Higher Education's Innovative Pedagogical Approaches and Teaching Practices

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Abstract. Engaging students in the classroom is becoming more and more challenging, especially in higher education. To overcome these challenges, innovative pedagogical approaches are essential. The study focuses mainly on innovative teaching practices used in undergraduate computer engineering courses. Various active learning methods are presented in the paper, including Think-Pair-Share (TPS), Flipped Classroom (Blended Learning), Peer Instruction (PI), Interactive brainstorming, Demo-Based Teaching (DBT), Project-Based Teaching (PBT), and Assignment-Based Teaching (ABT). This paper discusses each technique in the following order: (a) Which technique is appropriate for each topic; (b) A systematic framework for conducting these techniques; (c) Evaluation and Testing of these techniques; and (d) Chances of failure and solutions. It is not only imperative for students to learn through classroom instruction. However, it is also helpful for teachers to experience a sense of fulfillment when students are actively engaged in classroom learning.

Keywords: Pedagogy, TPS, Flipped Classroom, Peer Instruction, Brainstorming, Project Based Teaching, Demo Based Teaching, Assignment Based Teaching.

1 Introduction

The syllabus of higher education especially in engineering focuses on core courses, elective courses, and hands-on practical courses. Students are expected to apply this knowledge immediately in the industry. In most the Indian Universities, a semester pattern is followed. In every semester of the 4 years degree course, students are expected to learn 3- 4 theory courses and 2-3 laboratory courses. Some subjects are very theoretical and some courses require problem-solving. Over the past decade use of pedagogical practices in engineering education has increased. But there are many challenges in implementing active learning approaches in the classroom. In this paper,

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we tried to identify these challenges and tried to provide methods and practices to face these challenges

2 Background Work

Many efforts have been made over the past so many years to make classroom learning more effective and interesting to the students. Innovative pedagogies such as peer review, Think-Pair-Share, Flipped Classroom, Brainstorming, Assignment based learning, Demonstration based learning, project-based learning etc. have been used by various teachers. A few of such findings are discussed here.

Tullis, J.G et. al discussed in depth the implementation and the benefits of Peer Instruction with graphical representations [1]. Yusuf Ziya Olpak et. al presented recent trends in the implementation of Peer Instruction [2]. Catherine H. Crouch et. al reported data from the experiment of ten years of teaching with Peer Instruction in physics. Their results indicate increased student mastery of both conceptual reasoning and quantitative problem-solving upon implementing PI [3]. Marjolein Versteeg et. al. concluded that Peer Instruction optimizes comprehension of physiological concepts in medical students [4].

Ariana Sampsel et. al. recorded the effects of Think-Pair-Share on Students [5]. Confidence and Participation. Rathakrishnan et. al proved that Think-Pair-Share (TPS) develops Critical Thinking Skills in students [6]. Lukas Mundelsee et. al. has listed various advantages of Think Pair Share on in-class Students' behavior and their participation [7]. Raba, A. recorded the Influence of Think-Pair-Share (TPS) on Improving Students' Oral Communication Skills [8].

Nouri, J proposed flipped classroom strategy for low achievers to improve effective and active learning of the courses [9]. Chi-Pu Chou et.al. presented a case study on the effect of flipped-classroom on Language Learning [10]. Campillo-Ferrer et al. recorded the effectiveness of flipped-classroom on the self-learning of the students in the COVID pandemic situation [11]. Uzunboylu et al. presented a detailed review of recent literature on flipped-classroom [12].

Abdullahi Nase et al. studied the effect of Brainstorming on creative problem-solving skills among male students in Kuwait [13]. Ambo, Sitti et.al. also supported the study of an increase in students' creativity and innovation skills using brainstorming [14]. Simone M et. al. proposed the technique of conducting brainstorming for idea generation [15]. Zhengya Gong et. al. presented a systematic review of virtual brainstorming and its effect on creativity [16].

Ahmad Basheer et al. explored that the use of teachers' demonstrations significantly improves students' understanding of redox reactions [17]. Muhammad Arshad Hussain studied the effectiveness of demonstration methods to improve the student's understanding of the abstract concept of the six to ten age group [18]. Joyce Putnam et.al. demonstrated the role of demonstration teaching in the education of preservice and in-service teachers [19]. Upadhye Vaishali et al. presented demo-based learning as an effective teaching-learning pedagogy in STEM education [20].

