

A Holistic Approach for Teaching Design and Analysis of Algorithms Course in the department of Computer Engineering

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Abstract: A course Design and Analysis of Algorithms have prominent importance for higher studies and placement in IT Industry. Hence, the better understanding of this course will outcome in successful career formation. It has been observed that traditional teaching learning methodologies is not helping students to understanding the concepts briefly, to map algorithm to problem and in turn, it consequences in poor algorithmic skills, less success in higher studies and placement. In this paper, we discussed different innovative teaching-learning practices which help to enhance sympathetic of Design and Analysis of Algorithm course and which in turn result in good academic progress. Finally, the comparative analysis of the course attainment of previous two academic years is taken out that result in the manifest change in the attainment.

Keywords: Traditional Teaching-Learning Methodology, Course Attainment, Innovative Teaching-Learning practices.

1. Introduction

The traditional teaching learning methods has many limitations. As this methodology is totally teacher-centric it is very difficult for teacher to maintain attention of all the students throughout the lecture. Even though the teacher has outstanding knowledge of the subject, It has been observed that students cannot pay continuous attention more than 20 min in one hour lecture [1]. As class is intermingling of students with different capabilities and different learning abilities, one way teaching is not sufficient to understand the concepts easily. Hence, to built up two way communication and joyful learning in the classroom. In this paper we have discussed total four innovative teaching learning methodologies: Role Play, Think Pair Share, Flipped Classroom and Visualization Tool for Design and Analysis of Algorithms course and the results are calculated in terms of course outcome attainment.

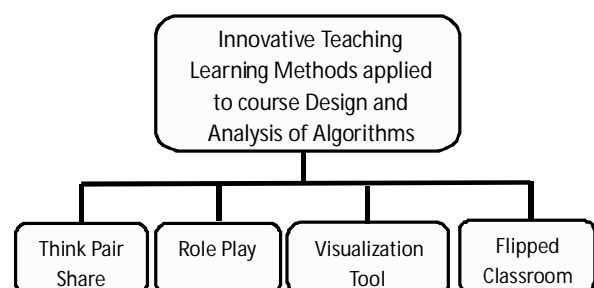


Fig. 1 introduced all innovative methodologies used for teaching different strategies of Design and

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Analysis of algorithms course like: Divide and Conquer, Greedy Method, Dynamic Programming and Backtracking Method. In next sections, shows the detailed activity plan for each methodology. Finally, the impact of innovative teaching-learning process has been analysed in terms of course outcome attainment and concluding remarks given in the last section.

2. Method 1: Think Pair Share

Think Pair Share (TPS) [2] activity is one of the

Table 1. Think Pair Share Activity for 0/1 Knapsack Problem

Phase	Questions	Duration (in Min)	Faculty Role	Students Role	Deliverable															
Think Phase	<p>A thief enters a house for robbing it. He can carry maximum weight of 5 kg into his bag. There are four items in the house with following weight and value. What items should thief take? He either takes or leaves the item.</p> <table><tr><th>Item</th><th>Weight</th><th>Value</th></tr><tr><td>Mirror</td><td>2 Kg</td><td>\$ 3</td></tr><tr><td>Silver nuggets</td><td>3 Kg</td><td>\$ 4</td></tr><tr><td>Painting</td><td>4 Kg</td><td>\$ 5</td></tr><tr><td>Vase</td><td>5 Kg</td><td>\$ 6</td></tr></table>	Item	Weight	Value	Mirror	2 Kg	\$ 3	Silver nuggets	3 Kg	\$ 4	Painting	4 Kg	\$ 5	Vase	5 Kg	\$ 6	10-15 mins	<p>1. Display problem.</p> <p>2. Ask students to solve it individually</p>	<p>Students have to analyse the problem, identify algorithmic strategy and write an <u>individual</u> answer in about <u>10-15 minutes</u>.</p>	<p>Subset of items that maximizes the profit without exceeding bag weight</p>
Item	Weight	Value																		
Mirror	2 Kg	\$ 3																		
Silver nuggets	3 Kg	\$ 4																		
Painting	4 Kg	\$ 5																		
Vase	5 Kg	\$ 6																		
Pair Phase	<p>Check your answer with your neighbour and see whether your solution is correct or not . If both having different answers then discuss the solution and rethink on problem and find out correct solution</p>	5mins	<p>Ask Students to check their answer with their neighbour , if answer is same then finalize it otherwise rethink, discuss and finalize one solution</p>	<p>Rethink and discuss with neighbour</p>	<p>One calculated subset of items i.e. optimal solution</p>															
Share Phase	<p>Invite few pairs and share the solutions among them. Give about 1 minute for each pair to explain their answer.</p>	10 mins	<p>-If any pair has different answer and at the end explain where exactly they missed the steps</p> <p>- Explain solution stepwise</p> <p>Two possible solutions</p> <p>(0,0,0,1) w=5 Profit=\$6</p> <p>(1,1,0,0) w=5 Profit=\$7</p> <p>Both solutions satisfied the constraints but, Second solution gives higher profit</p>	<p>- If not getting correct output compare with others and find out missed steps and correct it.</p>	<p>Correct sum of subset= (1,1,0,0) agreed by all.</p>															

