

# Collaborative Learning Tools for Data Structures

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## Abstract:

Collaborative learning makes the students to learn in a more formal way in a team. It increases the student engagement and there exists continuous interaction between the participants. It improves critical thinking and problem solving capabilities of learners. Courses which require these technical and soft skills can adopt Collaborative Learning strategies. Apart from the improvement in these skills, it also improves their behaviours in communication, team building skills among the students and so on. It ultimately shows greater improvement in their campus placement, which is the ideal objective of every graduate today.

## Keywords:

Collaborative learning, Active learning strategies, Flipped classroom, Think pair share, Data Structures, Lab Quiz

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## 1. Introduction :

The Computing domain is the vast changing field in this internet and mobile era. This field contains different computer hardware and software related courses for the students to complete their graduation in Computing or Information technology domain. Data Structures is one such course, and it is the most important course in this domain. All software recruiting Corporate looks for candidates who outperform well in the technical round, which comprises of questions mostly from the course Data Structures. As it is the foundation programme core course, it has been taught to students during their first or second year of programme. Students feel difficulty to learn all the concepts and relate these concepts to real time requirements and applications. Teachers are also unsure how to make the students to understand the concepts better.

The concepts have to be learnt in such a way that they have to be applied to solve the simple or complex problems during their technical rounds of campus recruitment process. Traditional classroom teaching method may not suffice this requirement. Also, there won't be enough time to train the students again on these concepts before their placement. In order to make the students to perform better during their placement, the course faculty has to adopt different teaching styles while delivering the concepts. Students do not learn unless they apply their learnt concept. Scenario based learning and the use of Active Learning Strategies (ALS) inside the classroom help

the students to remember the concepts for a longer period. This paper suggests some of the ALS and collaborative learning tools to teach Data Structures concepts so as to improve the class results. The paper is organized as follows: section 2 describes the related work, section 3 details the methodology, section 4 discusses the result and section 5 concludes the paper with the findings.

## 2. Related Work

All new pedagogical approaches like constructive and collaborative activities and visual demonstration for learning algorithms improved self learning among the students (Teresa et. al, 2003). Blended learning has been adopted (Xiaojing Liu, 2013) to teach Data Structures and Algorithms course. The faculty used this model for teaching methods and experiments through different techniques like visual demonstrations, project-based learning, eLearning, and so on.

Pair programming model has been adopted (Phil Maguire, 2014) to teach courses like computer programming, data structures, and so on for the students who have not studied computer science courses in their school days. Continuous assessment is carried out in different aspects like interdependence and co-ordination between the pair, and individual contribution to problem solving. Overall failure rate has been drastically reduced by this pair programming model. Attention Relevance Confidence Satisfaction (ARCS) motivation instructional model has been adopted (Yang et. al. 2016) for teaching Data Structures course. The assessment was carried out using Pair-programming model, and each student has been asked to comment on the other's program implementation of a Data Structure concept. This paper proposes yet another collaboration technique to improve students' performance in the course Data Structures involving various teaching styles through ALS techniques for content delivery. Jim Eison (2010) studied the importance of ALS inside the classroom and to create learning environment to have enhanced learning. Lauriet. al. (2008) proposed active learning strategies and examination methods for learning Data Structures and Algorithms using internet, small-scale demonstrations, and simulations. Students are asked to design solutions for practical applications

## 3. Methodology

This section describes the methodology that has been adopted to create enthusiasm among the students while learning Data Structures course and to maintain the same energy level till they attain their goal. Usually, the students on Day 1 of classes have to be handled with much interest. It is the right time and opportunity to motivate the student to learn this course. ARCS instructional model (Keller, 1990) says that the purpose of learning of the topic/course has to be clearly explained to the learners with the stated results. For example, the list of recruiting companies with high package can be made known to them. Alumnus who have got placement in these companies may create attention among the students. This definitely helps the fast learners to get motivated and build their self-confidence level. Figure 1 explains the framework of Active Learning Strategies for content delivery for the course.