Le Thu et al. presented a review of the implementation of the Project-Based Learning model in higher education [21]. Markula A et. al. has presented the implementation of key characteristics of project-based learning (PBL) within the context of science education [22]. Milan Maros et al. examined the effectiveness of teaching economics through project-based learning at secondary schools in the Slovak Republic [23]. Pengyue Guo et. al. presented a review of empirical studies on project-based learning with a focus on student outcomes [24].
Ulum Ömer discussed that assignments are practical tools to develop communicative skills and provide learning experiences in order to achieve the needed behavior change [25]. Joyce Jeanette et al. examined the quality of teaching based on the quality of classroom assignments [26]. Sunil A Bakhru et. al has proposed the use of assignment-based learning and Project Based Learning as an alternative to Continuous Internal Assessment. [27].

All these researchers agree that, using innovative teaching pedagogies, learning, and problem-solving skills. Applying these pedagogies to higher education has different challenges than applying it to the school level. The following section discusses the methodologies to apply innovative practices for undergraduate students.

3 Methodologies for Innovative Teaching

At a number of institutions that offer higher education, efforts have been made to introduce and experiment with modifications in the teaching methodology. A great deal of research has been done in this area. We all understand that education is a powerful tool for promoting social change and the advancement of every individual in society. To make the lessons interesting and to inspire the students, creative teaching methods must be adopted if the quality of education is to be raised. Innovative practice teaching involves using new or creative approaches to teaching and learning to improve student engagement, learning outcomes, and overall educational experience. It involves incorporating new technologies, techniques, or ideas to develop and implement solutions that enhance teaching and learning processes.
Innovative practices are essential for progress and growth in various fields, and they can lead to significant improvements in efficiency, effectiveness, and sustainability.

3.1 Peer Instruction / Peer Review

Peer instruction is a teaching method developed by Eric Mazur, a physicist at Harvard University, that involves students teaching and learning from each other in a collaborative environment. In peer instruction, the instructor presents a concept or problem to the class, and students individually think about and answer the question. Then, they discuss their answers with a nearby peer, explain their reasoning, and try to convince

their peer to change their answer if necessary. The instructor can then assess the student's understanding and provide further explanations or clarification.
This approach aims to promote active learning and engagement, as well as develop students' critical thinking skills and ability to communicate their ideas effectively. It has been found to be effective in improving student learning outcomes in various fields, including physics, engineering, and mathematics.
Here's an example of how the Peer Review strategy was implemented for the DC circuit module of the course Basic Electrical and Electronics Engineering offered to the first-year students of the Computer Engineering Programme and Information Technology Programme [28]. A group of 6 students per group, are selected by the teacher as per roll number. Peer review assignment was given to individual groups. Students are expected to work in groups. Evaluation rubrics were shared with the students, they were expected to review each other's work and enter the marks in the google sheets. After doing both quantitative as well as qualitative analysis some of the important conclusions drawn by the authors are as follows.

- Implementation of peer assessment as an active learning technique has proven to be beneficial to analyze and calculate the parameters of DC circuits.
- During the Peer Review process, students discussed alternative methods of analyzing the given DC circuit.
- As students were supposed to do an unbiased evaluation of their fellow classmates' assignments, strictly as per the rubric provided, it helped in instilling the sense and importance of professional ethics in the very first year of the engineering course. They got the opportunity to understand the significance of professional ethics through the actual implementation of the peer review.
- From the analysis of students' perception, it is clear that the Peer Review activity has enhanced students' engagement with the course content.

3.2 Think-Pair-Share (TPS)

Think-Pair-Share is a collaborative learning activity that encourages students to engage in active discussion and reflection on a given topic or question. The activity is typically broken down into three stages:

1. Think: The teacher poses a question or a problem to the class and gives students time to think about their responses independently.
2. Pair: Students are then paired up with a partner to discuss their ideas and share their thoughts. This allows students to clarify their own understanding and gain new perspectives from their partners.
3. Share: Finally, the teacher calls on students to share their ideas with the class. This allows the entire group to benefit from the collective knowledge and insights of all students.

