Active Learning Techniques for Effective Online Teaching and Learning in Higher Education

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Abstract : This article proposes active learning strategies for delivering engineering courses to the students in order to make learning more engaging, interesting, accomplishing, and joyful. The education system was impacted by the unprecedented situations generated by the Coronavirus pandemic from the last two academic years. The student community is also going through difficult situations on many levels. The primary challenge for teachers was to engage the students passionately in learning while maintaining a stress-free, healthy and fruitful environment in the online classes. For a stress-free teaching-learning process, adopting a variability in course content delivery methods would be a smart choice for teachers. This paper discusses the most effective active learning strategies in higher education. The work also highlights examples of implementation and an analysis of the effectiveness of active learning methodologies in terms of learners understanding, competency, satisfaction and knowledge gain. The findings indicate that the active learning strategy has assisted students in being more comfortable and engaged in effective learning in the online mode.

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1. Introduction

In earlier days teacher's role was to explain the concept using common techniques called chalk and board, and reading books. Keeping students engaged for complete one hour in the classroom is a challenging job for teachers. Normally if a class is having 40 or more than 40 students then this regular teaching learning technique may become fruitful for 50% students only. Also it has been observed that the actual listening span of a student is for maximum 30 minutes. After that students cannot give 100% attention and even a teacher explains the concept, 50% students will not grasp it. Again after next 15 minutes, 75% students will not give their attention in class.

In recent years, teachers are using various teaching aids like power point presentation, animations, videos and reference papers which helps to make the class more interactive and to increase student involvement (Sameer et.al., 2014). Up to some extent students' response seems to be worthy, as the contents reflected in power point are in numerous form with colorful images, diagrams, and colorful text. As technology trends are increasing drastically, experts are preparing videos either by explaining concepts in easy manner, or by creating animated videos and audio-visual

concept explanation. In this way, teachers are using these video clips as per their requirement and explaining the concept to the students. So instead of listening to teacher only, if in between different teaching aids are used then students' curiosity will increase towards learning.

Along with these teaching aids, now a days' all teachers are using various active learning methodologies to explain the concept in more interactive way. The active learning methods commonly used are Project based learning (PBL), Problem based learning, Think-Pair-Share, Flipped classroom, Mindmap, Jigsaw, Role play, Instant Quiz, etc. These tools focusses more on the technical concept. Gamification activities are widely being used by teachers, as almost all students attracts quickly and easily towards games. It has been observed that gaming activities becomes helpful to resolve common classroom issues like individual student participation, team work, talk time of instructor, opportunity to express, and explain the result. Gamification activities helps instructor to explain the concept from theory to practice and teacher becomes facilitator. Well known gamification activities which can be explored in teaching and learning are Crossword, Millionaire, Cryptex, Snake and Ladder, Scavenger hunts, bingo, dice games etc.

In current pandemic situation, the drastic change is reflected in teaching and learning process. With the help of various meeting platforms like Zoom, Google Meet, Webex, Microsoft Teams, GoTo Meet etc. students and teachers are communicating. Teachers and students are facing new challenges in an Online Teaching Learning (OTL) mode, and to fulfill the requirement, teachers are adopting new, interesting and innovative online teaching learning schemes. However, every coin is having two faces. The online teaching offer immense flexibility and a greater scope for interaction with and participation by the students. Also this strategy saves precious travelling time, money, and energy which was often the adverse situation for many students (Benta et.al., 2014). In addition to pre-recorded lectures, Short and on-the-spot quizzes, Discussion Forum, slot booking feature for doubt clearing as per student time, and concept-strengthening classes becomes an integral part of online teaching. To inculcate these features, to strengthen the execution of all required activities and to complete assessment, various Learning Management Systems (LMS) and Course Management System (CMS) platforms (Ninoriya et.al., 2011) are being used like Moodle, Canvas, Claroline, MyGuru2, Google Classroom, Schoology, Blackboard, Edmodo, Bodhi Tree and SAFE Tools offered by IIT Bombay etc.

