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Using Kolb's Experiential Learning Theory to Improve Student Learning in Theory Course

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Abstract : Data structures and Algorithms (DSA) is a mandatory course for all discipline students to get placement in IT companies and to participate in competitive examinations including GATE and TANCET for their higher studies in a computer science discipline. DSA course focuses on how to organize, manage and store data in an efficient manner, which facilitates to access data easily and at a faster rate. Different types of data structures, its functionality and its applicability are discussed in this course. At the end of the course, students will have the capability to identify the suitable data structure for a problem. Due to its importance and complexity, pressure will be created on faculty members, who are handling this course. From the perspective of the student, some students understand the concept but lack knowledge of how to apply it. The majority of students struggle to comprehend the data structure and are perplexed by it. Recent work focuses on how faculty members play a major role in active learning like developing models to explain the concept, conducting activities like role play, think-pair share, flipped classrooms and so on. In this work, a study was conducted in the course DSA which focused on reflective practice led by David Kolb's experiential learning theory. An experiment was conducted during Academic Year 2021-22 (Odd) in the course 18CS340 – Data Structures and Algorithms for a set of 54 students. It is inferred that the student gained a higher or deeper knowledge level in this course and is confident to identify appropriate data structures for real world problems. By engaging in reflective practice, faculty members can think around and reflect on their experiences, learn from them, make changes, and enhance their learning and instructional skills.

Keywords : Activity-based learning, Data Structures and Algorithms, Kolb's experiential learning, Reflective practice, Self-Learning.

1. Introduction

The COVID-19 outbreak, which began in March 2020, brought learning to a halt around the world, causing the worst global education disruption in history. Many governments closed schools for several weeks or months as measures attempted to restrict the virus's spread. Several educational researchers have expressed concerns about the consequences of COVID-19-related school closures on student academic attainment and learning variability.

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Data structures and Algorithms (DSA) is a mandatory course for all discipline students to get placement in IT companies and to participate in competitive examinations including GATE and TANCET for their higher studies in a computer science discipline. DSA course focuses on how to organize, manage and store data in an efficient manner, which facilitates to access data easily and at a faster rate. Different types of data structures, its functionality and its applicability are discussed in this course. At the end of the course, students will have the capability to identify the suitable data structure for a problem. This course helps the students to progress in the field of artificial intelligence, data base management systems, operating systems, and graphics.

DSA is one of the challenging course for a faculty member to handle and for a student to learn. The faculty member should practice 50:50 rule. First 50% time to discuss the concept (20%) and to discuss various problem and the suitability of the data structure (30%). Next 50% time for making the students to identify and defend the suitability of the data structure for the tutorial problem.

The students in a class have different learning capabilities. Some students understand the concept but lack knowledge of how to apply it. The majority of students struggle to comprehend the data structure and are perplexed by it. The faculty role is to enhance the capability of the students. The students have to spend a substantial amount of time for "learning by doing". It is critical to receive feedback from the teacher at each stage of the learning process in order to avoid learning misconceptions.

The course on Data Structures and Algorithms cannot be completed only through online lectures. The course is ineffectively handled by

- Online lectures for 60 minutes,
- Explanation of concepts by irrelevant active learning.
- Peer assignments,
- Online assignments.

Faculty members are unable to track the learning status of students. By better acquaintance of learning styles, student-centered teaching is applied to reform the course Data structures and Algorithms. Our study was guided by the following research questions:

RQ1: What effect do online learning and offline practices have on improving learning outcomes, student engagement, and student feedback?

RQ2: Does incorporating practice-based learning strategies lay the groundwork for promoting self-learning abilities?

By engaging in reflective practice, teachers can think around and reflect on their experiences, learn from them, make changes, and enhance their learning and instructional skills. They can choose an appropriate teaching technique for their students and teach them according to their abilities. Students can enrich their learning efficiency and learning effectiveness. To promote practice-based experiential learning (PBEL) in core engineering courses. The goal of practice-based experiential learning is (i) to perform self-evaluation; (ii) effective communication in multiethnic teams; (iii) to improve creativity and iv) to handle complex problems with simplicity.

Practice-based experiential learning (PBEL) effectiveness is evaluated by conducting a defined set of activities. Individual quizzes, group video presentations, team collaboration, and team tournaments are examples of activities that assist students in improving their practice knowledge. It elaborates on the implemented course design, fun-filled activities and assignments, and efficiency in improving scores. It is helpful for instructors to develop an innovative fun-filled learning environment by adopting student-centered course

The rest of the paper is organized as follows: Section 2 grasps a background discussion about the learning model approaches in different courses. Section 3 presents the Kolb experiential learning model. Section 4 shows the methods followed in the experiment. Section 5 reports the results acquired by following Practice based experiential learning. Section 6 briefs about the conclusion and future work.

2. Related Works

The traditional way of teaching is carried out by explaining the concepts through lectures. Lectures are teacher-centered education. Lectures tend to bore students as well, causing them to drift off or daydream because there is no activity going on and all they have to do is sit and listen. Compared to traditional lectures, active learning is more student-centered education. Active learning strategies (Phillips, 2005; Scheyvens, 2008) can be used to improve online learning at all stages of the teaching-learning process and can encompass a wide range of learning styles. Professors can provide equal opportunities for students to interact on a particular topic. Students are encouraged to collaborate and communicate with one another rather than listening solely to the lecture.