Following is the case study for Review and Discussion about memory management techniques for given data for second-year computer engineering course "Operating Systems"
Topic: Memory Management Activity:
Think – Pair – Share Relevance: To compare memory management strategies with respect to various attributes.

Methodology: Think Pair Share Activity: To compare Memory Management Strategies

THINK PHASE: (5 Min)

Teacher Do:

- Divide the class into 3 groups (Contiguous allocation, Paging, and Segmentation)
- Display a slide of criteria for comparison
    - Hardware support
    - Performance
    - Fragmentation
    - Relocation
    - Swapping
    - Sharing
    - Protection

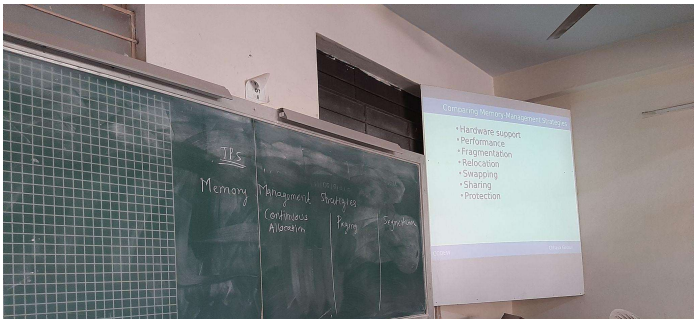


Fig. 1. Display Criteria for comparison of Memory Management Strategies

- Ask students to think and write for different MM strategies in their Notebooks

Students Do: Think, Recall, and write about criteria implemented in various MM Strategies in their notebooks

Fig. 2. Think Phase

PAIR PHASE: (5 Min)

Teacher Do: Ask students to discuss their points with their group members and come up with a clearer solution

Students Do: Discuss with their team and verify their answers, may add new points to their answer.

Fig. 3. Pair Phase

SHARE PHASE: (10 min)

Teacher Do: Ask a representative of each group to share their answer in front of the entire class.
Student Do: Summarize their answer and select a representative to share it.

Fig. 4. Share Phase

The Think-Pair-Share activity is a great way to encourage active learning, collaboration, and critical thinking. It helps students develop their communication skills, and encourages them to actively listen to and consider the ideas of others. It can be used in a wide variety of educational settings, from elementary schools to university classrooms [31].

3.3 Flipped Classroom

The flipped classroom is an instructional approach where students learn new content at home through pre-recorded videos or other resources and then apply that learning through activities, projects, or discussions in the classroom. The traditional model of classroom instruction, where students listen to lectures in class and do homework outside of class, is reversed in the flipped classroom model.
Here's an example of a flipped classroom approach [29]:
Methodology: Flipped Classroom was implemented for the Scheduling Algorithms of Operating Systems course of Second Year Computer Engineering students.
Flipped classroom technique consists of two phases as shown in Fig.4, which is structured as: Out-Class Activities and In-class Activities.

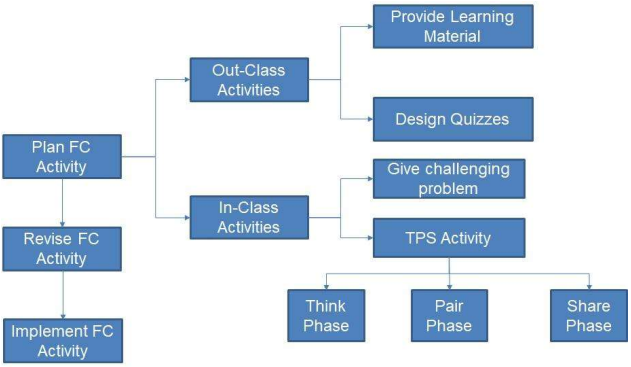


Fig. 4. Procedural steps commonly used for implementing Flipped Classroom technique

The flipped classroom model allows students to learn at their own pace and frees up class time for interactive activities and discussions that can deepen their understanding of the topic. It also allows the teacher to provide more personalized support and feedback to individual students, as they are able to work with students one-on-one during class time.