Section II explores the literature review on active learning methodologies used to explain the concepts from various courses. Section III describes five methodologies, Project Based Learning, Crossword Puzzle, think pair share, Quizzes and Polls, and Mind map which can be used to improve student engagement in the class. In section IV, the results after using various Active learning methods and Gamification methods have been presented which contribute lot to enhance student engagement in subjects like Digital Electronics, Basic Electronics and Electrical Engineering, Coding Techniques, Analog Communication, Internet of Things and Microcontrollers course of Electronics and Communication Engineering program.

1. Literature Survey

The COVID-19 outbreak forced to convert from traditional face-to-face teaching to an online format. An observational research in which faculty members and students from engineering completed survey and answered quantitative and qualitative questions to highlight the challenges they faced during online education. Study revealed a number of difficulties that have a detrimental impact on online engineering education, including logistical and technological challenges (Asgari et.al., 2021).

Claudiu Coman et al., 2020, discussed the impact of E-learning on the educational process and students' perceptions of using the online environment in the teaching and learning process. E-learning using online platforms like Moodle, helps lot for smooth delivery of online lectures, student-teacher contact and cooperation, web conferences, and chat. In order to develop and strengthen the E-learning system during Covid-19, they analyzed the student's perspectives by sending a Google form on Facebook with a few questionnaires.

The pandemic situation had moved us to make the teaching and learning process online and student-centered in which students can actively learn about a subject. To accomplish this, many new innovative methods have been adopted by various universities. The aim is to use these innovations approaches to

make the learning process more engaging and dynamic, encouraging students to participate actively in these innovations (Mohammed et.al., 2011).

For courses like Analog communication, Signals and Systems, and electromagnetics, active learning strategies like think-pair-share, turn and talk, Jigsaw are effective because they require a lot of basic principles to be retained (Sridevi Chitti et. al., 2020). Active learning technique like buzz activity through poster presentation, games, animated movies, and simulation tools is used to address the difficult problem of student involvement in learning (Snehal S. Patil et. al., 2020).

Several collaborative learning methods like Role play, Think Pair share, Jigsaw and Concept Map (Manju et.al., 2018) are used for effective teaching and learning. These methods helps to increase student engagement in the classroom as they focuses more on practical approach. Teachers are encouraged to use their professional judgement to review the suggested innovative teaching tools and decide on the most appropriate for meeting the needs of their students and deliver the essential content. As teachers know their students learning styles and needs, they can select numerous interesting strategies or adapt those suggested to deliver the content (Misseyanni, 2018).

Through formal and informal interaction with students, teachers build an educational environment that determines what students feel about learning. This has a significant impact on students' learning (Biggs et.al., 2011).

As result of online learning, the student-teacher connection becomes less intimate. Educators are required to transform the classroom into an online learning environment. What precisely does a teacher need to do to encourage students in an online environment? (Picar, 2004).

2. Methodology

Encouraging students to take a more active role in their own education is becoming influential. The focus is on learning, therefore instructors must include more active and student-centered learning approaches during course content delivery. More active the students are in the classroom, the more engaged they are in the learning process, and the more they utilize concepts in real application.

A. Project Based Learning

Project Based Learning (PBL) is a student-cantered pedagogy that incorporates an active learning approach wherein students are encouraged to actively explore real-world issues and problems in order to get a better understanding. Across many educational disciplines, problem-based learning has proven to be a very effective pedagogical paradigm. The first step in PBL is to assign tasks that will lead to design prototype or the development of a final product or object. Students examine the issues and come up with remedies. Students create a solution prototype by designing and developing it. One of the positives of using PBL is the student involvement in their own learning. It empowers learners to pursue their own interests and ways to address the issue that have been posed. A multidisciplinary project-based teaching learning approach can help students to improve the employment skills.