Collaborative learning requires students to learn in a much more formal way as part of a team. It increases student involvement and allows for continuous interaction between participants. It enhances the learner's analytical reasoning and problem-solving abilities. Collaborative Learning strategies can be used in courses that require these technical and soft skills. Apart from improving these skills, it also improves their communication behaviors and team-building skills among students. The visual demonstrations, flipped classrooms & think pair share, and project-based learning methods are conducted (Abirami & Kiruthiga, 2018) to deliver the concepts. Quiz, peer tutoring, and tests are made to assess the knowledge and skills gained through active learning strategies.

Peer learning is a form of collaborative learning in which students work in pairs or small groups to discuss concepts or solve problems. The concepts of the courses are explained through visualization tools. Woven Stories, (Myller & Nuutinen, 2006) a collaborative authoring tool, with Jeliot 3 to form JeCo, a new tool to visualize the concepts better. (Myller, 2009) conducted empirical research on students who are learning programming, data structures, and algorithms. The collaborative learning process and outcomes are analyzed in three different institutions utilizing three different visualization tools, namely Jeliot 3, TRAKLA2, and BlueJ. Jeliot 3 has more visualization options and a user-friendly tool.

Pair programming (Preston, 2006) is a well-known method for teaching complex, conceptual tasks. Pair Programming (Kuppuswami & Vivekanandan, 2004) used in practical laboratories would promote peer learning and boost students' confidence in their programming abilities. However there was no significant rise in final exam results for male students, there was for female students, indicating that this teaching strategy may have asymmetrical gender benefits.

In flipped classroom model, knowledge is conferred before the class, and knowledge embeddedness occurs during the class and it is learning-centered education. Based on the self-made online judge (OJ) and micro lessons on a massive open online course (MOOC) platform (Huang & Fan & Hu & Feng, 2020) flipped classroom activity is performed in the Data Structure course. Quiz in the class, Explaining and answering questions, Sharing, lecturing & questioning, and Discussion, analysis & evaluation are the activities conducted to assess their knowledge. The course related content delivery activities and assessment are shown in Table I.

Engineering education provided effective exposure to hands-on practice for much of the twentieth century. It was taught by developing professionals and concentrated on solving hard problems while students learned to conceptualize and design products and systems. However, as scientific and technological knowledge rapidly expanded in the late 1900s, engineering education evolved into the teaching of engineering science, deemphasizing actual engineering practice. Due to the pandemic situation, student education is sorely affected, and to fill the gap in chalk piece lecture, learning models and styles are innovated.

CDIO (Conceive – Design – Implement – Operate) (Zhong & Chiu & Lai, 2021) is a creative educational model for developing the next generation of engineering leaders. They bring numerous benefits because CDIO produces engineers with the knowledge, skills, and experience that it requires. Educators are interested because the CDIO syllabus serves as a foundation for curricular planning and outcome-based assessment in all engineering schools. Students are also excited because they will graduate with a unique set of personal, interpersonal, and system-building experiences that will enable them to flourish in real engineering teams and establish new products and systems. Practice-based experiential learning (PBEL) is proposed to promote students learning efficiency and learning effectiveness.

(Shi et. al, 2020) explains that the flipped classrooms promote the innovation and exploration of college teaching models. The negative impact of the collaborative learning explained (Zhan and Jie, 2021).

(Reba et. al., 2022) presented the implementation of an enhanced Jigsaw learning method and proved that learning outcome was improved and makes the learning process enjoyable.

3. Kolb's Experiential Learning

Experiential Learning theory, as its name implies, is concerned with learning through experience and a learning process in which knowledge is acquired by the combination of perceiving and interpreting an experience. Experiential learning opportunities are available in a variety of course and non-course-based formats, such as volunteer activities, service-learning, undergraduate research, overseas study, and concluding experiences such as internships, student teaching, and capstone projects. According to Kolb, effective learning can only take place (Morris, 2020) when an individual completes a cycle of the four stages: concrete experience (CE) (Minh & Kim, 2021), reflective observation (RO) (Dwolatzky & Tischler & Ben-Zvi Assaraf, 2021), abstract conceptualization (AC) (Zainal & Din & Abd Majid & Nasrudin & Abd Rahman, 2018) and active experimentation (AE) (Fewster-Thuente & Batteson, 2018).

Table 1: Background Discussion of Learning Models in Engineering Courses

Author	Course	Content Delivery		
(Abirami & Kiruthiga, 2018)	Data Structures	Visual Demonstration Flipped Classroom Think-Pair Share Backward design instructional model Project based learning	Quiz Peer Tutoring Lab exam Theory exam Project Assessment	Pass percentage Theory - 74% Lab - 80%
Mary & Blesswin & Raj & Sukumaran, 2017)	Data Structures	Mind Map Role Play Video Presentation Video Scribe Match the following Word Search Crossword Puzzle	End Semester Examination	No Failure
(Chandrasekaran & Anitha, 2021)	Computer Networks	Instructional Design with Socket Programming, Network Simulations, and Animations Design of Worksheets to promote Problem Solving Skills Field Visits Learning by Doing Online Quizzes for Formative Assessment Hands On Experience and TeamWork Promote Self learning and communication	Continuous Assessment Test Terminal examinations	Content delivery - 79.8%. Learners actively engaged in classes - 99.8%. Around 95% of the students supported active Learning strategies.
(Anitha & Jeyamala & Kavitha, 2018)	Web Technologies Laboratory	Project based learning	Assessment of Creativity Enhancement of Creativity	The average Creativity level is 60.6% for the group.
(Jeyamala & Abirami, 2020)	Problem Solving using Computers	Problem Based Learning	Quizzes for formative assessment	The majority of the students have scored greater than 60%

