

# Conceptualization of Data Structures Course using Visualization Techniques-A Case Study

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**Abstract:** Data Structures is a core course for Computer Science and Engineering discipline students which aims to cultivate undergraduate's abilities in selecting appropriate data structures to develop high quality application programs. But there are many complicated algorithms in it. This paper describes visualization of the data structures course which enables the students to master in this course and to attain the ease of learning. This paper also presents combination of active learning methods mixed along with online visualization as a case study conducted in K G Reddy College of Engineering and Technology to improve Critical Thinking skills.

**Keywords:** Data Structures, Effective teaching methods, Visualization, Critical Thinking Skills.

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## 1. Introduction

There is a huge demand for technical education in modern age. The pattern of life evolving in this age is very much different from the one we would find in our society even some fifty years back. Technical Education imparts knowledge of specific trade, craft or profession. General education has been substituted by professional technical education in many cases. Technical education offers good opportunity for employment and successful career.

Technical Education can meet the expanding demands of expanding society and to meet its multiplying demands. The industries, mechanized systems and scientific research centers all over the world prove beyond doubt that our tie with the past is snapped and instead of bare hands we must use machines and technology for all-round development and regeneration of human society.

### About Data Structures Course

Data Structures course introduces, how to solve a series of problems with computer, especially different kinds of data organization. Data Structures contents include Stack Queue, List, Graph, Search, Sort, etc. Basic Data Structures are used to solve problems in various fields of Computer Science and Engineering discipline (E.Horowitz, S.Sahni and Susan Anderson-Freed, "Fundamentals of Data Structures in C"). For example, multi-dimensional arrays are used in language compiling.

Data Structures course is used in every program or software system. Specific data structures are essential ingredients of many efficient algorithms, and make possible the management of huge amounts of data, such as large integrated collection of databases. Some programming languages emphasize data structures, rather than algorithms, as the key organizing factor in software design. In view of these problems, innovation thinking, formulation of new teaching program, preparation of new materials and development of network curriculum on the principle of spirit innovation could be designed.

#### Traditional Method of teaching Data Structures

Traditionally Data Structures course can be delivered by using chalk and talk method and the program can be explained on the screen using projector. But the learners of 21st century will be able to:

- (a) Learn best in relaxed environment.
- (b) Enjoy social environment.
- (c) Learn best when the content is presented in multiple modes such as visual, audio, etc.
- (d) Learn well in group and collaborative activities

But, in traditional teaching methods some deficiencies are:

- (a) Effectiveness of content is missed.
- (b) Group/collaborative learning missed.
- (c) Visualization of content is missed.

Problems faced while teaching Data Structures course are:

Using the knowledge of Data Structures as the carrier, which cultivate the student's innovative thinking ability and realize effective integration to the way of learning should be accounted. Collaborative and active learning methods (Dillenburg, Piere, Ed) in modern era play a vital role in achieving the multi dimensional skills.

The basis of collaborative learning is constructivism. The benefits of collaborative learning includes the promotion of faculty student interaction, increase the student to student relation, self- esteem, responsibility, prepare for real life social and employment situation. This paper followed collaborative teaching method to deliver a topic in

Data Structures course. One of the collaborative techniques followed is to build group interactions.

Course instructor can also plan a model for successful group functioning. Students should able to work together on the task in a group. Roles are important in group functioning. Functions of team include:

1. Brainstorming
2. Clearing the doubts
3. Summarizing
4. Challenging assumptions
5. Providing and researching information
6. Reaching a consensus.

Skills connect to data structures:

Variety of skills can be achieved with the data structures course. They are analyzing different methods for solving algorithms, identifying specific structure to organize the data, programming skills, solving complex programs.

With the development, application and popularization of computer technology and internet, e-learning education has become an easy way and effective learning for students (Xiaojing, Xiaoying Wang, Rui Wang, ICETIS, 2013). Essentially, it is about the transmission of the content using information technology and often refers to delivery using internet tools (TAO chen, Tarck Sobh). Students use a variety of computer technologies to access training materials. Knowledge, interpersonal communication is to be further developed, thus connects effective visualization based learning (Shirini Patel, 2014).

