

A Holistic Approach for Teaching Data Structure Course in the department of Information Technology

Ms. Varsha T. Lokare¹, Mr. Prakash M. Jadhav²

¹Information Technology, Rajarambapu Institute of Technology, Sakharale

²Mechanical, Institute, Rajarambapu Institute of Technology, Sakharale

¹varsha.lokare@ritindia.edu

²prakash.jadhav@ritindia.edu

Abstract: A course Data structures have prominent importance for higher studies and placement in software industries. Hence, the better understanding of this course will result in successful career formation. It has been observed that traditional teaching learning methodology is not helping students to showcase their learning's and in turn, it results in poor placement and less success in higher studies. So, in this paper different innovative teaching-learning practices are discussed which help in better understanding of data structure course and which in turn result in good academic development. Finally, the comparative analysis of the course attainment of last two academic years is carried out that result in the noticeable increase in the attainment.

Keywords: Traditional Teaching Learning Methodology, Placement, Innovative Teaching Learning practices.

INTRODUCTION

There are many disadvantages and limitations of traditional teaching learning methods. As this methodology is totally teacher-centric it is very difficult for teacher to maintain attention of all the students. Even though the teacher has excellent knowledge of the subject, one cannot guarantee 100% learning of all the students. As class is the mixture of students having different capabilities and different learning abilities, one cannot apply the same teaching methodology for all. So, in this paper we have discussed total five innovative teaching learning methodologies: Role Play, Think Pair Share, Flipped Classroom and collaborative learning, for data structure course and analyse the result on the basis of course outcome attainment.

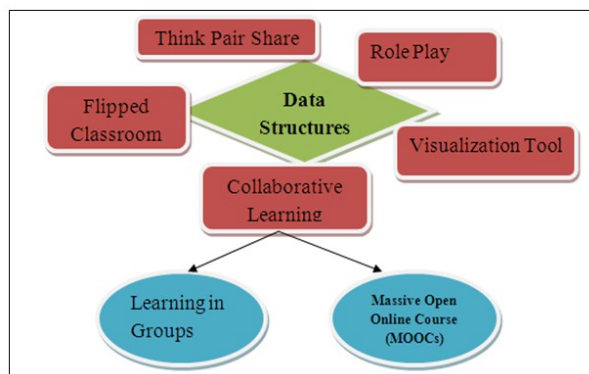


Fig. 1 Innovative Teaching Learning Methodologies

Figure No.1 highlight all the innovative methodologies applied for teaching data structure course. In next sections, the detailed activity plan for each methodology is given. 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.

METHOD 1: THINK PAIR SHARE

Think Pair Share (TPS) [1] activity is one of the innovative teaching-learning methods that help in better understanding of critical topics. In this method, teacher displays the problem statement and ask students to solve it individually then tell students to compare the result with neighbouring student i.e. pair and discuss. Finally, any one pair explains the solution in front of the class. Table 1 explains this activity which has been applied to understanding the real-time application of Heap data structure.