B. Crosswords Puzzle

Crossword puzzle game activity helps to make learning more enjoyable. It allows students to be more engaged in the learning process by giving them a recreational break during the lectures. Students can access and review the course material notes to solve the puzzles. Cross word puzzles helps students to remember, recall and understand the keywords. This active learning approach helps learners in improving the Lower Order Thinking Skills (LOTS). This activity is an enjoyable and recreational activity, helps to change study habits and skills, and create interest in the course contents (Crossman 1983).

C. Think Pair Share

Think Pair Share (TPS) is a collaborative learning method in which students work together to solve a problem or answer a question about a learning segment. This approach needs students to first think independently about a topic or answer to a question; and then share thoughts with classmates (Sharma et. al., 2019). Discussing with a partner maximizes participation, focuses attention and engages students in comprehending the reading material. It helps students to think individually about a topic or answer to question. It teaches students to share ideas with classmates and builds oral communication skills.

D. Think aloud (Quizzes and Polls)

The think-aloud strategy asks students to say out loud what they are thinking about when solving problems, or express out by responding to questions posed by teachers or other students. This approach may be used to fetch student attention and engagement in the classroom.

Taking quizzes and polls during teaching is a popular activity. It helps to keep students engaged in a class. After explaining the particular concept in class, teacher has to float simple question based on that topic. Teacher has to think always about how to make the class interactive. As in traditional classroom teaching, teacher was teaching and learners' job was to listen, take the notes, and grasp the concepts. To increase the attention span of student in online teaching mode, quizzes and polls contribute lot. The learning platforms which offers various game activities, quiz types and polls are Kahoot, Mentimeter, Class Dojo, Factile, Flipgrid and Slido etc. These learning platforms, really brings magic in learning to the students.

E. Mind Map

Mind Map is an innovative activity which enables students to think on particular topic, encourages a free flow of ideas and put the contents in chart form. Mind mapping is a influential practice that helps to imagine the concept, visualize the thoughts and communicate them to others. This activity also motivate student to sketch and represent the contents in free hand and with free mind. Given topic is broken in number of pieces or blocks and then represented in terms of drawing such that collectively it reflects the whole theme of the topic. Mind Map is a graphical representation of concept that convey the relationship between individual ideas and concepts. Students and teachers are using Mind Map activity for immediate note taking, project planning, and complex concept explanation. Mind map becomes an attractive and beneficial learning tool to help to brainstorm any topic, increase student performance, Incite critical analytical thinking, and think creatively (Abdurrahman et.al., 2015). Mind maps are often very beneficial in the writing process as it allows students to think about a topic or theme in a natural way.

3. Implementation And Results

This work recommends an active learning strategy for delivering engineering courses to learners to make electronics more engaging. PBL is one of the assessment tools used for the first year engineering students to explore Basic Electronics and Electrical Engineering course for continuous laboratory evaluation.

At the start of the semester, students were given an option of selecting open-ended design projects based on their interests. Pandemic conditions have shifted education to online mode. The majority of the students used an online circuit simulator to develop and build their designs. Few students were able to manage hardware components and actual implementation.

There was a lack of companionship and interaction among students as a result of widespread usage of online learning methods. Through the PBL activity, students were able to get to know each other more and collaborated on a project from different locations (Kenesha et. al., 2016).

Making the PBL activity a requirement in the course assessment rather than an optional, helped to foster participation of all the students. During the assessment process, everyone gets the opportunity to share his or her thoughts and ideas about the project. Evaluation of students done based on their design and synthesis abilities. Fig 1 shows the sample for the project titled single axis solar tracker system implemented using online circuit simulator like Tinker Cad.

The students' opinion towards the PBL activity (5-point Likert scale, where 1 represents towards a very small level, 5 denotes to a very great level) is collected for various courses.

