Effective Use of Various Active Learning Techniques for the Course Automation and Control Engineering

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***Abstract*— Outcome in the traditional setting of chalkboard teaching, students tends to remain in the passive mode and do not actively participate in the teaching and learning process. As a result of this, they may lose interest in the course content and conceptual understanding declines. It directly impacts their performance in the examination. With the use of active learning strategies, the subject teacher plays the role of facilitator and creates a conducive environment for students to actively participate in the teaching learning process. This paper discusses effective use of various active learning techniques implemented for the course of 'Automation and Control Engineering' for Third year undergraduate Mechanical Engineering Program at CCEW. Techniques such as expert lecture, open ended assignments, YouTube video for animation were employed for content delivery in theory as well as laboratory sessions. Performance evaluation was carried out by using techniques such as google quizzes and group activity on hydraulic and pneumatic trainer kit. Students' perceptions about the implementation of these active learning techniques are studied and analyzed which are reported in this paper. It is observed that as the results of this implementation students' overall understanding of the course content is enhanced.**

***Keywords*— Active Learning; Demo Based Exam; Open Ended Assignment; Oral Exam; Quizzes.**

I. INTRODUCTION

In the active learning techniques students work in the groups or individually during the class and the teacher plays the role of true educator. It is a student centric approach which helps students in achieving learning goals. Jenny Lloyd-Strovas (1) observed that implementing active learning techniques for the large classes is a challenging task due to logistical concerns which forces teachers to follow a traditional lecture based approach which leads to very less student-teacher interaction. To overcome the logistical challenges step by step, introduction of in-class active learning techniques are recommended by leading engineering educators in the Guide provided by Richard M. Felder (2). Development in Information technology has provided more effective and economical engineering education. Also due to development in devices, students can access the online material through mobile or laptop or desktop irrespective of specific to space and time. David R Wallace et al (12) develop the general web lecture structure. Generally a traditional offline lecture session is 60 minutes. 90 minutes online sessions can cover the materials in three short 30 minute sessions. Students give preference to animation video or powerpoint presentations with image. During the covid 19 pandemic situation, the teaching learning process was conducted in hybrid mode. The lecture sessions were conducted using Google Meet as an online platform. Some of the ACE lab sessions had been conducted offline. At the start of the semester planning was made to implement various methods for active learning in hybrid mode. When covid 19 norms were relaxed for November 2021, as per government regulations, students came to college for lab sessions. Some of the students were online and some of the students were actually present. But lectures were on online mode only. Subject teacher after discussion with senior faculties decided for open ended assignment and Demo based learning for Lab session to increase their active participation and better understanding for the ACE course. Current paper is focused on different content delivery methods and performance evaluation for said course.

II. LITERATURE SURVEY

Many faculty/course instructors explore different active learning techniques to help students for easy and effective learning. Some of the researchers have reported evaluation phases also as learning instances for students. Some of the earlier experiences for use of different active learning techniques such as use of Think-Pair-Share (Bewoor and Kulkarni, 2018), Project based learning (Patange et al. 2019) etc. are reported in the published literature. Some of such other techniques are revived here. Sandeep Desai (2022) had used some of the active learning techniques for 'Hydraulics and Pneumatics' course of final year Automobile Engineering students that include the Jigsaw technique, Muddiest point technique, Concept mapping, Case Study and Team-based learning. The different techniques are used for different segments of the 'Hydraulics and Pneumatics' course delivered to final year Automobile Engineering students studying in the final semester. He concluded that the passing percentage has increased by 21 % due to implementation of active learning techniques.

Cook and Babon (2016) have summarized that planned, regular online quizzes prove effective and enhance active learning. Quizzes work as an efficient preparatory tool in academics. If students are prepared for lectures and tutorial sessions by taking quizzes, they can participate and contribute during sessions and as a result the teaching learning process becomes enjoyable for students and teachers.