Visualization of the algorithms in data structures course have been introduced in this paper to provide effective teaching, to increase student concentration and attention, help students to understand and gain concepts more easily.

## 2. Visualization Tools and Methods

There have been a number of tools developed for the purpose of teaching and learning data structures. We will look at those specific to our problem domain.

1. The DSL Tool

This is an interactive tool. Data Structures Learning (DSL) was developed and used first as an experimental study that shows visualizations of algorithms (Alhousban, F.H., 2011). This DSL tool was extensively used by weaker students. A comparison was made of the students- DSL- use with their end of the year assessment marks which revealed that academically weaker students had tended to use the tool most. From the evaluation of the DSL tool, it was concluded that slow learners are keen to use any useful and available instrument to aid their understanding, especially of difficult concepts. The visualization can also be integrated with audio instruction to increase its effectiveness but implementation of AVL tree, B-tree and graph algorithms is not successfully implemented.

## 2. The Vedy Tool

Vedya tool used for visualizations of Data Structures and algorithm schemes (Segura, C., Pita, I., Virseda, R.d. Saiz, A.I., Soler.P, 2008). The pedagogical aim of Vedya was to facilitate the students by means of interactive learning. It can be used for most of the Data Structure topics such as stacks queues, binary search trees, AVL trees, priority queues, sorting and hash tables. It made interesting visualization techniques through a maze representation. Vedya tool helped students to benefit from complementary and interactive material.

## 3. Sketch based Interfaces

Engineering Education is entering a new era of teaching, learning and computing (Adamchick, V, 2011). The vision was to design a pen based computing environment in which student themselves would draw data structure using tablet and stylus.

## 4. Vidsaa Tool

A project which is used to develop a range of learning objects that helps a student to learn about the different data structures and algorithms (Kacha, C., and Ron, O, 2006). This is called VIDSAA (Visualization in Data Structure and Algorithms). This tool has covered Data Structures like Lists, Stacks, Queues, Trees, Sorting & Searching and Graph. A total of 55 animations are provided. In this tool the students can visualize the data structures using programs and flow chart representation. This feature was intended to enable the students to pause and think before moving to further steps of the animations and this was intended to provide an opportunity for students to become

critical thinking learners. VIDSAA was designed with a capacity to learn outside the classroom as part of their self learning.

The proposed method describes combination of mixed teaching methodologies as represented below

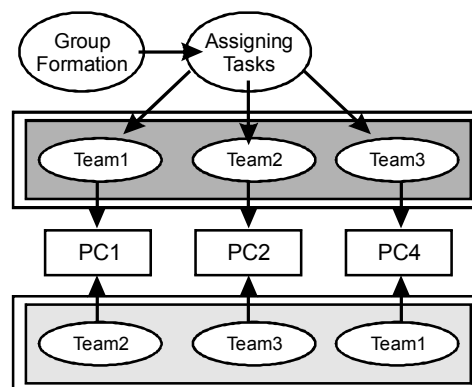


Fig.1 – Teaching Methodology

## 3. Case Study In Kgrcet

The innovative methods are required to learn the subject thoroughly. An attempt has been made to implement the new approach as a case study in K G Reddy College of Engineering and Technology (KGR CET), Hyderabad for Computer Science and Engineering discipline in Data Structure Course. This is associated to the following outcomes:

- (i) “Develop and Explain Data Structures concepts for linked Lists and trees”
- (ii) “Identify Data Structures balanced search trees, hash tables, priority queues, graph traversal algorithms”

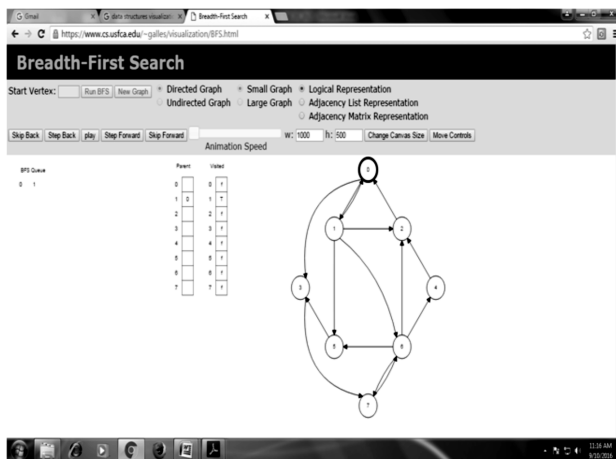
A step by step approach to teach Data Structures course with visualization techniques is implemented as follows:

