. As a team, students present their topic by referring the foreign universities website as well as either educational links for presenting their topic. Outcome of Assignment III is that the students are able to apply and analyse their chosen topic to any type of real world problems. Their presentation is evaluated using the standard rubrics prescribed by our college for seminar presentation.

From Continuous Assessment Test -1, it is clear that after using Active Learning Strategies for individual topic, the performance of slow learners is drastically improved in answering Part-C questions as shown in Fig. 5 when compared to other choice.

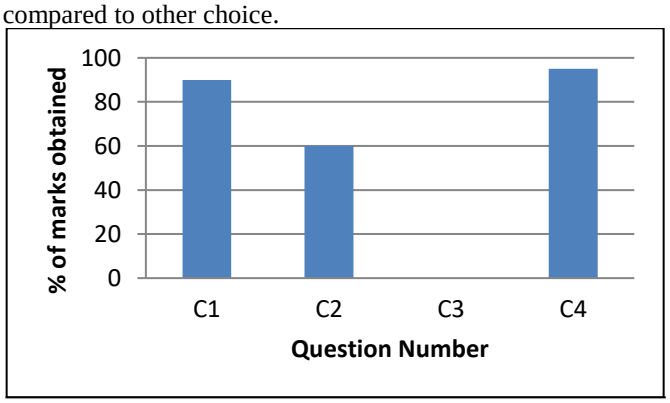

Fig. 5. Slow Learners performance in Part-C category

6. Conclusion

The impulse for creation of Quality Technical Education practices has aroused with the necessity of producing skilled manpower, enhance productivity thereby improving progression in individuals and the nation as a whole. Student centric Innovative Teaching Learning methodologies with a system of Continuous Assessment and Evaluation, with suitable support at all levels augmented by enrichment initiatives will result in Student progression. A structured mechanism to collect and

analyse data on student learning outcomes attainment at course level and programme level is essential to help in attainment of Programme educational objective, resulting in competent engineer for the society. By designing the learning outcomes for every topic as a micro level for each course in turn help us to achieve the Course outcomes for a particular course. This paper is just an initiative for attaining the course outcomes through learning outcomes(ILO). If each and every course offered in the department comes out with the suitable LOs, then the student understanding skill as well as cognitive skill can be automatically improved. This helps every department to come out with academic excellence.

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National Conferences. Her current research interests cover the scheduling algorithms, cloud computing and parallel computing, pedagogical aspect in teaching engineering education. She is the life member of Computer Society of India.