3.4 Interactive Brainstorming

Interactive brainstorming is a group activity where participants generate and share ideas around a particular topic, in a collaborative and non-judgmental environment. It encourages creative thinking and open discussion and often involves building on the ideas of others to come up with more innovative and well-rounded solutions. Here's an example of how interactive brainstorming might work:

Topic: Ideas for Improving the School Cafeteria

Introduce the topic: The teacher or facilitator introduces the topic of improving the school cafeteria and sets the ground rules for the brainstorming session. For example, everyone should have a chance to speak, all ideas are welcome, and criticism or negative feedback is not allowed.

Generate initial ideas: Each participant in the group is asked to write down one idea for how the school cafeteria could be improved. This is done silently and individually to allow each person to think without interruption or pressure.

Share ideas: Once everyone has had a chance to write down their idea, the facilitator asks each person to share their idea with the group. As each idea is shared, others in the group can build on it or offer alternative suggestions.

Group and prioritize ideas: After all ideas have been shared, the group can begin to group similar ideas together and prioritize them based on feasibility, impact, or other factors. This can be done by a show of hands, or by creating a voting system.

Action planning: Finally, the group can create an action plan for how to implement the top ideas. This could include assigning roles and responsibilities, setting timelines, and identifying any resources needed.
Interactive brainstorming encourages all participants to contribute and helps to generate a wide range of ideas, many of which may not have been considered without the collaborative effort of the group. By prioritizing and action planning, the group can move beyond just generating ideas and take concrete steps toward implementing them

3.5 Demo-Based Teaching

A demonstration or a real-world example is used by teachers to demonstrate a subject or skill to pupils in demo-based teaching. This method works especially well in topics like physics, engineering, and the arts, where practical experience can help pupils comprehend difficult or esoteric ideas.

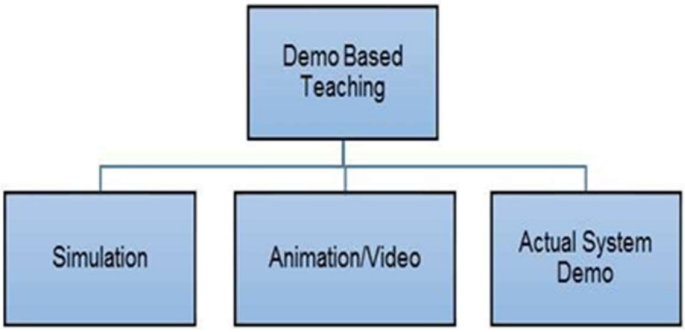


Fig. 5. Types of Demo-Based Teaching

A demonstration-based lesson is demonstrated here:
The course "Basic Instrumentation" is part of the second-year B. Tech Instrumentation and Control curriculum. Students learn about the design and operation of test instruments in this course. Cathode Ray Oscilloscope is one such testing device (CRO). This test equipment is widely utilized by students in their mini-projects, projects, and laboratory sessions for the testing and analysis of various electrical circuits.
For accurate analysis and testing, the students should be able to manage the numerous controls on this equipment. The theoretical course is designed to cover how these various controls operate. It becomes challenging for the pupils to picture the effects of each control in a classroom setting. It is simpler for the students to comprehend, remember, and repeat it if the impact of a change in the setting of each control on the CRO is shown. The activity was carried out as depicted in Fig. 6.