Li and Guo (2015) have studied the effect of student centric guest lecturing to promote students' engagement in the course content. Guest lectures were conducted in the question answer type interview format instead of in a traditional way where students receive information passively. It was observed that

when students are actively involved in the entire process of guest lecturing starting from team formation, preparing interview questions, recording of the sessions, it helps in developing interest in the course content.

Chareen Snelson (2011) has done comprehensive literature review of YouTube across disciplines. YouTube videos are very much beneficial for the online teaching learning process. Many universities and colleges have developed YouTube channels for online education. Authenticity of the YouTube content should be checked before it is shared with the student. This caution has to be exercised regarding YouTube.

Vinod Kumar et al (2015) concluded that the students are more attracted towards and enthusiastic about modern teaching techniques. They have implemented a new framework for the lab of hydraulic and pneumatic course. They observed that students' engagement has increased in the course and students move to structured enquiry and
also open ended enquiry.

Sandhu et al. (2002) has implemented different pedagogy for 'Introductory solid mechanics' course. They have included simulation, online lectures, electronic textbooks, online quizzes and case study for actual analysis of engineering problems in web based learning modules. Their objective is to determine the students' deep learning, curiosity, communication, enthusiasm.

Brauner et.al. (2007) have employed open ended assignments in the course "Medical Proteomics- from bench to bedside" in order to encourage the students to take the responsibility of their own learning. It leads to the development of problem solving skills and critical thinking. To measure the degree of responsibility taken by students, an inquiry matrix was used. It was observed that gradually students shoulder the responsibility in the segments such as framing questions, planning and performing experiments, applying knowledge to interpret the results. For the successful implementation of this technique, a high teacher/student ratio and more educational resources are required.

Gómez & Jansen (2017) has applied Design Based Learning approach to second year Electrical Engineering project wherein students have to design proof of principle contactless energy transfer system for the charging of electric vehicle wherein students have to develop proof of principle contactless energy transfer system for the One of the important characteristics of the Design Based Learning Approach is its open ended nature. Authors have studied its effect on the project in terms of the following two points: 1) Quality of the product design such as power transferred, efficiency etc., 2) students' progress which was monitored by developing rubrics including parameters such as understanding own specializations, overall system, communication, planning. For the consecutive three years the project was analyzed and it was summarized that open ended nature has a positive effect on the product design. Patange et al. (2019) has reported positive response in case of Course Level Project Based Learning approach for Mechatronics course of third year Mechanical Engineering. Both these studies have reported encouraging response from students to performing design iterations, validate the model built and assumptions and in turn develop critical thinking skills.

Cliburn et.al. (2010) have studied the students' preferences between structured and open ended assignments in the introductory computer programming course. As a solution to the high failure rate in the course, games are used as themes in the course assignments. Students were to choose between structured and open ended nature for four out of five assignments. In the open ended assignments, students have to put in extra efforts to study new concepts to design their own game while the structured assignment could have been completed based on the concepts already taught by the course instructor and clear guidelines were also available for the same. Authors have summarized that most of the students were comfortable with structured assignments and in the later part of the program, students can take up open ended assignments which develops independent thinking and designing.

The most popular website in the 21st century is YouTube. The students/learners access instructional material on a wide variety of topics designed in verbal as well as pictorial form with ease whenever demanded on YouTube. Wandago Benson Odongo et al 2016) also suggest that YouTube is only a complement but cannot substitute classroom instructors.

The literature review shows that authors have experimented with different active learning techniques and assessed their effectiveness for their respective course. Implementation of new pedagogy has increased in recent past years. Several techniques have been added to the list of active learning techniques. In the current paper, due to hybrid mode, various active learning strategies are used. An attempt has been made to apply different online active learning methods as well as offline active learning methods to deliver the entire course over the semester-long period to enhance the learning and understanding of the Automation and Control Engineering course for Third Year Mechanical Engineering students.