Teacher Centered:

The concept can be explained in the class room using chalk and talk method. The example of Data Structure concept can be explained through visualization. To visualize the Data Structures course, there are many websites available. In this paper chosen the site : <https://www.cs.usfca.edu/~galles/visualization/Algorithms.html>

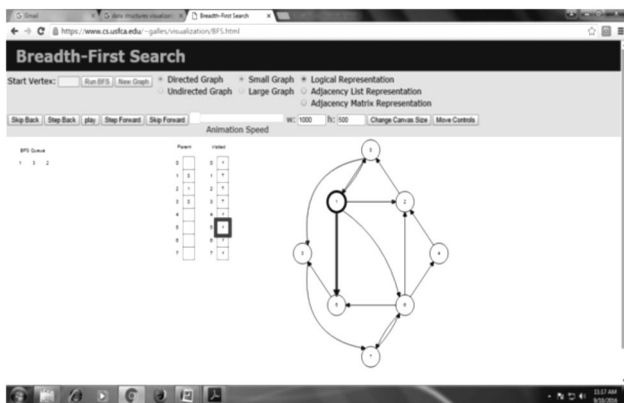
### Consider BFS Algorithm:

Actually Breadth First Search is the method of traversing a graph (visiting all the vertices). Initially we can start from any vertex. Then visit all adjacent vertices to that vertex. Again we need to visit adjacent vertices to those already visited vertices. This process continues until visiting of all vertices in the graph. In the example there are 8 vertices from 0 to 7. The first screen shot shows the initiation of the BFS process with initial vertex 0



**Fig. 2 – BFS Algorithm Example**

After the above process being visualized by the students in the next step the selected edge between two vertices is shown in red color. Here the students can easily identify which vertex is selected step by step.



**Fig. 3 – Step by Step Process of BFS Algorithm**

This process can be done for different inputs and different graphs. This process will take one to two lectures at the beginning of the approach for any one algorithm. Once the student understands this tool it takes not more than one lecture for demonstrating by visual approach.

### Student Centered:

The students can gain more skills when they do this execution themselves. Here the students are made into groups and given an algorithm to solve in the personal Computer (PC) in the laboratory where they can use the resource.

Here the students have been divided into groups of 5 to 6 members. One member is allotted as team leader who is good in concept, can communicate well with the team members and regular to the college. Each team represents different set of students which includes dull student, irregular student.

A problem is given to all the team leaders of the groups. The team leader can communicate the problem solution with their team members and execute with the help of the tool with multiple inputs. The problem given in one team cannot be shared to other teams. Different tasks are given to different teams.

Once all the teams have executed the algorithm (Blue shade shown in Fig. 1) the final output will be kept on the screen. Now the teams will rotate their positions and they have to identify the inputs for the output created by the other team members (Brown shade shown in Fig.1). This is a bottom top approach. The team can discuss among themselves and brainstorm. This will help in building the creative and critical thinking skills.

After completion of all the above process, an online quiz can be conducted. It can be useful in assessing the students about the new approach

### Formation of Groups:

Based on previous (Test 1) exam result and based on small quiz, who is high response can be considered as team leader. The better performance other than the team lead can be considered as second persons to those teams. In this way the teams can be formed. There are 30 members in the class and each team consists of 6 members.

### 4. Results And Observations:

As a case study the course has been taught in two methods. The topic is delivered without any visualization techniques and the same segment is explained and shown visually using the visualization

tools. The case study has been done and observed using online feedback from the students as well as an assessment conducted by the course instructor. It has been observed that most of the students have focused more on the visualization techniques for following the Data Structures course and also critical thinking skills have been drastically improved.