Table 1. Think Pair Share Activity for Heap Data Structure

Phase	Questions	Duration (in Min)	Faculty Role	Students Role	Deliverable
Think Phase	<p>Tieu owns a pizza restaurant and he manages it in his own way. While in a normal restaurant, a customer is served by following the first-come, first-served rule, Tieu simply minimizes the average waiting time of his customers. So he gets to decide who is served first, regardless of how sooner or later a person comes. Different kinds of pizzas take different amounts of time to cook. Also, once he starts cooking a pizza, he cannot cook another pizza until the first pizza is completely cooked. Let's say we have three customers who come at time $t=0$, $t=1$, & $t=2$ respectively, and the time needed to cook their pizzas is 3, 9, & 6 respectively. If Tieu applies first-come, first-served rule, then the waiting time of three customers is 3, 11, & 16 respectively. The average waiting time in this case is $(3 + 11 + 16) / 3 = 10$. This is not an optimized solution. After serving the first customer at time $t=3$, Tieu can choose to serve the third customer. In that case, the waiting time will be 3, 7, & 17 respectively. Hence the average waiting time is $(3 + 7 + 17) / 3 = 9$. Help Tieu achieve the minimum average waiting time. For the sake of simplicity, just find the integer part of the minimum average waiting time. Input Format: The first line contains an integer N, which is the number of customers. In the next N lines, the i^{th} line contains two space separated numbers T_i and L_i. T_i is the time when i^{th} customer order a pizza, and L_i is the time required to cook that pizza. Calculate the integer part of the minimum average waiting time.</p> <p>Input</p> <pre> 3 0 3 1 9 2 5 </pre>	10mins	<ol style="list-style-type: none"> 1. Display problem. 2. Tell students to solve it individually 	A student can think about it and write an <u>individual</u> answer in about <u>10 minutes</u> .	Minimum average waiting time.
Pair Phase	Check your answer with your neighbour and see whether your solution is correct. If both having different answers then discuss and rethink to finalize one	5mins	Tell Students to check their answer with their neighbour, if same answer then finalize it otherwise rethink, discuss and finalize one output value	Rethink and discuss with neighbour	One calculated agreed value
Share Phase	Invite few pairs to share their answer. Give about 1 minute for each pair to explain their answer.	10 mins	<p>- Note down, if any pair has different answer and at the end explain where exactly they missed the steps</p> <p>- Explain solution stepwise</p> $(3 + 6 + 16) / 3 = 25 / 3 = 8.33$ <p>the integer part is 8 and hence the answer.</p>	- If not getting correct output compare with others and find out missed steps and correct it.	Correct minimum average time=8 agreed by all.

METHOD 2: ROLE PLAY

Role Play[2] Activity: Second year B.Tech in Information Technology students were given following problem statement to understand the concept of **Time Complexity** in data structure.

Learning Outcomes:

- To understand the concept of Time Complexity
- Able to apply the time complexity theory to solve real life problems.

Problem statement: How to determine whether anyone in the room has the same Birthday as you?

Algorithm 1: You say your birthday, and ask whether anyone in the room has the same birthday. If anyone does have the same birthday, they answer yes.

Algorithm 2: You tell the first person your birthday, and ask if they have the same birthday; if they say no, you tell the second person your birthday and ask whether they have the same birthday; etc, for each person in the room.

Algorithm 3: You only ask questions of person 1, who only asks questions of person 2, who only asks questions of person 3, etc. You tell person 1 your birthday, and ask if they have the same birthday; if they say no, you ask them to find out about person 2. Person 1 asks person 2 and tells you the answer. If it is no, you ask person 1 to find out about person 3. Person 1 asks person 2 to find out about person 3, etc.

Activity Plan:

- Tell students to demonstrate each algorithm in a group in front of the class. (10mins)
- Ask Questions to the students:(10mins)

Question 1: For each algorithm, what is the factor that can affect the number of questions asked (the "problem size")?

Question 2: In the worst case, how many questions will be asked for each of the three algorithms?

Question 3: For each algorithm, say whether it is constant, linear, or quadratic in the problem size in the worst case.

- Assess the answers given by the students and finally display the correct solution.

Ans1: The problem size is the number of people in the room.

Ans2: Assume there are N people in the room.

In algorithm 1 you always ask 1 question. In algorithm 2, the worst case is if no one has your birthday. Here you have to ask every person to figure this out. This is N questions. In algorithm 3, the worst case is the same as algorithm 2. The number of questions is $1 + 2 + 3 + \dots + N-1 + N$. We showed before that this sum is $N(N+1)/2$.

Ans3: Given the number of questions you can see that algorithm 1 is constant time, algorithm 2 is linear time, and algorithm 3 is quadratic time in the problem size.

- Ask students to Categorized the above solutions in terms of complexity in Best, Average and worst case.(5mins)

- Display the correct answer.(2mins)

Best- Algorithm1- $O(1)$

Average- Algorithm2- $O(N)$

Worst- Algorithm3- $O(N^2)$

METHOD 3: FLIPPED CLASSROOM

Flipped Classroom [4,5] is one of the innovative teaching learning methodology that has been applied to teach Heap data structure for second year B.Tech class of Information Technology department.

Out-of-class Activity Design:

Learning Objective(s) of Out-of-Class Activity:

- Understand the working of Heap data structure
- Able to perform insert and delete operations on a Heap
- Build Minheap and Maxheap

Key Concept(s) to be covered:

- What is Heap?
- How to build Minheap?
- How to build Maxheap?