III. METHODOLOGY

The Automation Control and Engineering (ACE) course is offered as a program elective course to third year B. Tech. (Mechanical Engineering) students. 77 students from the third year Mechanical engineering department have registered for this course. Since the number of students was large, this is a large classroom. Some of the active learning methods for large size classrooms are padlet, muddiest point, one minute paper, Think pair share, project based learning, jigsaw technique etc. Course instructors need to make sure that fundamental concepts of course ACE are understood by the students for such a large size classroom as teaching was in hybrid mode. The syllabus for ACE covers basics of Hydraulic & Pneumatics components and hydraulic and pneumatic circuit design with addition to automation and control system block diagrams. Different pedagogy techniques have been implemented for active participation of the students in theory as well as lab courses. At the start of semester, September 2021, basic information about

different pedagogy techniques were given to the students which will be implemented in theory and lab sessions. Information communication tools (ICT), Expert lecture sessions by industry persons have been implemented in theory sessions. Practical based learning, open ended assignment have been implemented in ACE lab. With addition to CIE (Cumulative internal Examination) and SEE (Semester End Exam), Quizzes, Assignments and Demo based group activity used in performance evaluation. These techniques have been divided in two parts,

Part 1: Content Delivery

Part 2: Performance Evaluation

Following Fig. 1 shows different parts of content delivery for ACE course.

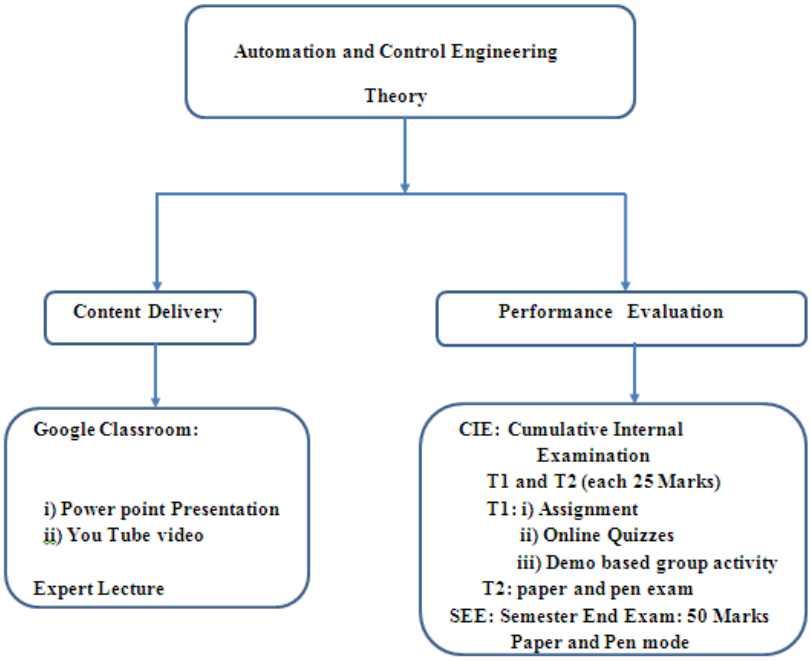

Fig. 1 Different parts content delivery and performance evaluation for ACE course.

Following Fig. 2 shows content delivery and performance evaluation for ACE lab.