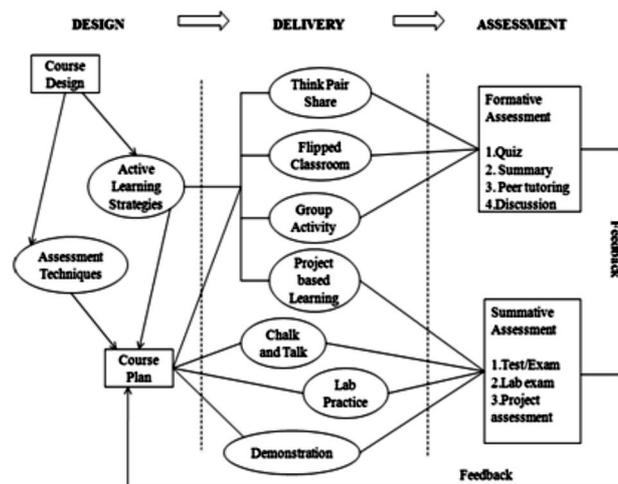


Figure 1 Framework of Collaborative Learning tools for a course

### A. Visual Demonstration

Along with the traditional classroom teaching, each session has to be prepared with the session plan by the course faculty. He/she can prepare ALS techniques for a topic in advance and make the learning environment ready for that purpose. Generally, the course Data Structures begins with the List data type, and then Stack, Queue, etc., Linked list data type can be well explained by using the video lectures and by the demonstration. Students with Visual style learning will easily grasp the concept and apply it to the problems.

## B. Flipped Classroom and Think Pair Share

Some topics can be covered by Flipped Classroom (FC) and Think Pair Share (TPS) activity. For example, the topic Circular Queue can be planned by this model. Pre-requisite is that the faculty has to complete the topic Queue before this FC activity. Circular queue is variation of Queue. Faculty can prepare learning materials and publish it to the students. Students have to learn the topic outside the classroom. FC activity can have some exercise and assignments in the topic, in order to ensure that all the students have completed this activity on time. Still, the faculty needs to ensure whether the students have understood the topic without any ambiguity. This FC activity can be followed by In-class activity using the technique TPS. Different problem on the topic has to be given to the students. Each student has to think about the solution for 2-3 minutes, then the solution has to be discussed with their peer/pair for 4-5 minutes and the solution has to be shared and discussed among all the students by any one group or by the faculty him/herself. Learning from the peer is more than learning through classroom teaching. This FC and TPS activities enable the students to understand the concept in a better way. Any misunderstanding or ambiguities in the concept are cleared immediately without any delay. All students are actively participating in the whole activity. The concept remains in their long time memory as they have completely engaged in the activity.

## C. Backward Design Instructional Model

Student engagement is the real challenge of a course faculty. The time at which the session is planned, and the physical and mental stability of the student are some of the factors that inhibit the student learning. The course faculty can overcome these issues by making all the learners to actively participate in the learning process. Backward design model says that objectives need to be informed in prior before instructional methods and assessment. For example, the students can be asked to frame questions from the set of topics. Then, Quiz can be conducted from these set of questions by dividing the class into groups. Depending on the time and the class response, the individual answer can be discussed in the class. This gaming activity keeps all the students energetic throughout the activity. The course faculty has to play moderator role and ensure that active participation from all the students. Some students may bring tough

and complex questions. This encourages the healthy competition between the students and they do deep learning in the topic in different aspects.

