Active Learning Strategies for Engaging Students in Higher Education

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***Abstract*—Rapid development in teaching-learning and its methodologies, technology has opened entirely new avenues for educational research. In active learning, students are exposed to course material through problem solving, case studies, discussion, think pair share, flipped classroom, role play, quizzes, gaming and other pedagogical methods. This proposed work experiments with multiple active learning approaches to engage and motivate reluctant learners. Learners are exposed to the purpose and design of active learning strategies such as quiz, game, case study and role play. Feedbacks and analysis of these implemented active learning strategies are excellent. Statistical analysis of active learning techniques indicates that there is improvement in student's academic performance, skills development and student's satisfaction. There exists a great deal of inter-relatedness across the strategies as one strategy invokes another by default. This work will help identify more targeted ways to assist teachers/learners in their efforts.**

***Keywords*—Case study, Engaging reluctant students, Pedagogical strategies, Role Play, Statistical Techniques.**

***JEET Category*—Choose one: Practice**

I. INTRODUCTION

Andragogy focuses on principles of learning in higher education. Higher education learners are independant and self-driven. It is necessary to make them active learners rather than passive listeners. In the teaching-learning process, one of the most important tasks is to engage active learners. It will be more effective and fruitful if appropriate technology or instruments are used. Extensive research has shown that active learning strategies are generally more effective and student centric than traditional learning. It promotes a wide range of desirable educational outcomes, including increased student learning and retention rates. Active learning stimulates students' learning, and can boost student's creative thinking skills along with other advantages. There are many active learning strategies that can be executed in a planned way. Some of them are debating about a topic or event, engaging students in case studies or simulations, self-monitoring their learning activity, constructing a quiz for use with peers, flipped classroom activity and many more. However, in active learning managing large classes is sometimes difficult. Conducting activity can create multiple distractions for students. Some students are reluctant and do not respond or participate actively in large classroom activities. From a teacher's perspective, difficulty in covering the entire subject/course, assessment of students, time management from planning to execution and using unfamiliar technologies are some of the challenges faced by them. The lack of interest in the subject/course, as well as traditional teaching-learning approaches, are the most common causes for having reluctant students in a class. These two issues can be addressed by incorporating new digital technologies such as having students create podcasts to explain their ideas, having them write their answers on a digital pad and pen, having them create short videos or animated presentations instead of writing or drawing on paper, and so on along with some offline activities such as walk around the class, encourage them for questions, grading for active participation etc. Our solution involves elaborating case study, flip classroom, quiz, gaming activity results and feedback to engage a large class and involve every student in the activities.

II. LITERATURE REVIEW

Active learning refers to the constructivist perspective of learning. Knowledge is actively constructed by the learner and integrated with his or her existing knowledge and experience. Several papers are referred for active learning, its strategies, models and approaches of active learning and the process of implementing effective learning. **(J. Patrick McCarthy and Liam Anderson, 2000)** report active learning vs traditional learning experimented on history and political science. **(Bonwell, C. C., & Eison, J. A., 1991)** says that active learning not only motivates the students' autonomy and increases participation in their learning process, but also places the teacher not as a mere transmitter of knowledge but as a facilitator or guide of that learning. **(Daellenbach K., Hayter, C. S. & Parker M. A., Pang, E., Wong, M., Leung, C. H., & Coombes, J., 2018;2019)** reports active learning promotes

student's creativity, which eventually determines their future employability and personal development. helping them to develop the skills that increasingly determine their future employability and personal development. **(Himdad A. Muhammad, 2016)** focuses on challenges in active learning and their solutions. As per the observations by them, main challenges in active learning are - course content, pre-class preparation, large class, teacher resistance, lack of materials or equipment and Students resistance. They also suggested a few solutions for these challenges. **(Chhaya et al, 2019)** presents a flipped classroom activity in detail as a case study. **(Sneha Tharayil et al. 2018)**, presents an analysis of the use of strategies to reduce student resistance to active learning in their undergraduate engineering courses. They collected interview data from 17 engineering professors of the USA for this. They concluded that there are multiple successful ways of implementing these strategies but one needs proper course planning too. Instructors should acknowledge the challenges of the implementing approach of active learning. **(Yadav et al., Bentley et al., 2011; 2011)** suggest providing students with feedback and support throughout the process and solicit and act on student feedback about the activities. Based on their experiences, (**Carlson and Winquist, 2011)** recommend ramping up slowly for implementing in statistics course workbooks. They recommend that the purpose and expectations of the activity should be explained clearly and activities should be aligned with other course assessments. (**O'Brocta, R, & Swigart, S, 2013)** shows that students often respond positively to active learning strategies; there are counterbalancing studies by Brent, R., & Felder, R. M., Wilke, RR, which show mixed student responses. Study by Yadav A et al., Lake, D shows negative student responses. While few prior studies empirically identify strategies instructors can use to mitigate student resistance to active learning, some studies by Yadav A et al., Bentley, FJB, Kennedy, S, Semsar, K., include advice on how to reduce resistance.