Fig 2 indicates the feedback analysis for the first year engineering course on Basic Electronics and Electrical Engineering for PBL Active Learning
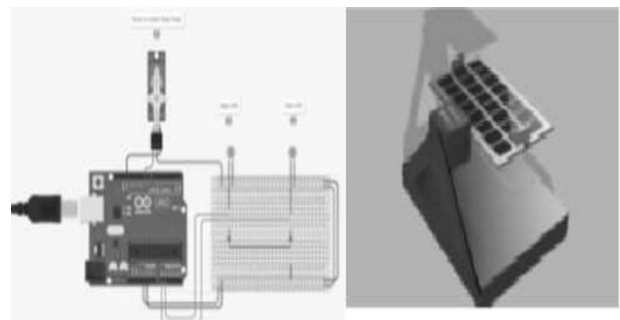

Fig. 1 : Single Axis Solar Tracker Project

Fig. 2 : Feedback from Learners on PBL Activity

Technique. As reflected from the feedback analysis, 95% students from the class supports this activity positively as they have scaled it to 5 point.

Crossword puzzle is an interesting gamification activity which helps to increase student active participation and involvement. After completion of module from the course syllabus this technique is used to understand the learning level of students.

Few courses like Microcontrollers, Internet of Things (IoT), Coding Techniques need students to memories a significant number of important terms or specified points, as memorizing and retaining the
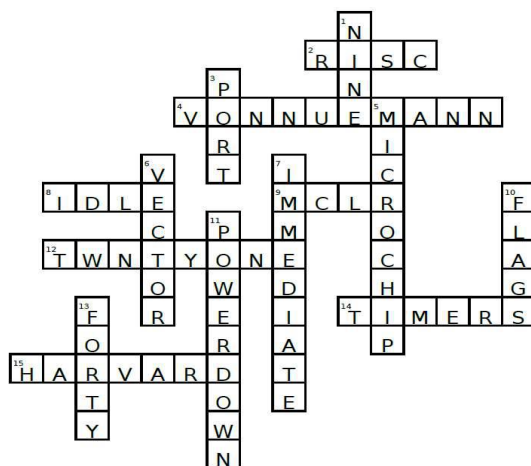

Fig. 3b : Crossword for Coding Technique Course

Across

2: The transpose of this matrix is used for decoding of linear block code at the receiver
5: The sum of any two code words in the code will yield another code word of that code
13: The matrix used to find codewords
16: The matrix used for single-bit error correction

Down

1: The minimum distance of a

linear block code is equal to the minimum ------ of its non zero codeword.

3: The number of places

between two binary sequences where they differ is called Hamming...............

4: The number of 1s in the

sequence a binary sequence is........weight.

5: The ratio of message bits and code bits
7: The bits which are added to the message bits
9: The code corresponding to each message is......
12: A fixed-length code in which k message bits are converted into a block of n code bits

Fig. 3a and 3b : Crossword Puzzle

correct answers might be challenging at times. Students recall the taught contents and finds the appropriate answer in a crossword puzzle exercise. Crossword puzzles are efficient appraisals of lecture content, and also helped students in improving their performance in online examinations. Fig. 3a and 3b shows sample Crossword puzzle for the Microprocessor and Coding Techniques courses respectively.

Moodle provides Crossword facility wherein sample questions can be given. After providing sufficient questions, and doing appropriate settings, the Crossword activity is initialized. With similar question bank, Moodle prepares different Crossword layouts for all students.

Fig. 4a. and 4b. indicates the sample Mind map sketches prepared by Final year B. Tech students for IoT course.