3. Method 2: Role Play

Role Play [3] Activity is applies to Backtracking Algorithmic strategy. Students were given following problem statement to understand the concept of Backtracking in Design and Analysis of Algorithm.

Learning Outcomes:

- To understand the concept of Backtracking.
- Able to analyse the time complexity to solve real time problems.

innovative teaching-learning methods that help in better understanding of Dynamic programming strategy. In this method, teacher announce the problem statement and ask students to solve it individually, then judge the result against with neighbouring student i.e. pair and discuss. Finally, randomly selected one pair explains the solution in front of the class. Table 1 give details of this activity which has been applied to understanding the real-time application of 0/1 Knapsack Problem.

- Solve any one problem using Backtracking approach.

Problem statement: Given 6*6 chessboards, place 6 Queens in such way that no two queens attack in column, row and diagonal.

Activity Plan:

- Discuss the problem in class.
- Apply Exhaustive search algorithm to solve the problem.

3. Identify time complexity of Exhaustive search which is very high i.e. $N!$ where N is the size of chess board.
4. Perform Brainstorming session to find out best suitable strategy to solve the problem in minimum amount of time. And Solution is Backtracking
5. Apply backtracking approach on 6×6 Chessboard to place 6 queens.
6. Draw 6×6 chessboards on the floor and randomly select 6 students from the class to stand on the board in such way the no two students come in a row, column and diagonal by applying backtracking approach.
7. Ask students to design search space tree to analyse the complexity of same problem using backtracking approach. Complexity is reduced from polynomial to factorial— $N!$

Fig. 2 shows the activity playing by students. This activity makes fun while learning and achieve joyful learning in classrooms.



Fig. 2 Active participation of students in Role Plays activity

4. Method 3: Flipped Classroom

Flipped Classroom [4] is instructional approach belongs to blended learning type which reverses the traditional Teaching learning approach. In this approach, students watch the lecture at home and communicate with the faculty via online discussion. This activity is applicable when the concept is large and complex which cannot be covered in single lecture. This activity is applied to teach Divide and conquer strategy—Min-max Problem for third year B. Tech. class of Computer Engineering department.

Out-of-Class Activity Design

Learning Objective(s):

1. Understand the working of Divide and conquer strategy
2. Able to find minimum and maximum element in the array using Divide and conquer strategy

Key Concept(s) to be covered:

1. What is Divide and conquer?
2. How to find max and min value in an array?
3. How to generate Recurrence formula to calculate time complexity of an algorithm?

The Video URL given to students to listen at out of class: https://www.youtube.com/watch?v=_pBZFW9RMIo&t=1380s

In-class Activity Design:

Learning Objective(s):

1. Apply the Divide and conquer strategy to solve the given problems
2. Analyse the complexity of algorithm

Key Concept(s) to be covered:

1. How to apply an algorithm to solve a problem?
2. How to generate Recurrence formula to calculate time complexity of an algorithm?

Activity Plan:

1. Ask Students to come to next class by watching the video:

https://www.youtube.com/watch?v=_pBZFW9RMIo&t=1380s

2. Teacher give the problem statements to solve in the class and design recurrence formula form Min Max algorithm.(2mins)
3. Tell students to solve it individually (15 mins)
4. Verify answer with neighbors (1min)
5. Tell few peers to solve the problem on board (5mins)
6. Discuss the answer with class(5 mins)

5. Method 4: Visualization Tool

For the better understanding of course, Design and analysis of algorithms visualization tools have used. Fig. 3 (a, b) and Fig. 4(a, b) are the tool screenshots taken.