Most of the active learning concerns have been sufficiently addressed through the existing literature but relatively little research on statistical analysis of effect of implementing active learning strategies on student's skill development, academic performance and on student's satisfaction. Sometimes teachers are also reluctant to change their teaching approach. This paper addresses the effect of some active learning strategies such as case study implementation, role play, quiz on students overall academic and skill development. Students feedback was also analyzed and results were also statistically analyzed using a chi-squared non parametric test. Applied techniques analytical results indicate that there is improvement in student's academic performance, skills development and student's satisfaction.

III. Methodology

In this research work we address three research questions. Questions are concerned with whether incorporation of the active learning strategy affects the student's skill, academic achievement standards and students' satisfaction with their learning process. More precisely, these three research questions are stated as:

Q1: Does the use of active learning strategy in an active learning setup affect the students' skills?

Q2: Does the use of active learning strategies affect the students' academic achievement?

Q3: Does the use of active learning strategies affect the students' satisfaction?

Two different courses "Statistics for Computer Science" and "Operating System" are considered for studying the effect of different active learning methods. Case study implementation, role play, flipped classroom, think -pair-share strategies were implemented in these courses.

The "Statistics for Computer Science" is an elective course of third year first semester computer engineering. To appropriately follow the course, students are familiarized with active learning methodology to be implemented and with the necessary information and communication technologies (ICTs) that they would need.

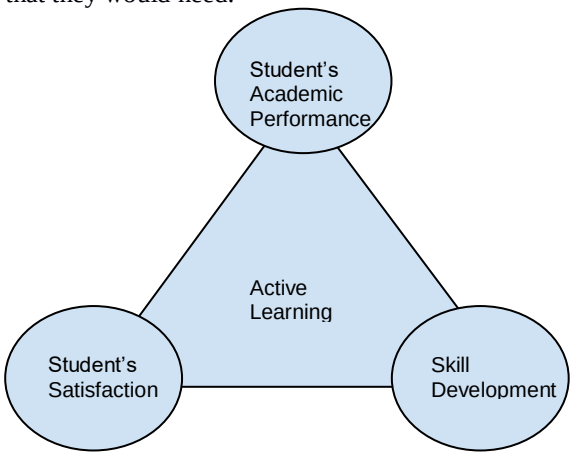

Fig 1: Considered parameters of Active learning

Students implement different case studies on the topics discussed in class using different open source tools and technologies. Idea is to improve their overall technical knowledge and skills, which eventually helps them in their employability as shown in Figure 2.

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Fig 2: Case Study implementation for Statistics for Computer Science course

Participants are a group of students who have studied the "Statistics for Computer Science" course for the last four years. Students individually choose a topic, download the relevant dataset, apply the suitable algorithms and Statistical Methods to reach the inference. This case study is presented to the teacher. Evaluation of the case study is based on the following rubrics.

- Depth of Problem Statement (General or Specific)
- Relevance of Algorithms and Statistical Methods and data set Chosen
- Inference Drawn
- Presentation

The result of case study evaluation is presented in Table 1. This data represents, number of students who opted for the "Statistics for Computer Science" course and scored >80 % and >90 % marks in case study implementation and presentation. Table 2 data represents, number of students who opted for the "Statistics for Computer Science" course and scored >80 % and >90 % marks in overall course evaluation (ESE). So table 2 data represents the students overall academic performance for that course.