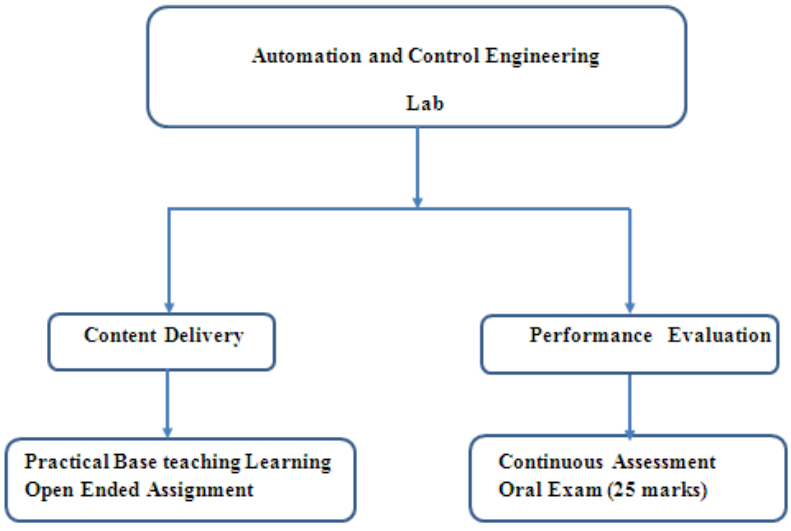

Fig. 2 Different parts content delivery and performance evaluation for ACE lab

IV. IMPLEMENTATION

The active learning strategies are implemented for Automation and Control Engineering courses of the third year mechanical engineering undergraduate program. Due to covid-19 pandemic situations, the teaching learning process was in hybrid mode i. e. theory classes were engaged online and some of the laboratory sessions were conducted in person. Table II shows the Course Outcome (CO) statement for ACE course. These statements have been framed by taking into consideration checks mentioned in table I.

Table I: CO statements checklist

	Check
1	Are they written using action verbs to specify definite, observable behaviors?
2	Does the language describe students' rather than teachers' behavior?
3	Do the outcomes clearly describe and define the expected abilities, knowledge, values, and attitude of students of the course?
4	Is it possible to collect accurate and reliable data for each outcome?

Table II: CO statement checks for theory Course

COs	**Course Outcomes**	**Check 1**	**Check 2**	**Check 3**	**Check 4**
CO 1	Identify automation need, level, required components & process control.	YES	YES	YES	YES
CO 2	Analyze given needs of automation to design Hydraulic circuit(s).	YES	YES	YES	YES
CO 3	Analyze given needs of automation to design Pneumatic circuit(s).	YES	YES	YES	YES
CO 4	Justify selected component(s)/system from given catalogue(s) for automation application under study.	YES	YES	YES	YES

Program specific outcomes (PSO) for the Mechanical Engineering Department are defined as shown in table III.

Table III: PSO statements

PSOs	Mechanical Engineering Graduate is capable of
PSO 1	Analyzing Mechanical engineering Systems to offer optimal solution(s).
PSO 2	Designing and developing mechanical engineering systems and equipment.

The course articulation matrix for ACE course is shown in table IV [It exhibits course outcomes' mapping with POs and PSOs]

Table IV: ACE Course Articulation Matrix

	Program Outcomes													
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO 1	1	2											2	
CO 2	1	2											2	
CO 3			3	3						3		3		3
CO 4				2	2							1		2

Competencies Performance Indicators for ACE course CO is shown in table V. Statement for Competencies and Performance Indicators (PIs) can refer in NBA website [17] and AICTE website [18].

Table V: Competencies and Performance Indicators- theory course

COs	**Competencies**	**Performance Indicators (PIs)**
CO 1	1.3,1.4	1.3.1,1.4.1
CO 2	1.4	1.4.1
CO 3	3.1, 4.2	3.1.4,3.1.5,3.1.6,4.2.1
CO 4	4.2	4.2.1

Table VI shows the Course Outcome (CO) statement for ACE Lab. These statements have been framed by taking into consideration checks mentioned in table I.

Table VI: CO statements' checks for ACE Lab

COs	Course Outcomes	Check 1	Check 2	Check 3	Check 4
CO 1	Set up and execute Hydraulic circuit(s) using an experimental kit.	YES	YES	YES	YES
CO 2	Set up and execute Pneumatic circuit(s) using experimental kit.	YES	YES	YES	YES
CO 3	Design Hydraulic/Pneumatic/Electro Pneumatic circuit for defined automation application.	YES	YES	YES	YES
CO 4	Justify selected component(s)/system from manufacturer's catalogue(s) for automation application under study.	YES	YES	YES	YES

The course articulation matrix for ACE lab is shown in table VII.