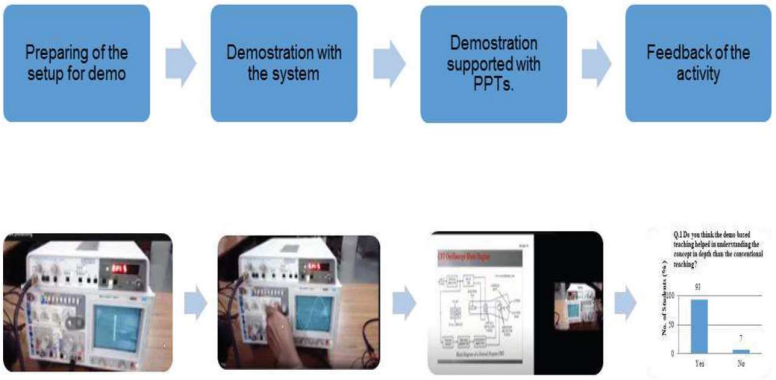


Fig. 6. Steps in demo-based learning implementation

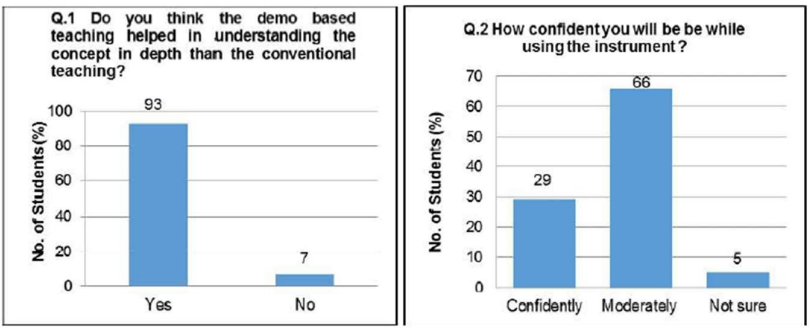
THE APPARATUS: A SURVEY QUESTIONNAIRE

The following questions were used to get student feedback on this activity:

1. Do you believe that the demo-based instruction helped you understand the idea more thoroughly than the traditional instruction?
2. How comfortable are you with operating the instrument right now?
3. Are you going to be able to match up the instrument's controls and internal circuitry?
4. Do you think this approach is suitable for the subject and is really helpful?

RESULTS ANALYSIS AND DISCUSSION

The feedback taken after the completion of the demo-based learning was analyzed with the help of the graphs shown in Fig. 7



(A) Response to Q.1 (B) Response to Q.2

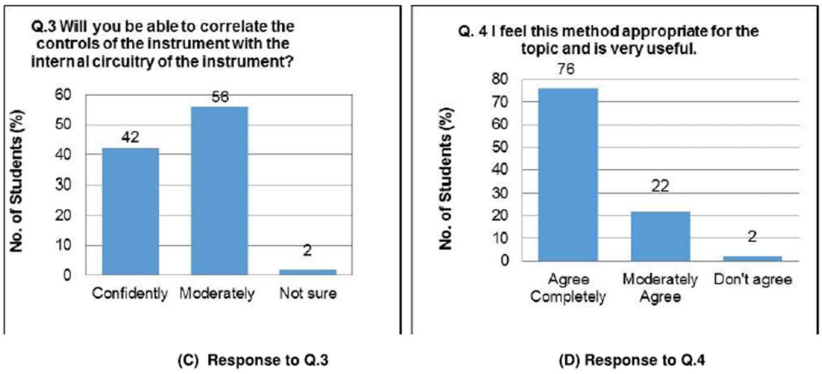


Fig. 7. Feedback analysis of demo-based learning implementation

By using demonstrations or experiments to illustrate the concept of density, students can go beyond memorizing definitions and formulas to see how density works in real-world scenarios. This approach allows for active engagement and hands-on learning, helping students retain information better and apply it to different situations.

3.6 Project-Based Teaching

Project-Based Teaching (PBT) is an instructional approach that involves students in active, authentic, and collaborative learning experiences, in which they work on complex, real-world projects to acquire and apply knowledge, skills, and competencies. In PBT, students engage in a variety of activities, such as research, analysis, problem-solving, design, and presentation, that help them develop critical thinking, creativity, communication, and teamwork skills.

Here's an example of Project-Based Teaching:

PrjBL/ PBL has been implementing one of the engineering courses named Business Intelligence for the last two consecutive years [30]. It is a completely project-based course. PrjBL/ PBL enhances students' various skills like domain knowledge, communication, presentation, and teamwork. There are various phases involved while designing the project in this course. Fig 8 shows the three-step methodological process to work on the collaborative project with a peer learning effect.