TABLE 1

CASE STUDY IMPLEMENTATION AND EVALUATION RESULTS FOR "STATISTICS FOR COMPUTER SCIENCE"

Year	2018-19	2019-20	2020-21	2021-22
No of students appeared in exams	51	85	110	130
No of students performed excellent >90	32	18	88	29
No of students performed excellent >80	42	59	92	69

TABLE 2
ESE RESULT OF "STATISTICS FOR COMPUTER SCIENCE"- ACADEMIC PERFORMANCE

Year	2018-19	2019-20	2020-21	2021-22
No of students appeared in exams	51	85	110	130
No of students performed excellent >90	1	4	43	36
No of students performed excellent >80	10	24	77	73

The "Operating Systems" course is a core course of second year, second semester computer engineering. Participants are a group of students who have studied the "Operating Systems" course for the last three years. Pedagogy technique Role Play is implemented to explain classical interprocess communication problems - Readers and Writers. Volunteers are invited to play the role of Readers and Writers. Two students are playing the role of semaphores. Black Board is used as a critical section. When Readers acquire a semaphore, all other readers can access the board but Writers have to wait. In contrast, if Writers acquire a semaphore, none of the readers or writers are allowed to access the board as shown in the following Figure 3.

Fig 3: Role Play

We conducted a quiz to cross check understanding of the students. Table 3 shows the set of questions asked.

TABLE 3
QUIZ FOR OPERATING SYSTEM READER WRITER CONCEPT

Q. N.	Question
1.	Semaphore is a/an _____ to solve the critical section problem.
2.	Which of the following is the atomic operation permissible on semaphores?
3.	The Reader Writer problems and its solutions have been generalized to provide reader writer locks on some systems . When a process wishes only to read shared data,it request the reader writer lock in

4.	The two kinds of semaphores are :____ and _____
5.	Concurrent access to shared data may result in _____
6.	The dining – philosophers problem will occur in case of _____
7.	A situation where several processes access and manipulate the same data concurrently and the outcome of the execution depends on the particular order in which access takes place is called _____
8.	The segment of code in which the process may change common variables, update tables, write into files is known as _____
9.	Which of the following conditions must be satisfied to solve the critical section problem?
10.	The bounded buffer problem is also known as_____

Table 4 data represents, number of students who scored >80 % and >90 % marks of the questions on Inter-Process Communication topic. Table 5 data represents, number of students who scored >80 % and >90 % marks in overall course evaluation (ESE). So Table 5 data represents the students overall academic performance for that course.

TABLE 4
ROLE PLAY IMPLEMENTATION AND EVALUATION RESULTS FOR "OPERATING SYSTEM LABORATORY"

Year	2017-18	2018-19	2019-20
No of students appeared in exams	77	77	81
No of students performed excellent >90	1	1	29
No of students performed excellent >80	39	21	49

TABLE 5
ESE RESULT OF "OPERATING SYSTEM LABORATORY" - ACADEMIC PERFORMANCE

Year	2017-18	2018-19	2019-20
No of students appeared in exams	77	77	81
No of students performed excellent >90	2	0	9
No of students performed excellent >80	47	15	47

• IV. INFERENTIAL STATISTICAL ANALYSIS

Inferential statistical analysis is a branch of statistics that helps to draw conclusions and validate the findings from data. Hypothesis testing is a type of inferential statistics, where we form the hypothesis and make conclusions to validate the findings. The findings are validated based on the value of the test statistic, the critical value, and the confidence intervals. If the test statistics value is greater than the critical value, the null hypothesis is rejected and if the test statistics value is less than the critical value the null hypothesis is accepted. Chi Square test is a non-parametric test for hypothesis testing for categorical data. Here the aim is to validate the finding that students' performance is improving using the case study and role play pedagogy technique. The chi square test is best applicable for validating the finding here. Chi-squared test for one-way classification is used to test the results as shown in equation 1. Chi-squared test is non parametric test which is majorly used for statistical analysis of categorical data. Here this research study has categorical variables such as student's performance, skill development to analyze.

$$\chi^2 = \Sigma \frac{(O-E)^2}{E} \quad (1)$$

Where
O: Observed frequency
E: Expected frequency
$\mathbf{H_0}$=r_1:r_2:r_3…

Here, for given data, r_1:r_2:r_3… values are 1:1:1…., which indicates that academic performance results are the same over the years. Expected frequency is calculated as :-

O_1+O_2+....= n
r_1+r_2+...= r
E_i=(n/r)*r_i

H_0: Null Hypothesis: Students performance is equal over years.
H_a: Alternative hypothesis: Performance is increasing over years.
Observed frequency ie O is given in table 1, table 2, table 4, and table 5.