Table VII: ACE lab Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO 1	1	2										
CO 2	1	2										
CO 3			3	3						3		1
CO 4				2	2							1

Competencies and Performance Indicators for ACE lab are as shown in table VIII. Statement for Competencies and Performance Indicators (PIs) can be found on NBA website [17] and AICTE website [18].

Table VIII: CO Competencies Performance Indicators

COs	Competencies	Performance Indicators (PIs)
CO 1	1.3,2.3	1.3.1, 2.3.1
CO 2	1.3,2.3	1.3.1, 2.3.1
CO 3	3.1, 3.2,4.2,10.2,12.2	3.1.4,3.1.5,3.2.1,3.2.2,4.2.1,10.2.2,12.2.1
CO 4	4.2,5.1,5.2	4.2.1,5.1.2,5.2.2

A Content Delivery

Following section describes different techniques used in theory as well as for lab in ACE course in content delivery.

1) ICT Tools (Information Communication Technology Tools)

Due covid-19 period at the starting of semester lectures were conducted online. For ACE theory course in AY 2021-22 Semester I Google classroom was created. In regular classroom sessions lectures had been delivered with the help of PowerPoint Presentations (.ppt file). For some of the topics e.g. working of external gear pump, internal gear pump you tube video animations were also shown. The Web-based lectures are important because they afford students of different learning styles the same ability to learn the material [6]. Online lectures are primarily intended as a main resource, allowing the students to learn ACE course. Every lecture has been recorded. Separate document has been created which shows details of date wise content covered and recorded lecture link. It has a major advantage since if any student was not able to attend the lecture in their respective slot, they can refer to the recorded lecture link. The online lecture presents the material covered in traditional class lectures.

2) Expert Lecture

For ACE course subject, (unit 4: Pneumatic system: pneumatic circuits by cascade method and (Unit 3 Hydraulic system: proportional and Servo valves) had been taught in online lectures. Additional expert lectures have been given on these topics by Industry persons. Industry person delivers the content looking at syllabus for that topic and practical oriented application has been discussed. Students actively participated in the expert lectures and cleared their doubts related to the topic. It gives better understanding for students and she can clear her understating by active participation during lecture. The understanding of students for expert lectures has been evaluated after lecture by taking quizzes.

Following Fig. 3 and 4 shows a snapshot of expert lectures.