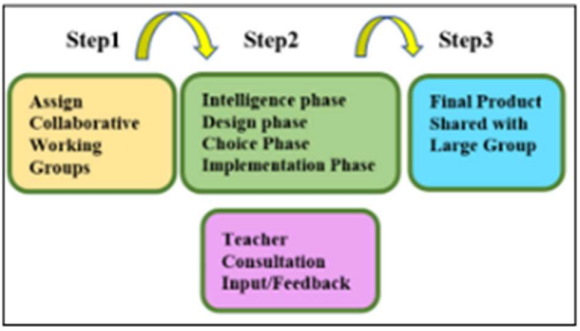


Fig. 8. Methodological process to assign and share the PBL study

The End, of Course, survey form is designed to gather information and feedback about the course. There are two classes for this course with 65 students in each class. The survey form is collected from all the students enrolled in the course. After the analysis of the survey, it is observed that PBL has improved the understanding of course contents. In the student's opinion, PBL is a great tool for student learning and around 76% of students are satisfied with this approach.

By engaging in a PBT activity, students not only learn about environmental conservation but also develop important skills and competencies that are essential in the 21st century. Moreover, they become more motivated and engaged in the learning process, as they see the relevance and significance of what they are learning to their lives and the world around them.

3.7 Assignment-Based Teaching

Assignment-Based Teaching (ABT) is an instructional approach that involves students in completing specific tasks or assignments that demonstrate their understanding of a topic. In ABT, the teacher assigns individual or group tasks that require students to apply the knowledge and skills learned in class to real-world situations. Students receive feedback on their work, which they can use to improve their understanding of the topic.

Here's an example of Assignment-Based Teaching:

The course of Machine Design involves the scientific approach to formulate a layout/plan for a mechanical system to perform specific functions thereby fulfilling the need. The course deals with designing individual machine elements and the overall systems, through analysis of failure modes, material features, manufacturing aspects, and cost considerations, along with maintainability and safety concerns. The broad scheme of learning assessment for the ‘Assignment Based Learning for the course of ‘Machine Design’, is as follows

- Students are given the assignments during lab sessions based on the progress of syllabus coverage during theory lectures.
- Each assignment consists of 4 to 6 questions based on the concerned topic. The assignment is mapped with the course outcome. Each question is mapped to aspects like memory-based, conceptual, analytical, and application based.
- The students are allowed to refer to the textbooks and class notes to complete the assignment and submit it on the next turn.
- The assignment is thoroughly checked and graded by the teacher. If necessary, the required corrections are suggested.
- Ten assignments are given in the first ten weeks from the commencement of the semester. During this period, the students being well-versed in the design of individual machine elements are ready to take up a design project based on a practical application.
- The students are divided into groups of 4 each and a project-based assignment for the given practical application, is given to each group.
- Each group does extensive brainstorming to figure out the approach and to come up with a strategy. Each group finalized their plan by discussing it with the teacher.
- Each group carries out the design starting from scratch and the process is done in a step-by-step manner. Each step is monitored and mentored by the teacher.
- After completion, each group prepares a design report and drawings of the system, using suitable software packages.
- The report and the drawings are assessed by the teacher.
- The batch is now divided into groups of two students each. Each group is assigned a topic related to the above project-based assignment. The pair does a literature search and comes up with a PowerPoint presentation on the assigned topic. The presentations are assessed by the teacher.

The assignment-based learning greatly helped the students in learning the course of machine design, with the following benefits

- The teacher can know the understanding level of the students very closely, on a weekly basis, which is helpful in planning the content and delivery of the subsequent lectures appropriately.
- Project based assignment greatly enhances the critical thinking and analytical ability
- Project-based assignment enriches the project report writing and drawing skills
- Project-based assignment and Presentation based assignment improves teamwork and collaborative learning skills.
- Presentation-based assignment demonstrates the presentation skills
- Working with small groups of students ensures better mentoring and individual attention

4 Concluding Remark

Higher education pedagogy has undergone many changes over the past two decades. Traditional teaching methods are still employed by many institutions, but many are adopting innovative approaches to teaching and learning. Teachers also tend to adopt new teaching methods as innovation and creativity are recognized as the essence of learning. Many researchers have concluded that the use of innovative teaching and learning methods has significantly improved student performance, and many institutions have also reported improved class attendance. increase. Feedback from our students and teachers on our innovative teaching methods is very encouraging. Innovation is a continuous process and faculty apply innovative methods to improve the quality of education, enhance creativity, empower people, and ultimately achieve our country's Human Development Index.

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