Out-of-class Activity Design

Uploaded Video URL :

<https://www.youtube.com/watch?v=XL7Ga1YZN4A&feature=youtu>

Learning Objective	Assessment Strategy	Expected duration (in min)
Understand the concept of Heap	<ol style="list-style-type: none"> Draw Min Heap Draw Max heap Delete root element Insert new element 	<ol style="list-style-type: none"> 05 05 02 02

Duration of Screencast : 5:16 min

In-class Activity Design:

Learning Objective(s):

- Apply the Heap concept to solve the given problems
- Design Heap data structure and perform insert and Delete operations

Key Concept(s) to be covered:

- Min Heap Building
- Max Heap Building

Activity Plan:

- Tell Students to come in next class by watching video <https://www.youtube.com/watch?v=XL7Ga1YZN4A&feature=youtu>
- Teacher give the problem statements to solve in the class (2mins)

3. Tell students to solve it individually(5mins)
4. Verify answer with neighbor (1min)
5. Tell few peers to solve the problem on board(5mins)
6. Discuss the answer with class(2mins)

METHOD 4: COLLABORATIVE LEARNING

This teaching learning methodology has been applied for Data Structures Laboratory course to enhance the programming skills of the students.

A] Learning in Groups [3]

1. In lab, 20 students are divided in to groups of 4 students and set of five problem statements given one for each group. It was instructed to all groups to solve one problem statement that was assigned randomly by the teacher.
2. All group members need to discuss and write algorithms in a notebook to solve assigned problem statement.
3. Once the algorithm finished, all group members individually implement that algorithm on a computer.
4. After successful completion, one group leader write and explain the code on a blackboard.
5. Group leader role is in rotation, so that every student will get a chance to speak up and share his/her knowledge with others.
6. Even though if any student is weak in programming can able to improve his/her programming skill by working in a group.

B] Massive Open Online Course (MOOCs)

IIT Bombay had organized MOOCs for data structure course during academic year 2015-16. In this course emphasis is on developing the ability to write programs to solve practical computational problems Participants will get to read and understand many sample programs, and will have to write several on their own. This course deals with procedural programming, and attempts to inculcate good programming practices in a novice programmer. Total 45 students out of 75 got an Honor certificate from IIT Bombay, also I as a course teacher got an appreciation certificate.

Activity Plan

1. Student and Faculty registration on IIT Bombay Moodle.
2. The programming assignments and quizzes were displayed on Moodle along with deadline by IITBombay.
3. During practical session students forms groups and solve the assignments and upload within deadline.
4. Finally the marks out of 100 given
5. Students those were score marks greater than or equal to 40, got certificate from IIT Bombay.

METHOD 5: VISUALIZATION TOOL

For better understanding of the course Data structure visualization Tool has been used. Figure 3 and Figure 4 are

the Tool screenshots taken. This tool is freely available on link:<https://www.cs.usfca.edu/~galles/visualization/Algorithms.html>