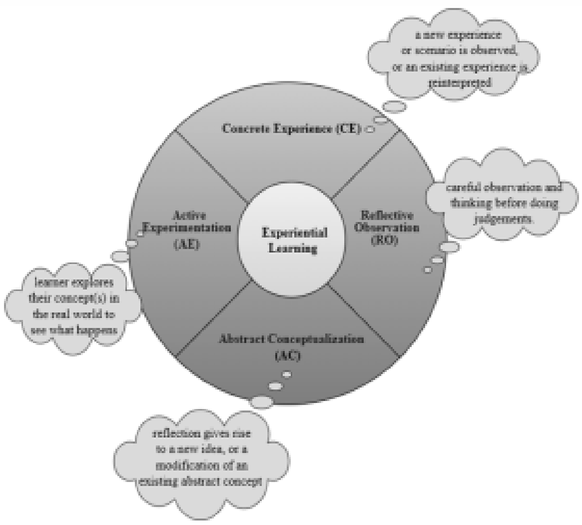

Fig. 1 : Kolb's Experiential Learning Style (morris, 2020)

Kolb's experiential learning style is depicted in Figure 1. Each learner participates in an activity or task during a concrete experience. Kolb believed that involvement was the key to learning. Learners must actively participate in the task to acquire new knowledge. Following the concrete experience, the learner takes a step back to reflect on the task. Reflective observation allows the learner to ask questions and share his or her experiences with others. Communication is crucial because it allows the learner to identify any gaps between their understanding and the experience itself. A strong vocabulary also allows for a comprehensive review of the events that happened. Abstract Conceptualization reflects on new ideas and elevates them to the level of abstract concepts. It entails interpreting the experience and comparing it to their current understanding of the concept. Learners can analyze new information and revise their conclusions based on previously known concepts. Active Experimentation is the process by which participants apply the new knowledge and experiences they gained at the start of the learning circle. Participants are capable of making predictions, analyzing tasks, and making future plans based on the acquired knowledge. The benefits of participating in experiential education opportunities are as follows: a better grasp of the course material, a broader perspective on the world and a sense of community, an understanding of their abilities, aspirations, passions & virtues, possibilities for collaboration with a wide range of organizations and individuals, the satisfaction that comes from assisting in meeting community needs and builds self-confidence and leadership abilities. Practice-based experiential learning (PBEL) is proposed to enrich learning efficiency and learning effectiveness.

4. Methods & Materials

The study was conducted during Academic Year 2021-22 (Odd) for 2020 admitted students III Semester 'A' Section students. The number of students in that section is 54.

A. Experiment Setup

1) Students

They joined the college when the world was struggling due to covid-19. The students completed their first year and 25% of their third semester in online mode. The number of students for the experiment is 54.

Table 2 : Course Outcomes of Data Structures and Algorithms

COs	Course Outcomes	Bloom's Level
CO1	Apply the concepts of stack and queue for suitable applications in trade-off with time and space complexity.	Apply
CO2	Illustrate the operations like insertion, deletion, traversing on the nonlinear tree data structure.	Understand
CO3	Choose appropriate binary and multiway search trees for performing searching operations, with an understanding of the trade-off between the time and space complexity.	Apply
CO4	Manipulate disjoint sets by performing union, iterative find- set operations.	Apply
CO5	Demonstrate the concepts of advanced data structures including a heap in various applications.	Apply
CO6	Show the avoidance of collisions in the hash tables using collision resolution techniques including open and closed hashing techniques.	Apply

2) Sampling Method

The students are ordered based on the non-increasing order of their internal assessment marks.

$$s_1.mark \geq s_2.mark \geq \cdots \geq s_n.mark$$

where $s_{i.mark}$ indicates internal assessment mark of the i^{th} student and there are n number of students.

Then the students are divided into m teams such that

$$\{s_i, s_{(i+m)}, s_{(i+2m)}, \cdots, s_{(i+km)}\} \in \{Team\}_i$$

where $i+km \leq n$

The average assessment marks and number of students in each team are approximately same. $avg(s\_i.mark+s\_(i+m).mark+\cdots+s\_(i+km).mark) \cong avg(s\_j.mark+s\_(j+m).mark++s\_(j+km).mark)$

where $1 \leq i,j \leq m$.

3)

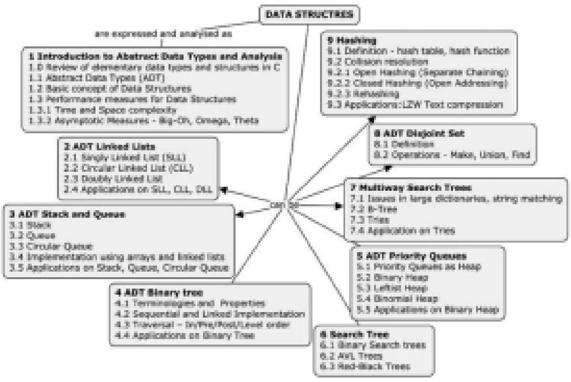

Fig. 2 : Concept Map of the Course

Course

Third Semester Course 18CS340 – Data Structures and Algorithms. Initially, 25% of the course has been conducted in online mode. Table II presents the course's learning outcomes, which are organized according to Bloom's taxonomy of the psychomotor

