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Towards Enhancing Engineering Education through Innovative Practices in Teaching Learning

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Abstract: ***Engineering is a discipline which demands lot of analytical skills, technical expertise and intuitive understanding. The quality of students produced by engineering institutes is deteriorating at a rapid pace. Academic Institutions play a major role in creating high quality engineers with needed skill set to face global competition. However, the use of conventional teaching learning pedagogy limits producing high quality engineers. The proposed pilot study, aims at incorporating innovative methods in teaching learning pedagogy such as collaborative learning, peer learning, technology enabled learning and participative learning strategies for students with different learning styles. The impact of employing the innovative methods are assessed using students feedback, course end survey and assessment results. A significant improvement in the student performance claims the effectiveness of proposed techniques to improve the in-depth understanding, employability rate and knowledge level of budding engineers.***

Key Words: ***Pedagogy, teaching learning, active learning, col-laborative learning, peer learning, technology enabled learning.***

I.INTRODUCTION

Engineering is the most sought degree by the students com- munity world wide. Albert Einstein said, "Scientists investigate that which already is; Engineers create that which has never been ". Engineers are the creators rather than investigators. Engineering is a challenging degree with exciting career op- tions in different avenues like IT sectors, core engineering and management with lucrative salary benefits, still making it as highly demanded study option by most of the students. Engineering is a versatile career that creates a difference in the society and lives of human.

Every year about 1.5 million students enroll in engineering degree in India. But the amount of students graduating out, lacks essential skills required to compete in the global arena. This calls for a complete study and analysis on various reasons that produce engineering graduates with low skill-set. A study conducted by 'Aspiring minds' in [1] claims that, 'Engineer Education In India Fails To Impart Requisite Skills'. The study reported that only 4.7% of graduated Indian students possessed the required skills.

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The lack of quality education in India is the reason for such small numbers. The study also analyzed that mushrooming of self-financing engineering col- leges with lack of infrastructure and admitting students of low caliber with high capitation is the prime reason for producing low quality students. 'Make in India' program of Government of India aims at making India a pioneer in manufacturing sector, but with the quality of engineering graduates produced it is difficult to achieve such high ambitions.

An article [2] in 'The Economic Times' says that 'India is in the middle of an engineering education crisis '.The study emphasised on the reasons for producing low quality graduates. The reasons include low quality colleges, lack of infrastructure, inability to produce high quality students with existing infrastructure and education.

An article [3] in 'The Hindu' news reports that 'Quality of engineers very sub-standard in India'. In this case, many engineering institutes produce engineers of very sub standards, where as the students coming out of IIT's and NIT's move to foreign countries for better career prospects.

Considering the importance of improving the quality of education in Indian Engineering institutes, many works in literature focused on changing the traditional teaching learning paradigm. Activity based learning, active learning, technology enabled learning, collaborative learning, participative learning and peer learning are techniques employed to bring a change in the conventional method of teaching employed in engineering institutes.

In [4], the quality of engineering education is improved by employing Information and communication technology (ICT) based teaching. Video lecturing, discussion forums, change in assessment pattern, industry partnership courses were used to check the effectiveness of the ICT based teaching method.

Collaborative learning is employed for programming course in a E-learning environment [5]. In that study, metrics such as knowledge sharing, level of learning, work experiences and overall productivity are assessed to analyse the student per- formance. A significant improvement claims that collaborative learning can be used as pedagogical tool to enhance teaching learning capabilities in a programming course.

Peer learning was used as a pedagogic tool in [6]. Learning through peers, colleagues, students in and outside the uni- versity improved the skillset in a research environment. Peer learning improved critical thinking, problem solving skills, self learningskills.In addition, it is more learner centric thereby an effective tool for knowledge acquisition and transfer [7].

Amir et.al [8] analysed the learning behaviour of students and faculty members at university level. In that study, it was clear that the learning styles of students vary based on gender, age and course type. Different learning strategies such as participative learning, competitive learning and cooperative learning gained significance among the student community.