Immediately after completing few segments an online feedback has been taken to find out the students' approach and ease towards the visualization approach. It has been observed that 75 percent of the students are satisfied and want to continue with the new approach and 20 percent are still seeking for the traditional approach and 5 percent are neutral. The response has been shown as the pie diagram in the Fig. 4

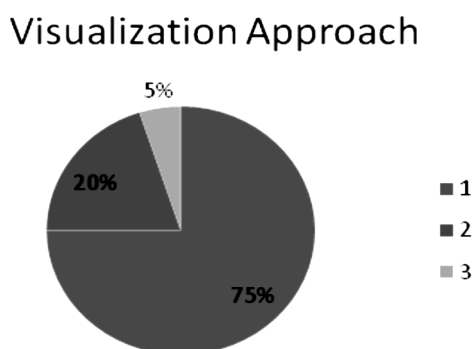


Fig. 4 – Student Feedback Representation

The negative response towards the approach is identified due to various reasons. Few students are unable to use the software effectively and as the simulation has been linked to the concept the students should understand the concept well before using the tool.

An online test has also been conducted to observe the performance of the students like quiz, objective, etc as shown in the screenshot Fig. 5. To conduct this test careerride.com website has been used

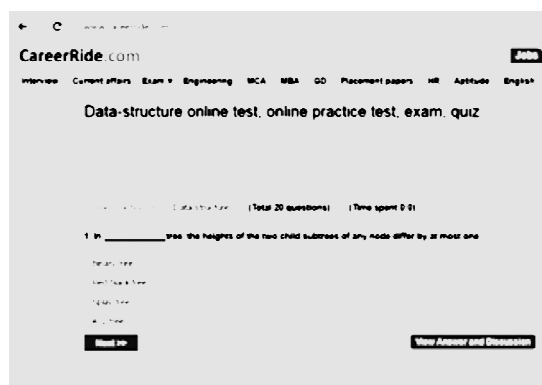


Fig. 5 – Online Test Example

Before introducing the visualization techniques to the students, the subject knowledge has been tested using an individual written test including descriptive and objective questions. The questions are so framed to test the critical thinking abilities of the student. As a second phase a retest has been conducted after the completing the same concept using visualization techniques. It has been observed that the student knowledge and also the critical thinking abilities have been improved after introducing this new methodology of teaching. It has been graphically shown in the below Figure.

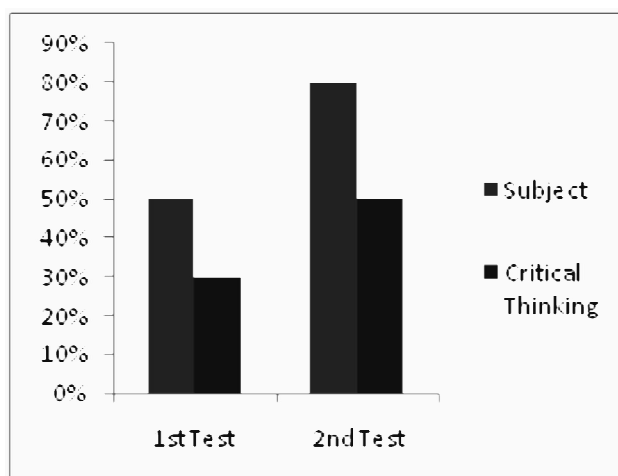


Fig. 6 – Graphical representation of student improvement

The student performance can be increased by proper training of the tool and the lack of using the tools from the freshman courses. As this technique has been shown good results a separate application can be designed and developed in the future so that the students can have ease of access while executing and simulating the content. These types of techniques will definitely help in achieving the skills of the students in every dimension by properly planning with some collaboration techniques.

## V. Conclusion

This paper shows a practical approach of Data Structures course using a technology tool for enhancing student knowledge and skills. The impact of these visualization tools reflects student's multiple learning styles. The goal was to convert teacher-centered traditional approach to technology-based student-centered approach using visualization techniques. The observations carried out clearly represent the change of teaching methodologies for the 21st century learners.

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