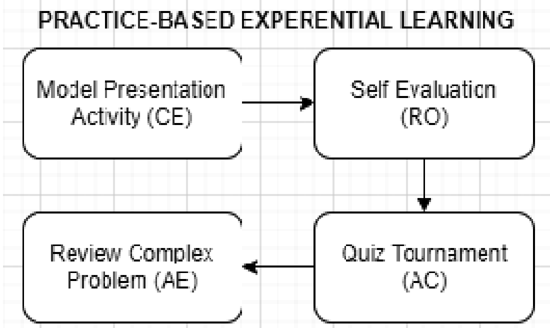

Fig. 3 : Activities conducted to improve knowledge

processes. Figure 2 shows the concept map of the course.

c. Kolb's cycle of learning in the course Data Structures and Algorithms

Initially, 25% of classes were conducted in online mode then followed by offline classes. To cope with the knowledge, practice-based experiential learning is implemented based on Kolb's cycle of learning which comprises four levels of knowledge improvisation as shown in Figure 3.

1) Model Presentation Activity - Concrete Experience

The objective of the model presentation is to ensure that the students understand the concepts. For a better understanding of Data Structure and Algorithms, the topics are broken into sub-topics and assigned to students.

The rules of this activity as:

- Batch size 2 or 3.
- Each batch has to identify a topic.
- Present the concept using an active learning tool, such as role play, model, chart work, video presentation, animation, etc.

Table III shows the batch details, topic identified and active learning strategy. Figure 4 shows the model generated for the assigned topics such as stack, queue, linked list, red-black tree, hashing, balanced binary

Table 3 : Team & Activity Details

Team No.	Reg. No.	Name	Reg No.	Name	Reg No.	Name	Topics	Name of the Activity	YouTube Link
1	20C088	Srinidhi Ranjith	20C086	Sornamugi DS			Stack	Demo - Model	https://youtu.be/[illegible]
2	20C038	Dolkar	20C005	Archana M R			Linear Queue	Demo - Model	https://youtu.be/[illegible]
3	20C076	Sankaravignesh	20C009	Balaji	20C017	Nithish	Circular Queue	Demo - Chart	https://youtu.be/[illegible]
4	20C047	Lakshay Kumar J	20C066	Rakesh S	20C006	Aswin	SLL	Demo-chart	https://youtu.be/[illegible]
5	20C062	Prasidha S	20C081	Shrinidha S S			DLL	Demo - Model	https://youtu.be/[illegible]
6	20C029	Dharsana V	20C012	Sujalakshmi P			CLL	Demo- model	https://youtu.be/[illegible]
7	20C074	Sanjay V	20C018	Dhaneeswaran			BT - Traversal	PPT - Animation	https://youtu.be/[illegible]
8	20C054	Mohamed Saffi.M	20C017	Jaya kumar.R			BST – Search, Insert	PPT- Search and Insert	https://youtu.be/[illegible]
9	20C075	Sanjay	20C105	T.P.Venkatesh	20C073	Sai Vethsan	BST - Delete	Demo - Chart with Cards	https://youtu.be/[illegible]
10	20C024	Guhan	20C013	Infant Vinoth P			AVL Tree – Single Rotate	Demo-Model	https://youtu.be/[illegible]
11	20C058	Manasvini	20C064	Raj Prabha E			AVL – Double Rotate	Demo - Chart, balls	https://youtu.be/[illegible]
12	20C015	Chinnaya Prabhu	20C091	Sumanth Srinivas	20C080	Shiv Naren	RB Tree - Insert	PPT - Insertion Tips	https://youtu.be/[illegible]
13	20C046	Krishna Sameer	20C014	Jagajeet Pattas P K	20C030	Elamukilan P	Red Black Tree - Delete	PPT- Cases with Bins	https://youtu.be/[illegible]
14	20C070	Bidhyanth S	20C004	Arun Kumar M			B-Tree	PPT - Animation	https://youtu.be/[illegible]
15	20C014	Carolina J	20C053	Meenakshi M			Tries	PPT-Animation (online Visualization Tool)	https://youtu.be/[illegible]
16	20C087	Aalle Tony	20C010	N Gopal Sankar	20C077	Saravana	Binary Heap	PPT - Insertion, Deletion, Time Complexity	https://youtu.be/[illegible]
17	20C039	Joshua S	20C105	Venkata Ramana			Leftist Heap	Demo - Chart	https://youtu.be/[illegible]
18	20C060	Prakashraj	20C012	Bharanidharan	20C031	Harihara	Skew Heap	PPT-insertion, merging &demo	https://youtu.be/[illegible]
19	20C025	Hari Kiraman A.P	20C002	Alex Allan Raja V			Binomial Queue	Demo - Chart and Model	https://youtu.be/[illegible]
20	20C100	Vandhini Sri A	20C089	Subalakshmi			Open Hashing	PPT and Demo	https://youtu.be/[illegible]
21	20C040	Kalpamatavi S	20C012	Harshini M			Closed Hashing	Demo - Chart and Model	https://youtu.be/[illegible]
22	20C071	Bodhan B	20C106	Vignesh R			LZW Compression	PPT-Encoding and Decoding	https://youtu.be/[illegible]
23	20C048	Lakshmi Priya B	20C055	Muthu Aiswarya			Disjoint Set	PPT - Application	https://youtu.be/[illegible]