Down:
1. No. of Interrupt Sources for AT89S8253
3. Allows controller to communicate with external world
5. Manufacturers of PIC Microcontrollers
6. Interrupt with fix location
7. MOV A,#25H Addressing Mode of Instruction
10. bits changes as per the result after an arithmetic or logical operations
11. Mode in which the oscillator is stopped
13. Number of Pins for AT89S8253

Across:
2. Computer with hard-wired unit of programming
4. Architecture with unified Data and Code memory
8. Mode in which CPU puts itself to sleep while all the on-chip peripherals remain active
9. External reset pin in PIC18F4455
12. Address lines in PIC18F4455
14. Used to crate delay
15. Architecture with separate Data and Code memory

Fig. 3a : Crossword for Microprocessor Course

Fig. 4a. Mindmap (Wireless Technology)

Fig. 4b. Mindmap (IoT Protocol)

Fig. 4a and 4b. Sample Mindmaps

Mind Map shown in Fig. 4a. reflects the concepts related to ZigBee protocol and the sketch is drawn using XMind online Application and Fig. 4b. displays the Mind map with freehand sketch drawn for HTTP protocol. This activity is executed for the topic wireless techniques and protocols of IoT. Students have selected the techniques as per their choice and interest. Many students created mind maps using online software like XMind and MindMeister, while other students used free hand drawing to complete the task. This activity really captivated students, as they gained access to a platform that allowed them to represent ideas in graphical form without restriction.

Fig. 5a and 5b. represents the quizzes conducted during the lecture and response collected from students using Mentimeter. Fig. 5a. is the word cloud type of response received from Final year students for Internet of Things course. Fig. 5b. is the response for multiple choice question in bar chart format for Third year students conducted for coding Techniques course.

1. Name the hardware platforms that you used for IoT based Projects

Fig. 5a. Word Cloud

2. Which coding technique has memory?Fig. 5b. Multiple Choice with Bar chart

Fig. 5b. Multiple Choice with Bar chart

3. Non coherent detection technique requires the knowledge of transmitted carrier frequency and phase at the receiver.

Fig. 5c. Multiple choice with Donut

Fig. 5a, 5b and 5c. Quizzes

Fig. 5c. shows the student answers in Donut format for Analog Communication course. This is one of the interesting activity which helps to keep students engaged and alert in class. Joyful learning with Mentimeter helps to increase student involvement and attentiveness in the class. Using this platform, teacher can conduct quizzes and take polls by asking questions and collect the answers in different forms like word cloud, multiple choice, open ended, Q&A, Select answer, Type answer etc.

The instructor had to deal with a significant number of students with varying levels of prior experience and initial knowledge. Additional constraints in online teaching include logistical/technical problems, insufficient hands-on training, lack of engagement in classes, difficulty maintaining focus, and fatigue from Zoom. Think Pair Share active learning activity was beneficial to address these challenges. TPS exercises, helped the majority of students to enhance their conceptual knowledge (Kothiyal, et.al., 2014). Digital electronics is a mandatory course for all electronics, electrical, and computer engineering majors. TPS tool is used in course content delivery for various digital design concepts and mini projects.

Table 1 :
Sample For Tps Activity For Digital Electronics Course

| Read the Given Design Problem Statement	What is my response to design problem?	What does my partner think?	What will we share?
Design a code converter that converts BCD to Excess-3 code.	Design approach is to minimize number of gates in the circuit	Design approach is to minimizes the number of ICs. Discuss , compare individual design and come up with best design solution.	Share the design solution having the optimized power and hardware requirement.
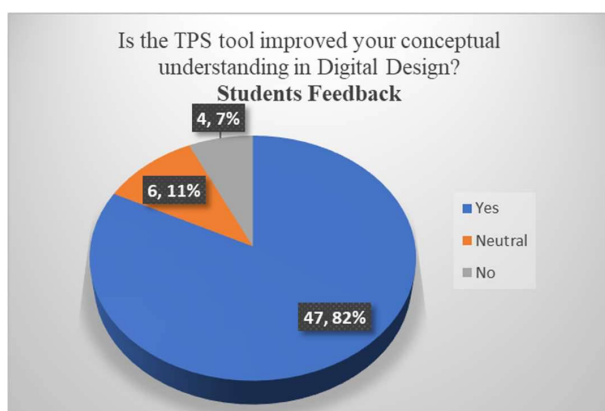
Fig. 6. Students Feedback on TPS activity

Various learning modules are planned into design problems for students to "Think" about it and try to devise a solution on their own, and then discuss their ideas with partners for getting best solution, and share the solution with whole class. Table 1 shows the sample of design problem taught in the class for the course of Digital Electronics using TPS. TPS appears to have helped in the development of logical and conceptual design skills, as well as the development of a higher order skill set in learners, as revealed by the student's results and feedback. Fig. 6. shows the feedback from the class of 60 students for the TPS tool used during course delivery.