This tool is freely available on following link: <https://visualgo.net/bn/sorting>

With the help of this tool, student can easily analyse different sorting algorithms and its complexity.

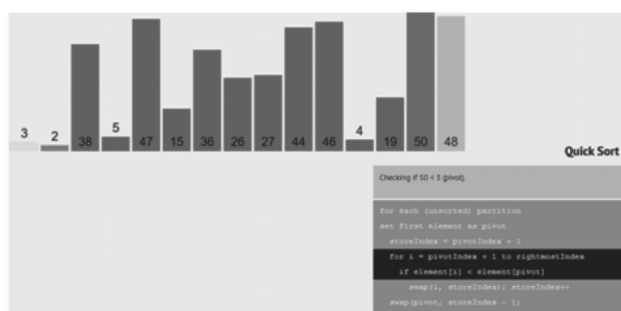


Fig. 3 (a) Sample Sorting Algorithms and their working on Visualization Tools

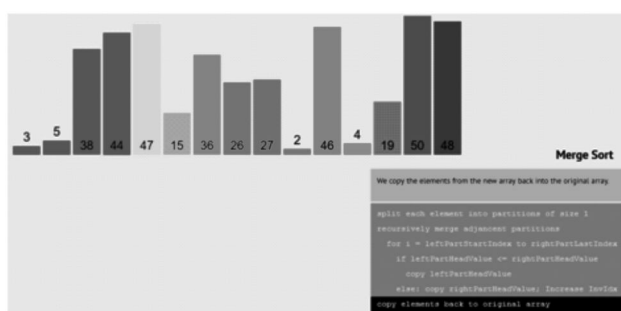


Fig. 3 (b) Sample Sorting Algorithms and their working on Visualization Tools

Greedy algorithm Techniques are also studied with the help of above said visualization tool. We have studied two different points like Prim's Algorithm and Kruskal's Algorithms. Fig. 4 (a,b) shows the sample RESULT ANALYSIS:

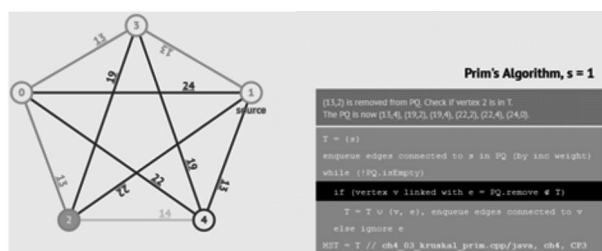


Fig. 4 (a) Sample Greedy Algorithms and its working on Visualization Tools

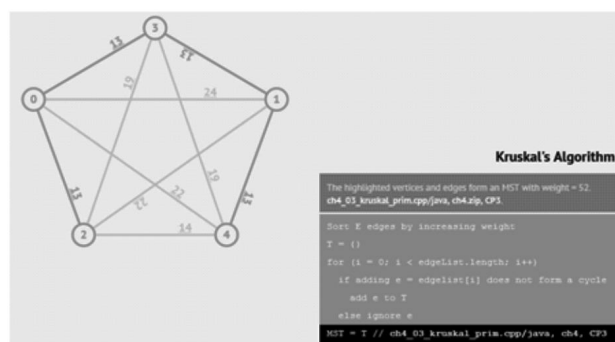


Fig. 4 (b) Sample Greedy Algorithms and its working on Visualization Tools

In our Rajarambapu Institute of Technology Engineering College, we have adapted Outcome-Based Education (OBE) System. We are intended to adopt innovative teaching-learning practices to fulfil the stakeholder requirements. It enhances student's knowledge and makes a joyful learning environment in the classrooms.