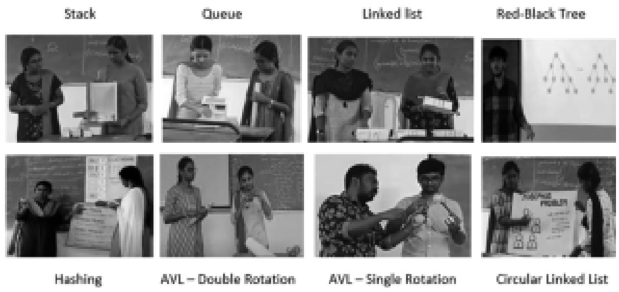

Fig. 4 : Model Presentation Activity.

search tree (AVL Tree) with single & double rotation, and Josephus problem using circular linked list. The outcome of the Model Presentation Activity is effective communication, and creativity to develop models.

2) Self Evaluation - Reflective Observation

The objective of self-evaluation is to reflect on and observe these experiences from different perspectives. Each batch has to record the model presentation activity and uploaded the video in YouTube social media. For privacy reason, the students are instructed to make their YouTube video visibility setting as unlisted. The last column in the Table III, contains the YouTube link of the model activity recorded video.

Each student does self evaluation of the presentation and also randomly review some peer presentations. A Google form is circulated among students to record 5-scale rating (very good, good, average, poor, very poor) of the peer group video content. The parameters considered for evaluation are as follows:

- Audio Quality - Audio needs to be audible and clear to viewers without noise interruption.
- Video Quality - While playing the video, the voice of the presenter needs to be synchronized with the content in the video. Video quality should be clear and high resolution.
- Aspect Ratio - Video should be portable to all device aspect ratios without installing any additional hardware or software.
- Clarity of presentation - The presentation needs to be elaborate and crisp but not to be vague. It should be easily understandable to viewers without compromising the quality of the content.

- Concluded within the stipulated time - the concentration capacity of normal human beings is about 15 minutes. The presenter needs to conclude his presentation within a stipulated time.

- Completeness - The presenter should include the definition, how it works (i.e. operation), application, advantages and disadvantages of the topic to be presented.

- Presentation skills - The presenter must deliver the presentation through online software tools.

Table IV depicts the Google form that contains parameters considered for self-evaluation using a 5-point rating scale. The outcome of this activity is self-evaluation.

3) Quiz Tournament - Abstract Conceptualization

The objective of quiz tournaments is to apply the learned concept to a given problem scenario. Figure 5 shows the details of the activity as:

- The students are divided into 2 groups (Group A & B).

Table 4 : Self Evaluation Parameter Format in Google Form

Parameters	Very Poor	Poor	Average	Good	Very Good
Audio Quality			✓		
Video Quality			✓		
Aspect Ratio				✓	
Clarity of Presentation					✓
Concluded within the stipulated time				✓	
Completeness				✓	
Presentation Skills				✓	

- Each group is subdivided into 5 teams with a team size of five or six.

- Each team identifies a topic and prepares 10 MCQs (Multiple Choice questions). Sample question is shown in Figure 7.

Group	Team Name	Member 1	Member2	Member 3	Member 4	Member 5	Member 6	Topic
A	Team A1	20C008	20C091	20C034	20C048	20C089		Leftist Heap
	Team A2	20C003	20C080	20C033	20C062	20C076	20C023	Hashing
	Team A3	20C057	20C031	20C014	20C025	20C047		Binary Search Tree
	Team A4	20C018	20C009	20C086	20C106	20C098	20C071	Binary Search Tree
	Team A5	20C073	20C064	20C105	20C024	20C002		Linked List
B	Team B1	20C019	20C100	20C022	20C046	20C038		BST
	Team B2	20C075	20C028	20C039	20C017	20C015	20C103	Heap
	Team B3	20C010	20C066	20C012	20C053	20C054		AVL Tree
	Team B4	20C074	20C077	20C070	20C055	20C040	20C004	B-tree
	Team B5	20C007	20C012	20C081	20C088	20C060		Heap

Group	Level I		Level II
	Selected	Wildcard	Winner
A	A3, A5	A1	A1
B	B4, B3	B5	

Fig. 5 : Tournament Details

- Two level quiz is conduced as Round 1 (Intra-Group Quiz) and Round 2 (Inter-Group Quiz).

Round 1:

- Each team conduct quiz for other teams in that Group.

- The time allotted for each question is straight 60 seconds.

- One question per team without pounce/pass.

- For the correct answer, 10 points are awarded to the team and no negative points for the wrong answer.

- The team with the maximum score is qualified for the next round. (Group A – A3 & A5, Group B – B4, B3).

- Wildcard Round is conducted for non-qualifiers to choose one qualifier from each Group (Group A – A1, Group B – B5).

Round 2 'Prancing at the Occasion'

- The unqualified teams conduct this activity to the qualified teams.

- It consists of 15 normal and 5 marquee questions.

- If a tie break situation happens, the points for marquee are doubled at the stake of double loss in case of incorrect answers.

- The one who first raises the hand and correctly answers is awarded 10 points.

- The points are gradually decreased for the Second, Third, Fourth, and fifth are awarded 5, 3, 2, and 1 point respectively.