There are a few challenges in implementing active learning methodologies in the online mode which includes technical issues like power outages, poor internet connectivity, and robust E-learning platforms.

One of the challenges in active learning methodology implementation is educators' readiness to adapt to changes in traditional teaching methods and influencing students' views about online learning.

Teachers needs to put in extra effort to design activities, which requires strong technical expertise of course contents, a creative mindset, skills in execution and assessment.

For evaluating efficacy of the activities, feedback data is collected online. The feedback form was sent as a link on the google classroom through the google forms, during the first, second and third trimester of the 2020–2021 academic year.

Table 2 showcases the cumulative feedback from students on the usage of active learning methods used

Table 2 :
Cumulative Feedback on Active Learning Methodologies

| Methodology Used	Performance Parameters	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
PBL, Cross-Word, Think Aloud , TPS, Mind Map	Learners Understanding Level improvement	1	3	9	47	120
	Learners competence level boosted	1	3	9	49	118
	Learners confidence level increased	1	3	10	45	121
	Learners Satisfaction Level Increased	1	3	11	50	115
	Learners Enjoyed Activities	1	3	8	46	122
	Learners Performance Boosting	2	3	8	47	120
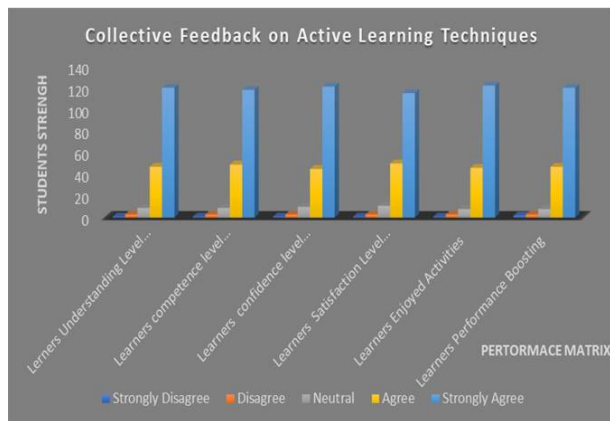
Fig. 7 : Collective Feedback from Learners on Active Learning Techniques

in three trimesters for the academic year 2020-21. COVID-19 forced a global and abrupt conversion of traditional face-to-face instruction to online instruction in the academic year 2020-21.

Collective feedback analysis shown in Fig. 7. reflects that 93% students have confirmed that they are getting benefits with active leaning methodologies.

5. Conclusion

This paper explores our experience in implementing active learning techniques to develop and teach a courses like Microcontrollers, Digital Electronics, Analog Communication, Coding Techniques and Internet of Things to the undergraduate engineering students. A new approach of integrating PBL with the University's assessment model has been developed, executed, and assessed for several courses in the Electronics and Communication Engineering. Students' responses and analysis demonstrate that the adoption of active learning strategies benefited 93 % of students by enhancing their interest, grades, basic understanding and drive for self-directed learning. Employers always look for important abilities in students such as responsibility, creative thinking, deadline sensitivity, resource management, team work, presentation skill, and logical decision-making. These skills are enhanced by active learning methodologies used during course delivery and assessment. Learning really happens in the online and offline classrooms, when teachers adopt effective planning and active learning strategies in teaching. In view of both students' feedback and the attainment level of course objectives, we can conclude that active learning strategies are effective and useful in Teaching and Learning for higher education.

Leave this section as is for the double-blind review process.

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