## D. Project based learning

Students can be asked to form project teams with 3-4 members. Restrictions can be posted to each group such that each team must comprise of good, average and poor learners. Each team has to take real time problems like Hospital management, Library management, etc. The students have to use Software Engineering practices like requirements collection, design diagrams and application development to solve these real time problems. Through these projects, they learn how to apply Data Structure concepts into this application. They learn how to integrate different modules, how to write generic modules to suit another module, etc. Each project team and the individual are assessed by the faculty team. Team formation, problem identification, etc. can be planned and done during the initial period of the course. The progress of each team is monitored at each term and the suitability of Data Structure being applied can be verified. At the end of the course, the project can be demonstrated by the project team. During the entire tenure of the course, the students are completely engaged and it improves their knowledge, skill and attitude.

## 4. Results and Discussion

The Traditional class room teaching method is used for all courses irrespective of their complexity level and their importance. Teacher centric curriculum is being slowly changed to learner centric curriculum to overcome this issue. Suitable instructional design models are being used inside and outside the classrooms now-a-days to improve the understanding ability of students. Collaborative learning tools are applied for the course Data Structures to different batches of students and their performance is analyzed.

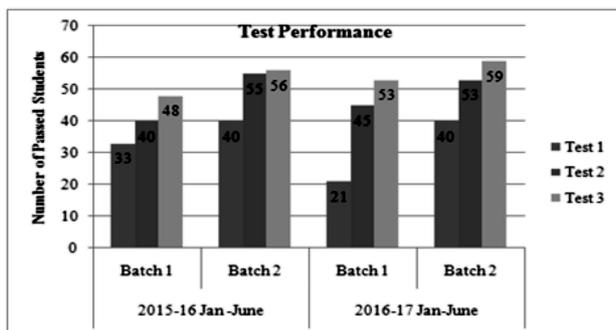
Table 1 describes the nature of data for which this experimental study has been considered. Faculty F1 handles Batch 1 of 2015-16, faculty F2 handles Batch 2 of both 2015-16 and 2016-17 and faculty F3 handles Batch 1 of 2016-17. Faculty F2 uses ALS tools and techniques in his class whereas faculty F1 does not. Table 1 shows the total number of students, and regular/lateral students participated in this activity. Lateral entry students are diploma degree holders and join this programme during the second year of four

year period of study. Generally, they have comparatively little programming knowledge and feel very difficult to cope up with this syllabus. The implementation of collaborative learning techniques helps them to perform well in their examinations.

**Table 1 Data Set Description**

Year	Faculty	Batch	Number of Students	Regular/Lateral
2015-16 Jan - June	F1(not handled ALS)	Batch 1	66	57 / 9
	F2 (handled ALS)	Batch 2	70	59 / 11
2016-17 Jan - June	F3 (handled ALS)	Batch 1	63	56 / 7
	F2 (Handled ALS)	Batch 2	68	60 / 8

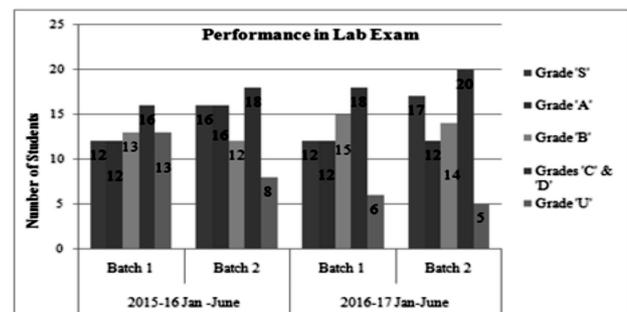
During the course period of study, there are three continuous assessment tests, one end semester examination and laboratory examination. Faculty F2 followed ALS techniques like collaborative learning tools throughout the period. The results of Batch 2 show continuous improvement in all tests, as shown in Figure 2.