- For every third wrong answer, they deducted 7 points from the total score.

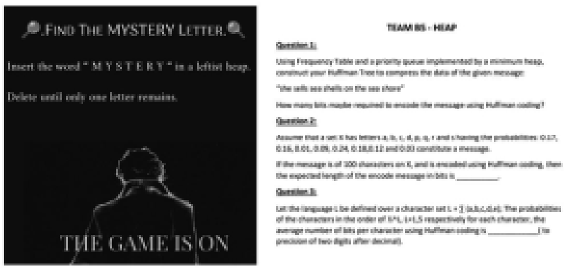

Fig. 6 :Sample quiz question for the tournament.

- The final title is given to the team with the highest points. (Team A1 is the winner)

The sample quiz question for the quiz tournament is shown in the Figure 6.

4) Review Complex Problem - Active Experimentation

The objective of reviewing complex problems is to share the knowledge equally with all the students. From the previous 3 levels of activities, the student gains better knowledge about the DSA course. Active experimentation activity is conducted to evaluate the knowledge level of the students.

Figure 7 shows the review complex problem activity (Zig-Zag Puzzle Activity). The primary intention of the activity is to improve the knowledge level of average and low scoring student. The details of the activity as

- Based on the observation of the student's performance in the previous level of activities, different knowledge level students are divided into group of size 5 or 6.
- Each group consists of average scoring students, low scoring students, and topper students.
- For each group a random complex problem is assigned.
- Round 1 (10 minutes): Each group has to discuss the solution for the question assigned to them.
- Each member in a team has to disseminate and form a new group of size 5 or 6.
- Round 2 (20 minutes): Each member in the new team has to explain the learned solution to other members in that team.
- Round 3 (30 minutes): The average or low scored student has to present any one of the learnt solution to the entire class.
- At the end, all the complex problems are solved.

Fig. 7 : Review Complex Problems

5. Results & Discussion

The performance of internal and terminal examinations for the course DSA are analyzed in three different scenarios and the report is taken as a piece of evidence for RQ1.

Scenario 1: 2019 – 2020 batch

They joined the college when the world was functioning as normal. The students completed their first year and 100% of their third semester in offline mode without any active learning strategies. The number of students for the experiment is 54.

Scenario 2: 2020 – 2021 batch

They joined the college when the world was struggling due to covid-19. The students completed their first year and 100% of their third semester in online mode by following some active learning strategies like quiz, flipped classroom. The number of students for the experiment is 54.

Scenario 3: 2021 – 2022 batch

They joined the college when the world was struggling due to covid-19. The students completed their first year and 25% of their third semester in online mode with active learning strategies. The number of students for the experiment is 54.

Expected attainment:

The process for calculating attainment of course outcomes is shown in Fig. 8. It is calculated for each course outcome of a course based on the average performance of the students in end-of-semester exams for that course during the last three academic years. The average percentage of students achieving the required proficiency is the expected level of attainment. The highest grade at which the overall percentage of students is greater than 50% serves as the baseline for determining the required performance

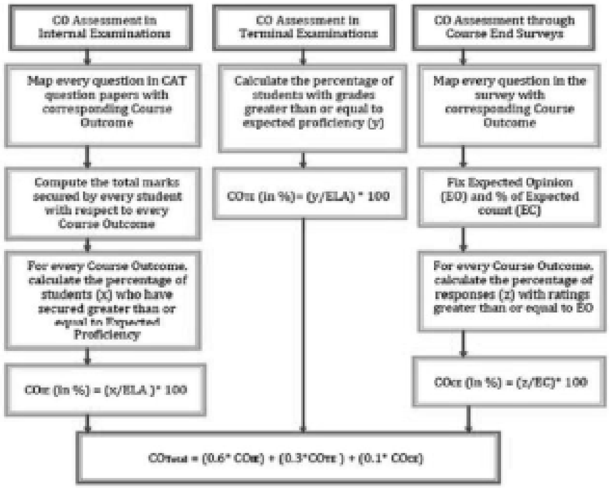

Fig. 8 : Process For Calculating Attainment of Course Outcomes

in each subject. The projected level of achievement is set 20 to 30% higher than the level of achievement. Expected proficiency and Expected level of attainment is set for all the courses and used as target for course attainment calculation.

Scenario 1: 2019 – 2020 batch

The expected and obtained attainment of course outcome for scenario 1 is depicted in Figure 9a. It infers that the expected attainment is higher than obtained attainment for every course outcome in the course and shows the student's performance level in every course outcome. In CO1, 78 % of students performed well out of the expected 82% of students performance. Similarly, other course outcomes are depicted clearly. The classes are conducted in an offline mode like teacher-centered education. The

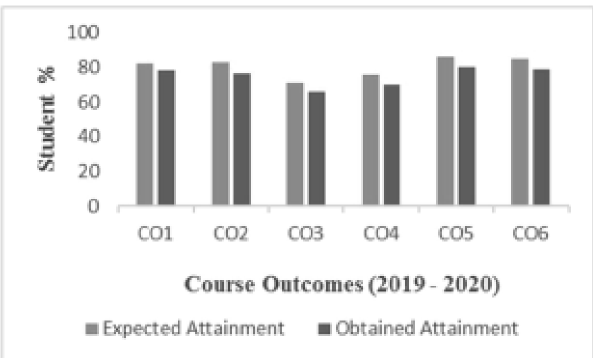

Fig. 9a: Student Involvement Concerning Course Outcomes in the 2019 – 2020 Academic Year

obtained attainment of Course outcomes is lowered due to a lack of concentration in teacher-centered education.