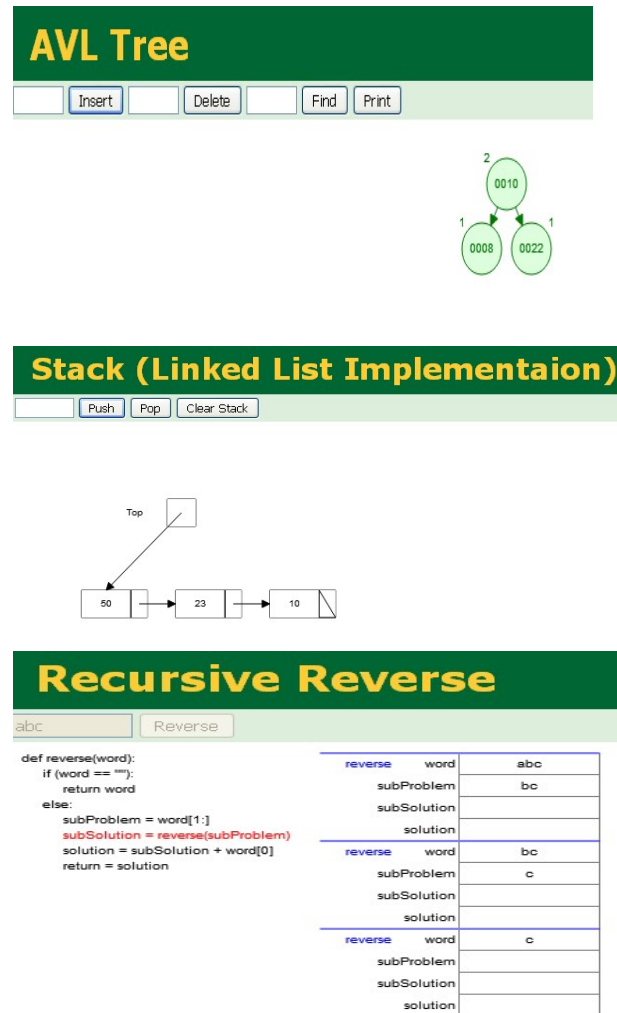


Fig. 2 Sample Data structures on Visualization Tools

RESULT ANALYSIS:

Experimental Methodology:

In our Rajarambapu Institute of Technology Engineering college, we are using IONCUDOS software to measure the course outcome attainment, program outcome attainment and in turn Program Educational attainment. As the main goal of Outcome-Based Education (OBE) is to fulfil the stakeholder needs, we are concentrating on different innovative teaching-learning practices in our institute and department to enhance the student's knowledge.

To measure the impact of innovative teaching-learning methodologies, the comparison has been made for course attainment both direct i.e. marks obtained and indirect[6]

i.e. course end survey received from students. The analysis of last two academic years 2014-15 and 2015-16 is carried out for data structure course to measure the students understanding in terms of course attainment. Analysis has been made on total 150 students. Table No.2 shows the predefined course outcomes that need to be satisfied by the students.

Table 2. Course Outcomes for data structure

Course Outcomes	
CO1	Discuss primitive operations, strengths and limitations of standard data structures.
CO2	Implement various data structures both linear and non linear using C language.
CO3	Explain the need for data structuring techniques.
CO4	Demonstrate the use of the standard data structures using relevant applications.
CO5	Choose appropriate data structure while building applications.

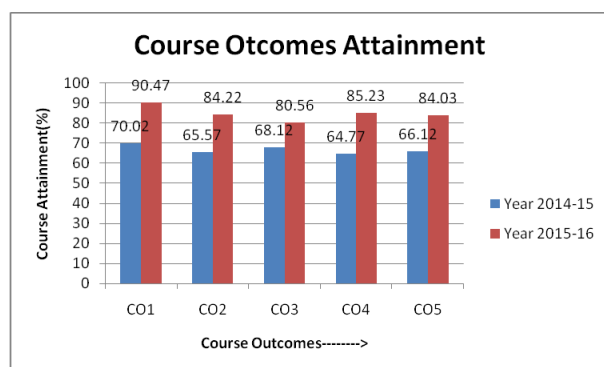


Fig. 3 Course Outcomes Attainment

From Fig. 3, it is observed that CO1 is associated with the basic understanding of the data structures, as visualization tool is used for learning of the students there is around 20% increase in the CO1 attainment in the academic year 2015-16. CO2 is associated with programming skills, as learning in groups and MOOCs has applied during Lab sessions, it is observed that there is approximately 22% increase in CO2 attainment as compared to previous year. CO3 and CO4 are associated with the need of the data structures; from the graph it is observed that Flipped Classroom and Think Pair Share activity helped students a lot for a better understanding of the concept. Finally, CO5 is associated with application phase in that also approximately 18% increase is shown.

CONCLUDING REMARKS

Traditional Teaching methodology has many limitations and disadvantages. In Today's modern era, it needs to switch to innovative teaching-learning practices highlighted few such practices that are used for teaching data structure course in the last academic year 2015-2016. It is observed that modern teaching learning practices like

Think Pair Share, Flipped Classroom, Role Play, Visualization Tools result in better understanding of theoretical concepts associated with data structure course. Also, the learning in groups and MOOCs helped students to increase their programming skills.

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