V RESULT AND ANALYSIS

Case study implementation results, role play pedagogy implementation results and its effect on student's academic performance is analyzed.

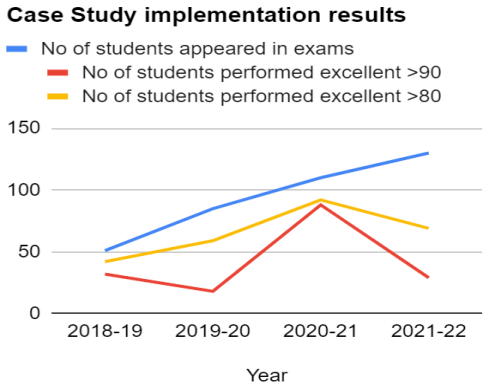


Fig 4: Case study implementation results for "Statistics for computer science"

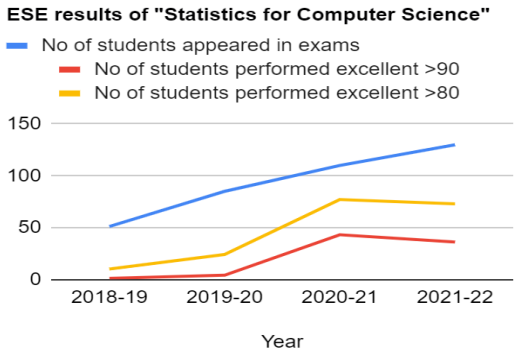


Fig 5: ESE results of "Statistics for Computer Science"

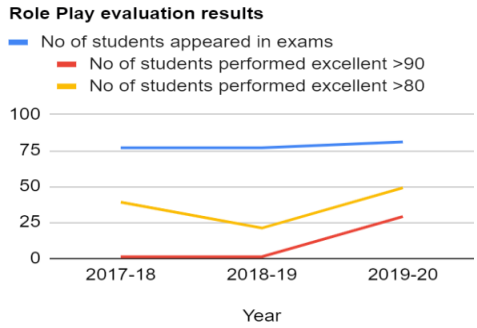


Fig 6: Role play evaluation results for "Operating system"

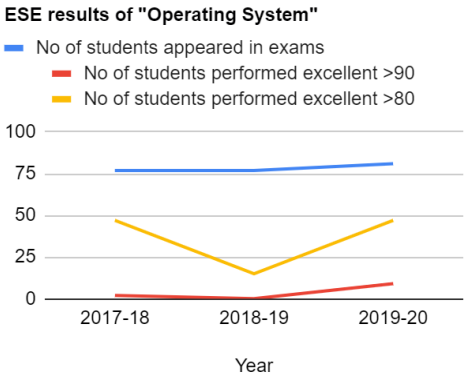


Fig 7: ESE results of "Operating System"

Visualization in Figure 4, 5 ,6 and 7 shows that results over the years need to be validated for performance improvement. Inferential statistical techniques are applied for this purpose.

Chi square test applied on observed data, as discussed above. Results of chi square test on case study implementation and role play pedagogy technique revealed, at a significance level of 5%, that there were significant differences between the results of case study and role play implemented and evaluation results over the years. Table 6, Table 7, Table 8 and Table 9 represent the results of the chi square test applied on data mentioned in Table 1, Table 2, Table 4 and Table 5.

TABLE 6
RESULTS OF CASE STUDY IMPLEMENTATION AND EVALUATION OF "STATISTICS FOR COMPUTER SCIENCE"

	Calculated chi-squared value for df = 3	chi-squared table value(critical value) for df = 3
No of students performed excellent >90	19.98	7.815
No of students performed excellent >80	70.91	7.815

TABLE 7
RESULTS OF ESE OF "STATISTICS FOR COMPUTER SCIENCE"- ACADEMIC PERFORMANCE

	Calculated chi-squared value for df = 3	chi-squared table value(critical value) for df = 3
No of students performed excellent >90	66.57	7.815
No of students performed excellent >80	75.43	7.815

TABLE 8
RESULTS OF ROLE PLAY IMPLEMENTATION AND EVALUATION FOR "OPERATING SYSTEM LABORATORY"

	Calculated chi-squared value for df = 2	chi-squared table value(critical value) for df = 2
No of students performed excellent >90	50.60	5.991
No of students performed excellent >80	11.07	5.991