Scenario 2: 2020 – 2021 batch

The expected and obtained attainment of course outcome for scenario 2 is depicted in Figure 9b. It infers that the expected attainment is higher than obtained attainment for every course outcome in the course and shows the student's performance level in every course outcome. In CO1, 71 % of students performed well out of the expected 81% of students performance. Similarly, other course outcomes are depicted clearly. The classes are conducted in an online mode like teacher-centered education. The obtained attainment of course outcomes is lowered due to a lack of student participation in activities. As the activities is conducted online mode, students faced isses including internet and eye irritation. This feedback has been collected during class committee meeting.

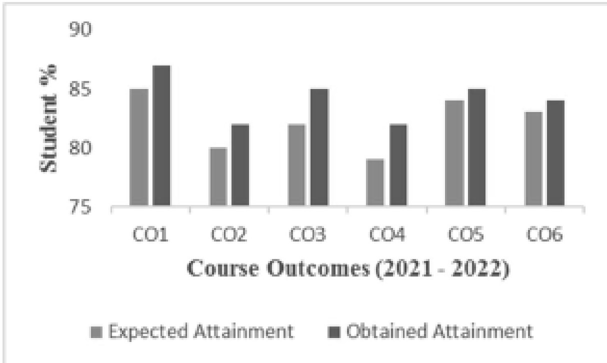

Fig. 9c : Student involvement concerning course outcomes in the 2021 – 2022 academic year

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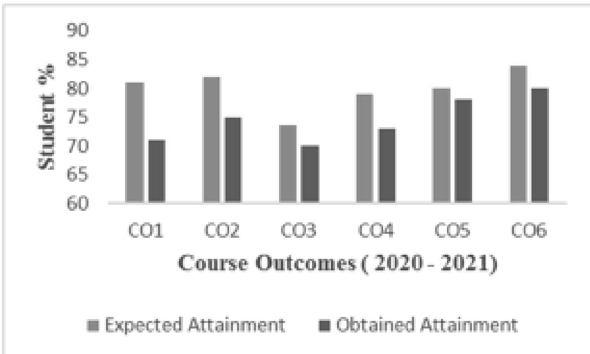

Fig. 9b : Student Involvement Concerning Course Outcomes In The 2020 – 2021 Academic Year

ario 3: 2021 – 2022 batch

The expected and obtained attainment of course outcome for scenario 3 is depicted in Figure 9c. It infers that the obtained attainment is higher than expected for every course outcome in the course and shows the student's performance level in every course outcome. In CO1, 87 % of students performed well and exceeded the expected 85% of student's performance. Similarly, other course outcomes are depicted clearly. Initial 25 % of classes are conducted in online mode and the rest of the classes are in offline mode. Student-centered education is followed for the course "Data Structures and Algorithms. The obtained attainment of Course outcomes is increased due to the presence of student participation /involvement in activities.

The student participation is assessed by conducting an internal examination in all three different scenarios. The performance level assessed for every course outcome is illustrated in internal exam (Figure 10) and external exam (Figure 11). Due to a lack of knowledge in depth and student involvement, Scenario 1 and 2 have fluctuation in every outcome. Student and learning-centered education induce student engagement and improve concentration and in-depth knowledge. With the help of active learning strategies, scenario 3 outperforms in all course outcomes.

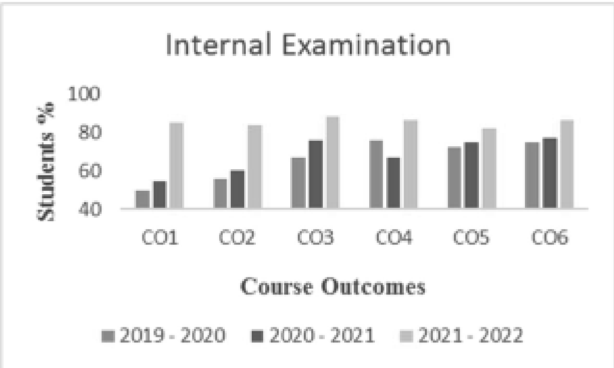

Fig. 10 : Performance of Internal Examination Compared With Previous Batches.

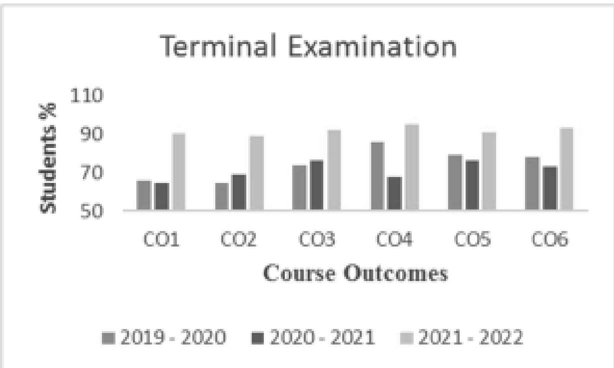

Fig. 11 : Performance of Terminal Examination Compared With Previous Batches.