Cooperative learning style was used to help students with different learning style to achieve team work and deep learning [9]. Results claimed a significant improvement in scores of students with cooperative and competitive learning styles.

Activity based learning was used for teaching an Engineering theory course in [10]. Activities such as roleplays, games, case studies, usage of tools were implemented and the results were evaluated using student feedback. Results show that students were more satisfied with activity based learning when compared to conventional learning method.

Monotonous teaching learning limits active participation of students in class room activities and listening lectures continuously. [18][19] This problem can be overcome by inducing interest among the students through usage of innovative methods in teaching learning. Therefore our work focuses on introducing innovative methods in teaching learning paradigm such as collaborative learning, peer learning, technology enabled learn- ing and active learning strategies for students with different learning styles. The performance of the proposed pedagogical change in teaching learning is assessed in terms of course end survey, student feedback and assessment results for students with different learning styles defined by Grasha-Reichmann [11].

The paper is organized as follows: Section II describes the conventional teaching method; Section III discusses the methodology employed. Section IV evaluates the performance of the proposed teaching learning paradigm. Section V concludes the paper and discusses the future scope.

II.CONVENTIONAL TEACHING METHOD

The conventional teaching method includes preparation of lesson plan with Course Outcome (CO), course contents and teaching methodology for respective course contents. The course outcomes are defined based on Bloom's taxonomy [12]. The course delivery is based on conventional teaching aids like chalk and board, presentation slides (Over head projector and multimedia projector). The assessment pattern includes a continuous assessment for 50 marks and End semester evaluation for 50 marks. The continuous assessment includes two periodical tests, assignment, tutorial and quizzes. The end semester evaluation includes a written examination comprising the course syllabus. The conventional teaching learning framework is shown in Fig 1.

A. Framework

The framework of the proposed innovative practices in teaching learning [20] is depicted in Fig 2. The performance of the proposed pedagogic change is assessed in terms of student feedback and assessment results.