To measure the influence of implemented teaching-learning methodologies, we have analysed the course outcome attainment of the current year with past academic years 2015-16. The course attainment is basically divided into two categories i.e. direct and indirect attainment. [5, 6] Direct attainment is calculated using different evaluation strategies like In semester examination, unit tests and End Semester Exams. Course Exit survey is carried out at the end of semester to calculate indirect attainment. In This survey, questionnaires has given to the students that

Table 2. Course Exit Survey for Design and Analysis of Algorithms

Survey Questions	CO Mapping
Are you able to identify the fundamental strategies in algorithmic design?	CO1 and CO2
<input type="radio"/> Disagree <input type="radio"/> Agree <input type="radio"/> Fairly Agree <input type="radio"/> Strongly Agree	
Are you able to solve problems in computer science & engineering using various algorithms?	CO3
<input type="radio"/> Disagree <input type="radio"/> Agree <input type="radio"/> Fairly Agree <input type="radio"/> Strongly Agree	CO4
Are you able to analyse a given algorithm and assess its efficiency?	
<input type="radio"/> Disagree <input type="radio"/> Agree <input type="radio"/> Fairly Agree <input type="radio"/> Strongly Agree	CO5
Are you able to design and give pseudo code for algorithms, solving a variety of problems using the major design strategies?	
<input type="radio"/> Disagree <input type="radio"/> Agree <input type="radio"/> Fairly Agree <input type="radio"/> Strongly Agree	

mapped with Course Outcomes and ask them to rate the questions shown in Table 2. Analysis has been made on total 156 students. Table 3 shows the predefined course outcomes that expected from students at the completion of the course. graphs and their working.

Table 3. Course Outcomes for Design and Analysis of Algorithms

	Course Outcomes
CO1	Learn basic algorithmic strategies
CO2	Identify the appropriate algorithmic strategy suitable for given problem
CO3	Design an algorithm for given problem
CO4	Analyse complexity of algorithms
CO5	Solve the problems using appropriate algorithmic strategy

Table 4. Mapping of Algorithmic Strategy with applied teaching-learning Activity

Algorithmic Strategies	Teaching-Learning Activity	CO-Mapping
Divide and Conquer	Flipped Classrooms	CO1, CO2, CO3, CO4, CO5
Greedy Approach	Visualization Tools	CO3, CO4, CO5
Dynamic Programming	Think Pair Share	CO1, CO2, CO5
Backtracking	Role Play	All CO's

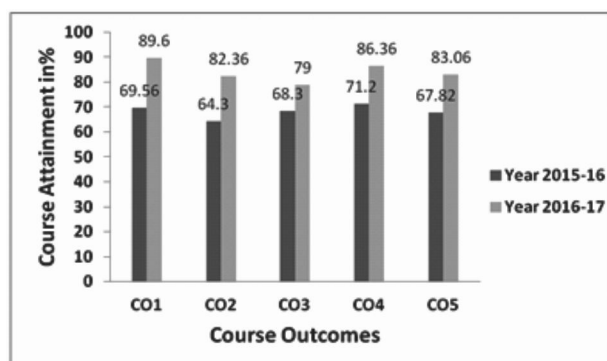


Fig. 5 Course Outcomes (CO) Attainment

In this paper, Innovative teaching-learning activities applied on different algorithmic strategies shown in table 4. In this paper, think pair share activity mapped with CO1, CO2 and CO5. Role play and Flipped classrooms teaching-learning activities are mapped with all COs i.e. every activity concentrate on identifying the algorithmic strategy, designing an algorithm, analysing the complexity—space complexity and time complexity and problem-solving with a suitable strategy. Visualization Tools is

basically used to understand the actual implementation of the algorithm using an example. Hence, this activity correlates with CO3, CO4 and CO5.

From Fig. 3, it is observed that CO1, CO2, CO3, CO4 and CO5 are increased with around 20.04%, 18.6%, 10.7%, 15.6% and 15.24% respectively as compared to previous year. Course outcomes of course Design and Analysis of Algorithms is increased by 15.86% in 2016-17. From the graph, it is observed that all innovative teaching-learning methodologies helped students a lot for a better understanding of the concept.

6. Concluding Remarks

Traditional Teaching methodologies are insufficient in today's modern era to grasp the concepts more clearly. To overcome limitations and disadvantages, it is essential to switch to innovative teaching-learning practices. In this paper, we have highlighted few such practices that are used for teaching Design and Analysis of Algorithms course in the last academic year 2016-2017. It is observed that modern teaching-learning practices like Think Pair Share, Flipped Classroom, Role Play, and Visualization Tools result in better understanding of algorithmic skills and problem-solving skills associated with Design and Analysis of algorithms course. Also, it helped to build joyful learning environment within students.

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Video selected by author for flipped Classroom:
https://www.youtube.com/watch?v=_pBZFW9RMIo&t=1380s

Link for visualization Tool:

<https://visualgo.net/bn/sorting>