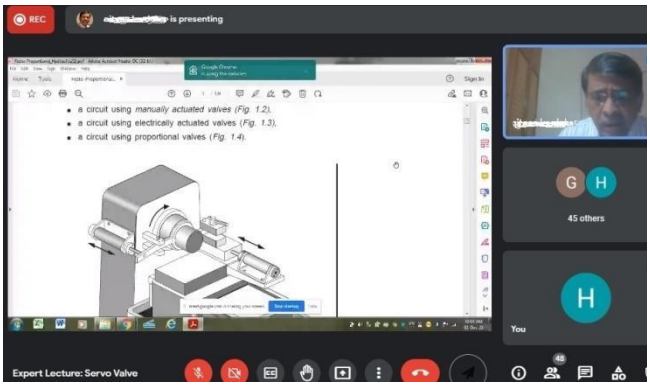

Fig. 3 Expert lecture session –Hydraulic System

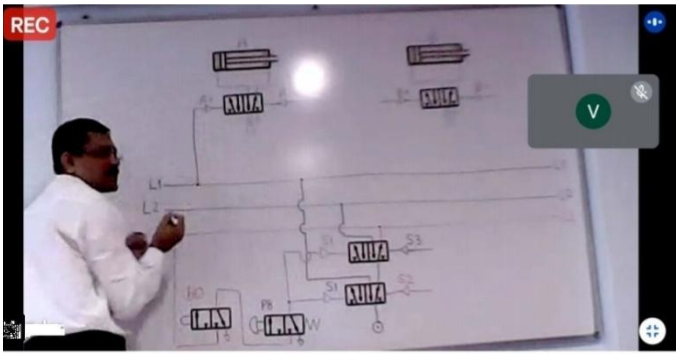

Fig. 4 Expert lecture session - Pneumatic Systems

Following are the content delivery methods in in ACE Lab

3) Practical Based Learning

Initially the lab sessions were conducted online due to covid-19 norms. Through video actual working of the different circuits had shown. But students' understanding level was less due to online mode. When covid-19 norms were relaxed then students came to the college physically. Again working on different circuits on hydraulic and pneumatic trainer kits shown to the students in offline mode. Students also practiced the creation of basic circuits on hydraulic and pneumatic trainer kit on their own.

4) Open Ended Assignments

For ACE Lab course in a group of 5 students, this activity had been assigned. Students should frame the question for a real life application based on Automation and Control Engineering. They should design the system as per the requirement in the problem statement and by referring to the manufacturer's catalog they should select the component. Finally the student created documents which covers, problem statement, circuit diagram, basic calculation and selection of components from manufacturer's catalogs with its reference/specification.

B Performance Evaluation

The ACE theory course is evaluated in 2 different modes, Continuous internal examination (CIE) and Semester end exam (SEE) evaluation. Continuous internal examination has 2 parts i.e. T1 and T2 each have 25 marks and SEE has 50 marks. For ACE lab oral exam is conducted which is for 25 marks. T1 for said course has been evaluated through assignment and quizzes on expert talk and demo based group activity in the lab. Following sections explain details for the performance evaluation of ACE course.

1) Assignment

Four units have been assessed through assignment. Assignment questions involve basic conceptual understanding and few of them are numerical (which was not possible to assess through the online quiz mode). Time duration was given to students. Subject teachers while evaluating the assignment have added comments in the assignment then return to the students in Google classroom.

2) Quizzes

After expert lecture sessions by industry persons, within a week's time online quizzes had been scheduled/set based on content of expert lecture. Regarding the quizzes already informed to the students before the expert lectures. Quiz questions involve basic understanding of that subject. 12 questions are asked per instance of the quiz. Submitting a quiz displays the correct and incorrect answer giving an instant answer to the question. It gives an immediate idea about the level of understanding of the students to the faculty for said course. Corrective measures have been taken based on the result of quizzes. (e.g. clearing the doubts, explaining the circuits by practical implementation in lab sessions).

3) Demo based group activity in Lab

Sufficient time is given for students to learn as well as understand the hydraulic and pneumatic circuits which they can build on the hydraulic and pneumatic trainer kit in ACE lab. In each group 5 students were there. Near the end of teaching of course this activity was carried out. For each group circuit name was given instant and within 15 minutes they should build the circuit on a trainer kit and explain the working of the circuit to the examiner .This was followed by question & Answer session for the given circuit. Fig. 5, Fig. 6 and Fig. 7 shows sample photographs for demo base group activity. Students had prepared and run pneumatic circuit on pneumatic and hydraulic trainer kit

Fig. 5 Demo based group activity: circuit prepared by students on hydraulic trainer kit

Fig. 6 Demo based group activity: circuit prepared by students on pneumatic trainer kit

Fig. 7 Demo based group activity: hydraulic trainer kit

4) T2 exam and Semester end exam

Syllabus for T2 was the first 3 units and for SEE the complete syllabus was there in the exam. Both T2 and ESE were paper and pen mode.

5) Lab Evaluation Oral Exam

Questions were asked during oral exams on an Open ended assignment problem and its solution and lab experiments. Students need to justify the selections of components from manufacturers catalog for open ended assignments. The marks for ACE oral exam are 25 marks.