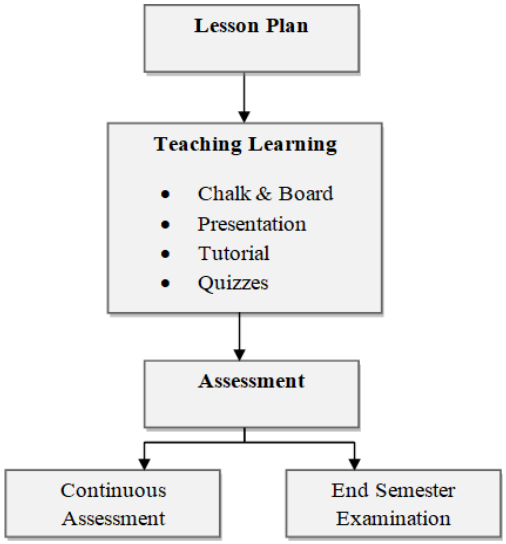

Fig. 1: Conventional Teaching Learning Framework

III.METHODOLOGY

A. Study group

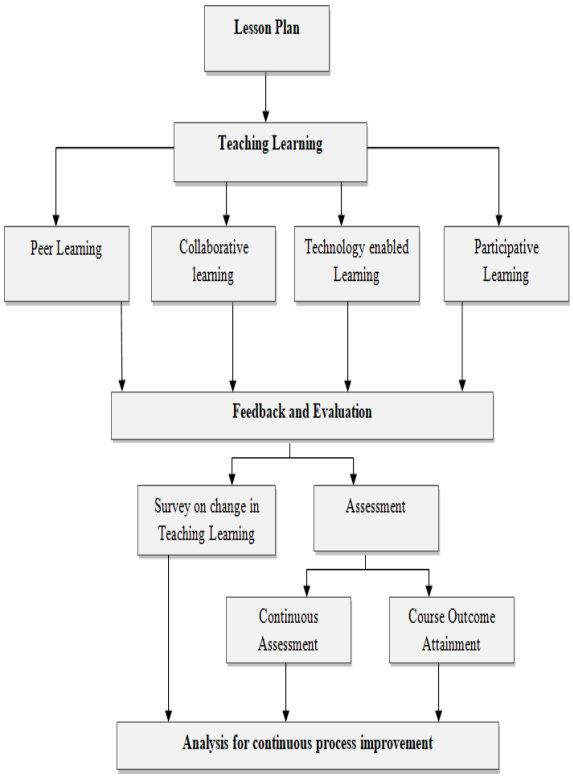

Fig. 2: Framework of proposed pedagogic change

The study group comprises of 70 students from the department of Electronics and Communication Engineering. The experiments were done on the study group attending the course titled 'Communication Engineering' in the sixth semester of their Bachelor's degree in engineering. In the group 36 students (52%) were male and 34 students (48%) were female.

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Based on the feedback and test analysis further ramifications are done for continuous process improvement.

B. Innovations in Teaching Learning

To improve the quality of teaching learning and to make students actively participate in the class environment four types of best practices are employed. The best practices are peer learning, collaborative learning, technology enabled learning and participative learning.

Peer Learning : Students learn from peer groups and fellow learners in a comfortable way rather than under an authority. Peer learning encourages students to share ideas and makes them more learner centric [13]. As part of improving teaching learning, peer learning was implemented by clustering students into groups. The students are clustered in a group of 5 based on their interest and each group is assigned with a advanced technical topic in 'Communication Engineering' course. The proposed topic to each group is an end to end system which was built using the fundamentals discussed in the class.

Peer learning methodology employed was evaluated using a group presentation on the technical topic. Each team presented the topic to the fellow class mates and faculty member. It was observed that each group presented the topic to their best using information gathered from different sources and text book. Students interacted with the presenters and clarified their doubts. Scores are awarded to the students based on content delivery, understanding level and ability to answer questions.

Collaborative learning: Collaborative learning is a group activity that involves students working together to obtain solution to a problem [14] [17]. 'Communication Engineering' course aims at building end to end telecommunication sys- tem with focus on modulation techniques, noise performance, receiver design etc. Studying the concepts of this course in a theoretical way is more abstract and students do not appreciate the subject. To understand the concepts practically implementing systems that simulate the theory concepts is essential. MATLAB is one such simulation tool that uses a proprietary programming language developed by Mathworks to implement end to end communication systems.

Collaborative learning is effective in teaching programming course [5] . Hence Collaborative learning is introduced to learn MATLAB. Students were split into groups and asked to implement a small problem statement using built-in matlab functions. In the later stage students were asked to write their own matlab functions. In this way, students acquired knowledge in MATLAB programming language.

Collaborative learning was evaluated based on the logic used in code and the generalizing capability of the developed code. Students exhibited team work and shared easy ways of writing a code.

Technology enabled Learning : The current generation of students are more tech-savvy. The use of technology to teach students has gained attention in recent past [15]. The process of dissemination of information and elicit response from students is a huge task.

A massive open online course (MOOC) courses aims at providing high quality study materials to student/faculty community worldwide. The MOOC courses offered by Cours- era, edX, NPTEL are of high standards. The students are clustered in a group based on their MOOC course interest and the provider. Students are encouraged to complete a MOOC certification to acquire in depth knowledge. The response of students to MOOC course was minimal.

Technology enabled learning was evaluated by asking assignments and quizzes from MOOC materials. Furthermore, extra credits were given to students who completed MOOC courses with good grades.