**Figure 2 Success rates of Students in Tests**

Faculty F1 (2015-16) did not adopt ALS strategies in his class and he followed only traditional classroom based teaching. Having analysed the Test 1 results of Batch 1 and Batch 2 of the year 2015-16 and 2016-17, the Faculty F3 had been asked to follow the similar ALS strategies in his class. Hence Faculty F3 used ALS strategies like Flipped classroom, video demonstrations, Think-Pair-Share(TPS), seminar presentation by students, role play, project based learning, etc., in addition to Chalk and Talk method. As a part of this, Students were also actively involved in various activities assigned by the faculty. Circular queue Concept in data structure had been given as Flipped Class room activity. Concepts in non-linear data structures such as Binary trees, Binary search trees, AVL trees, B-Trees, Splay Trees were taught to

students using visual demonstrations. Students were asked to register in the website visulago.net and experience the visualizations of all concepts in data Structures. Some of the problems based on Data Structure concepts were taken from GeeksforGeeks website and given as Think-Pair-Share activity. Students had been asked to give seminar presentations on topics like External Sorting and Hashing. A set of students were identified and they were asked to demonstrate concept of Binary search tree and Quick sort through role play. In order to improve the Student's programming skills, Students were asked to solve problems in the hacker rank website. Students attempted easy level of programming challenges. Students were also motivated to try the medium level of programming too. Students were also allowed to work in teams to implement data structures concepts in their mini projects. Most of the batches had applied linear data structures concepts in their projects and very few had implemented non-linear data structures. At the end of course completion, Students were asked to complete end semester feedback survey through our department feedback analysis tool. It was observed that adopting ALS strategies created a positive impact on the Students' Performance. It resulted in the improvement of success rate of Batch 1 (2016-17) in their Test 2 and Test 3. Assessment of projects usually happens before Test 3 and it helps the students to perform better in the test.

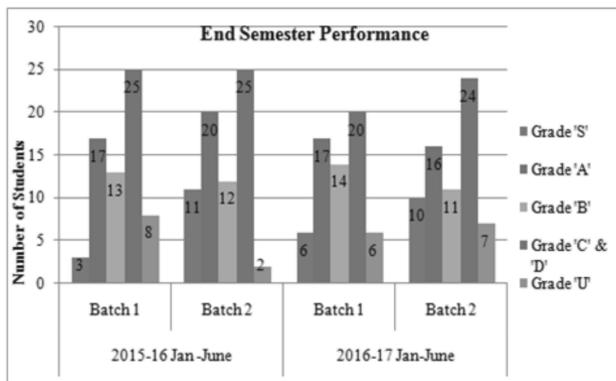


**Figure 3 Performances of Students in Lab Exam**

Concepts which are being learnt in the classroom are being practiced by the students in their laboratory classes. ALS techniques help them to apply their knowledge for problem solving. Figure 3 shows the performance of students in lab examinations. Batch 2 shows better performance when compared with Batch 1 of 2015-16. Marks between 90-100 belongs to Grade S, 80-89 belongs to Grade A, 70-79 belongs to Grade B, 60-69 belongs to Grade C, 50-59 belongs to Grade D, and < 50 marks belongs to Grade U. Number of students getting pass marks (grades S, A, B, C and

D) is increased and number of failures is decreased.

Figure 4 shows the performance of students in End Semester examination. Number of student getting 'S' grade is comparatively high for the batch of students where ALS and collaborative techniques have been followed. Number of failures is also minimal.



**Figure 4 Performances of Students in End Semester Exam**

Among 20 lateral entry students, only 6 students failed in theory examination and 9 in lab examination for the year 2015-16. It resulted in 70% pass percentage in theory and 55% in lab examinations. Among 15 lateral entry students, 4 students failed in theory exam and 3 students failed in lab examination for the year 2016-17. It resulted in 74% pass percentage in theory and 80% in lab examinations. Thus results of lateral entry students have been improved to a greater extent.

## 5. Conclusion

Student engagement is the challenging task for the course handlers. Students have much distractions and diversions and not listen to the class keenly. So, classroom teaching should be blended with traditional and active learning strategies. Collaborative learning tools and techniques make all the students to actively participate in the learning. These activities definitely have positive impact in their performance. The results showed that there is improvement in the knowledge they gained (through theory examinations) and the skills they acquired (through lab examinations).

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