Course Outcome Attainment

Attainment has been calculated for ACE course theory and Lab.

COs Attainment are calculated in line with the guidelines given in National Board of Accreditation [17]. For CO attainment Benchmark score is decided as (60% of the maximum marks). Target levels are set as

Level 1: Less than 40% students scoring marks more than the Benchmark score

Level 2: 40% to 60% students scoring marks more than the Benchmark score

Level 3: More than 60% students scoring marks more than the Benchmark score

V. SURVEY QUESTIONNAIRE

To study and analyze the effectiveness of different techniques implemented for ACE course, a survey questionnaire was prepared. The objectives of the survey were to measure 1) the enhancement of students in the teaching learning process 2) enhancement of conceptual understanding 3) enhancement of better understanding developed in the courses. There were five questions in the questionnaire. Students' responses were recorded on a four point scale. The survey Questionnaire is as shown in the Table XI (Number of students participated in the survey = 37)

Table IX: Various Active learning Survey Questionnaire

Sr. No.	Statement	Strongly Agree	Agree	Disagree	Strongly Disagree
1	I can co relate the Expert Lectures content with real life applications				
2	Practical based group activity enhanced the learning of Automation and Control Engineering course				
3	Open ended assignment on Industrial Circuit Design enhanced the learning of Automation and Control Engineering course				
4	YouTube video link for animation helps in better understanding the topic				
5	Quizzes on expert lecture help me better understanding of the ACE course				

VI. RESULTS AND DISCUSSION

In this part of the paper, the students' responses to the survey questionnaire are presented. The responses are analyzed to understand students' perception about the implementation and effectiveness of the active learning strategies. Course outcome attainment levels for theory as well as for lab of said course have been compared with current year and previous year. Table IX and X show the same.