The academic performance of students is represented in grades. The grading system is used to identify the student's knowledge level and provide additional support to them. Table V shows the grade and its range of marks. Figure 13 shows the number of students who secured S, A, B, C, D, and U grades in percentage for all 3 scenarios. In the 2019 – 2020 batch, less number of students secured S grades, and more students secured C grades. Few students have failed the exam. In the 2020 – 2021 batch, less number of students secured S grades, and more students secured C grades. Few students have failed the exam.

In the 2021 – 2022 batch, more number of students secured S grades, and an equal number of students secured B and C grades. No students have failed in this batch. The academic performance of students in the internal and external examination concerning course outcome shows the effect of online learning and offline practices (i.e. evidence for RQ1).

The ultimate aim of Practice based Experiential learning is to improve in-depth knowledge. The learning model improves the class average performance (i.e. evidence of RQ2). The average performance of batch 2019 – 2020 is shown in Figure 13. The average performance of batch 2020 – 2021 is shown in Figure 14. The average performance of batch 2021 – 2022 is shown in Figure 15.

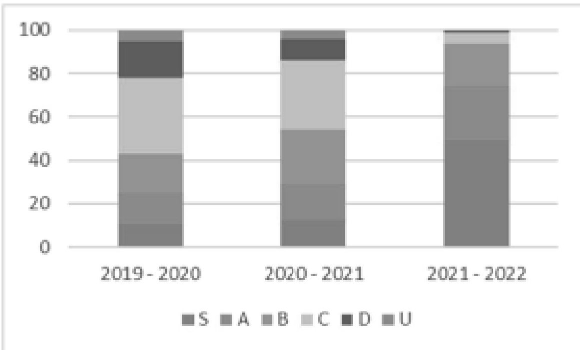

Fig. 12 : Grade of Terminal Examination Compared With Previous Batches.

Table 5 : Academic Grading Scale

Grade	Range
S	90 and Above
A	80 – 89
B	70 – 79
C	60 – 69
D	50 – 59
U	Below 50

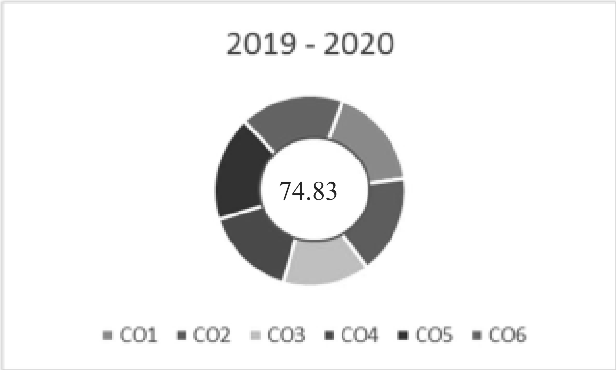

Fig. 14 : Average Attainment of Course Outcomes In 2019 – 2020.

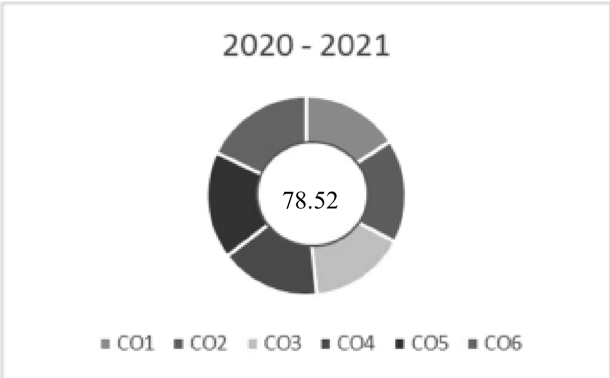

Fig. 15: Average Attainment of Course Outcomes in 2021 – 2022.

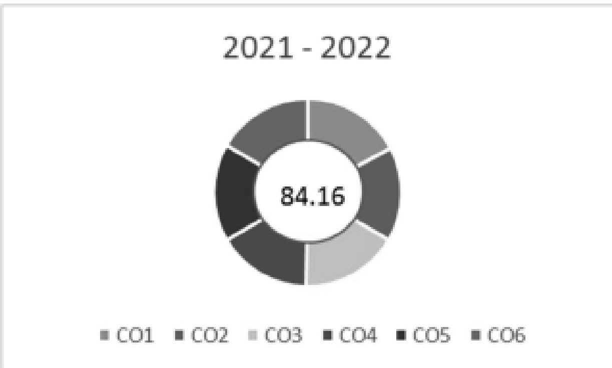

Fig. 15 : Average Attainment of Course Outcomes in 2020 – 2021.

Compared to the two previous batches, the 2021 – 2022 batch outperforms in all course outcomes, internal examination, and terminal examination. The knowledge and skills are improved by participating in all conducted activities.

6. Conclusion

The performance of the students has enhanced by the experiment conducted based on David Kolb's experiential learning theory. The enhancement was achieved via self-evaluation and gained skills including effective communication in multiethnic teams, improving creativity, and solving complex problems. Student's in-depth knowledge and academic performance are improved with the help of Practice based experiential learning. In every aspect, student participation and scores are enhanced by fully immersing themselves in activity and practice based learning styles. Nearly at most 50% of students secured an S grade in the terminal exam who studied in the academic year 2021 – 2022. The average course attainment of the class is greatly upgraded compared to previous year batches. The conducted experiment is not only for student involvement, and includes faculty participation.

This research work can be extended to other engineering courses, placement training and enhancing faculty's participation to conduct more activity based learning styles. Need to design specific learning styles for slow and fast learners to enrich their concentration and learning skills.

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