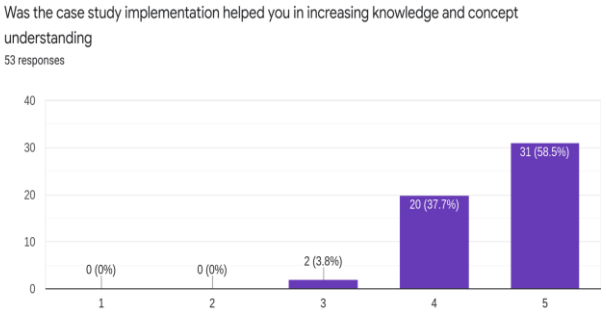
TABLE 9
RESULTS OF ESE OF "OPERATING SYSTEM LABORATORY" - ACADEMIC PERFORMANCE

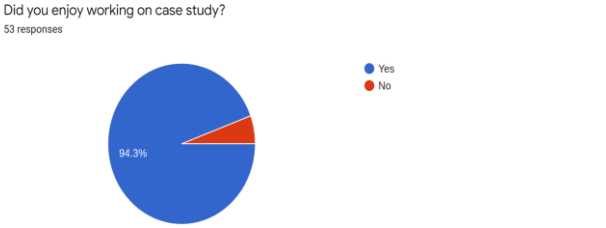
	Calculated chi-squared value for df = 2	chi-squared table value(critical value) for df = 2
No of students performed excellent >90	12.20	5.991
No of students performed excellent >80	18.78	5.991

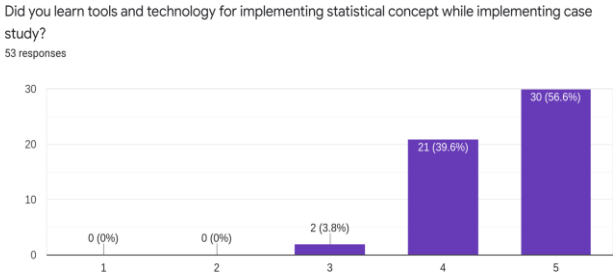
In the above given results table, the calculated chi-squared value is greater than the critical value, so the

null hypothesis is rejected. Which eventually says to accept the alternate hypothesis. According to the alternative hypothesis results show improvement in performance and in ESE results if we include case study implementation, role play in course. That eventually helps their skill development.

Feedback was given by the students and it was analyzed to observe the student's satisfaction in terms of case study implementation, role play quiz, concept learning, effectiveness, and lifelong learning. Following are the analyzed results of feedback.







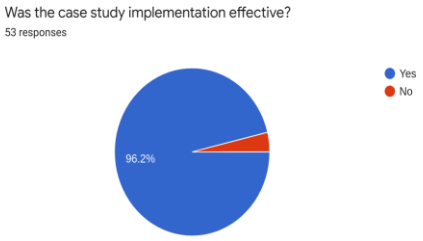


Fig 8: Feedback on Case Study

Marks of Operating System role play quiz was also analyzed in Figure 9. Results show that role play was very much helpful.

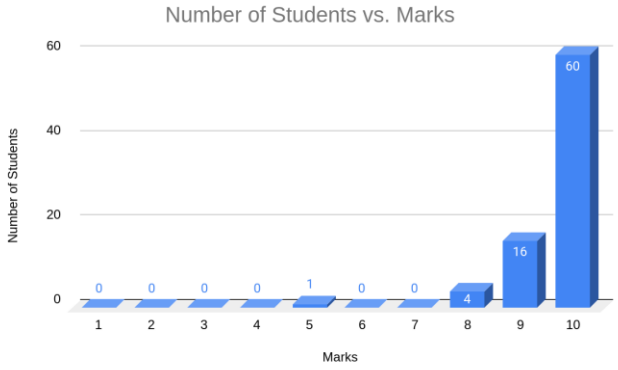


Fig 9: Analysis of Quiz result

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VI Conclusion

We present the statistical analysis of implemented active learning techniques. Case study, role play, quiz are considered as pedagogical techniques here. Statistical results validate the implemented technique. Statistical results show that active learning techniques help students to improve their knowledge building, concept understanding, skill development and satisfaction. The systematic execution of active learning techniques will enhance the engagement of students. Other active learning techniques such as Z to A method, flipped classroom, think-pair share can also be executed and validated using this same statistical method. Students feedback also ensures the results of applied learning techniques.

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