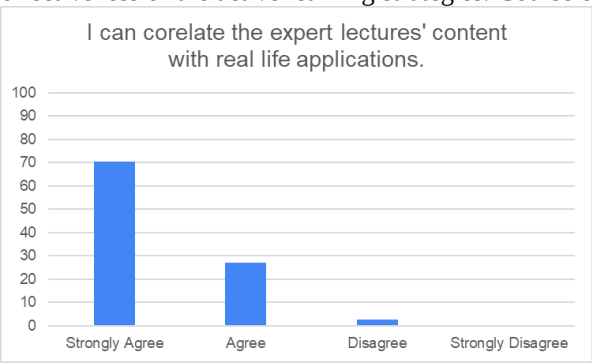

Fig. 8 Correlate the expert's lecture content with real life applications

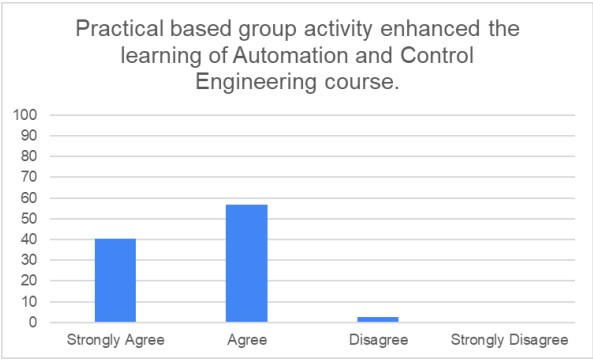

Fig. 9 Practical based enhanced the course learning

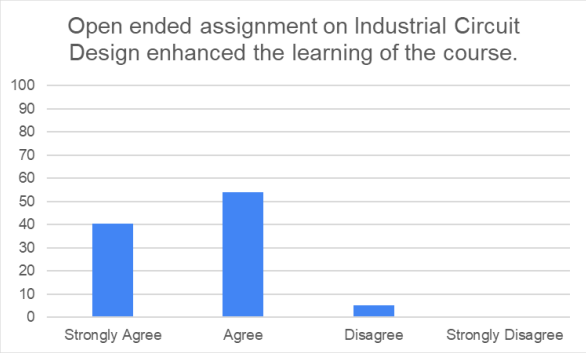

Fig. 10 Open ended assignment enhanced the course learning

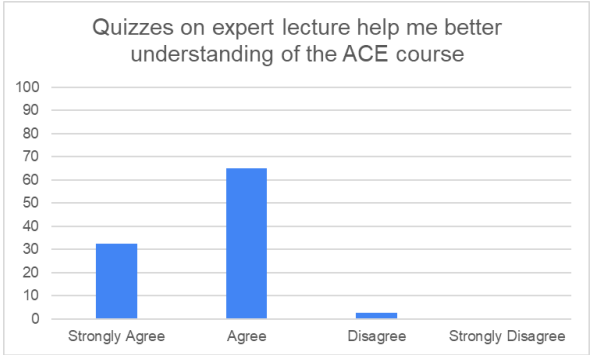

Fig. 12 Quizzes help for better understanding of topic

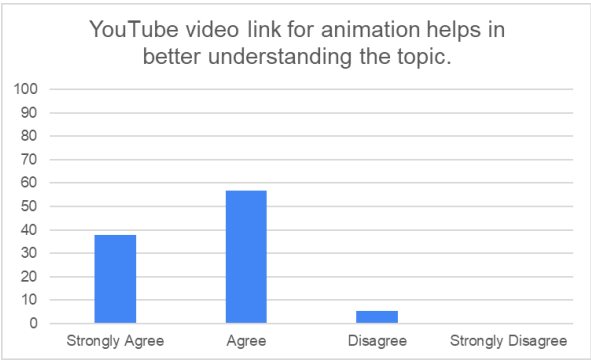

Fig. 11 Animation helps in better understanding

Table X: Comparison of CO attainment levels – Theory course

	A.Y. 2020-21		A.Y. 2021-22	
COs	**CIE**	**SEE**	**CIE**	**SEE**
CO1	3	3	3	3
CO2	3	3	3	3
CO3	3	3	3	2
CO4	1	2	-	3

Table XI: Comparison of CO attainment Levels – Laboratory course

	A.Y. 2020-21		A.Y. 2021-22	
COs	**CIE**	**SEE**	**CIE**	**SEE**
CO1	-	3	-	3
CO2	-	3	-	3
CO3	-	3	-	3
CO4	-	3	-	3

The Analysis of the students' responses is as follows.

- All The results of the feedback suggest that methods implemented for ACE course had a positive impact on students' learning. Response to, through feedback questionnaires such as 70 % students correlates the Expert Lectures content with real life applications. 56.8 % students agree Practical based group activity enhances the learning of Automation and Control Engineering course. 54.1 % students agree Open ended assignment on Industrial Circuit Design enhanced the learning of Automation and Control Engineering course. 56.8 % of students agree that a Youtube video link for animation helps in better understanding the topic. 64.9 % students agree quizzes on expert lectures help them better understand the ACE course.
- Demo based group activity was carried out in a team which enhances the team spirit and team management which is useful for their professional life. Also it creates the interest in the student as physical involvement of components.

- From table X, we can conclude that attainment levels are increased for CO4 for the semester end exam of ACE course.
- From table XI, we can conclude that attainment levels are the same for all COs of ACE lab course for semester end exam.
- This paper shows benefits of the new pedagogy techniques implemented for ACE course. Same techniques can be implemented in future for ACE and as well as for other courses.

CONCLUSIONS

Different Active learning strategies were implemented in the program elective course Automation and Control Engineering of the third year undergraduate Mechanical Engineering program.
It was experienced that the students' participation in the classroom was increased which resulted in the development of abilities such as communication, working in teams and problem solving ability. It thus concludes that active participation of the students avoids the lectures from becoming monotonous and helps to develop an interest in the course under consideration and better Course outcomes attainments level.

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