Google classroom service offered by google is effective in achieving technology enabled learning. Google Classroom combines the services offered by Google Drive for storage, Google Docs, Sheets and Slides for writing, Gmail for elec- tronic mail and Google Calendar for maintaining deadlines. An exclusive folder is created for each class in the corresponding user's Drive, where the student can submit their work for teacher's grading. Sharing of files, conducting assignments quizzes, grading/commenting assignments w.r.t to prompt sub- mission and content becomes easy with Google classroom. Mobile version of Google classroom helps in quick access. Teachers can monitor students progress and can assign grades and provide comments for the assignments.

Participative Learning : In participative learning both the teacher and students actively involve in improving the teaching learning process. It is a mutual learning process that aims at building a good relationship between teacher and students [16]. In this method of teaching students tend to be independent but under the control and supervision of the teacher. To enhance teaching learning, participative learning was achieved by segregating students into groups. The students are clustered in a group of 5 based on the teacher's choice. Care is taken in such a way that each group involves students with different learning styles and grades. Each group is assigned with a advanced technical topic in 'Communication Engineer- ing' course. The course materials for the topic is shared by the teacher. Participative learning methodology employed was evalu- ated using a group presentation on the technical topic. Each team presented the topic to the fellow class mates and faculty member. It was observed that each group presented the topic to their best using information gathered from multiple sources. Scores are awarded to the students based on content delivery, extra effort taken by the students and ability to answer complex questions. Participative learning improved the understanding when compared to peer learning as the material is shared by the teacher. However, there was a gradual decrease in the amount of responsibility owned by the students practicing participative learning .

The innovative teaching methods employed in the proposed work is shown in Fig 3.

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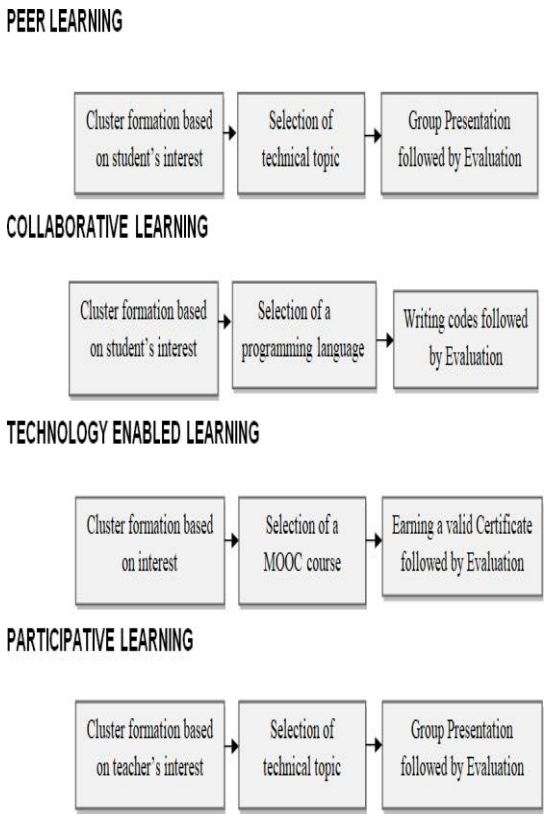

Fig. 3: Innovative teaching methods

IV.RESULTS AND DISCUSSIONS

The innovative practices employed in teaching learning using peer learning, collaborative learning, technology enabled learning and participative learning are evaluated on students with different learning styles. The learning styles proposed by Grasha-Reichmann is used for the evaluating the study and shown in Table I

Learning styles	***Description***
Avoidant	Students with low grades and irregular to classes
Participative	Students ready to accept responsibilities and more peer friendly
Competitive	Students focus more on grades and suspicious of their peers
Collaborative	Students collaborates with their peers actively
Dependent	Students always depends on their friends and teacher
Independent	Students work on their own with minimal teacher guidance

Table I: Learning styles proposed by Grasha-Reichmann

Table II shows the percentage of students in different learning styles. From the table, it is evident that dependent learning style is dominant followed by collaborative, participative, independent and avoidant styles.

Learning styles	***Percentage of students (%)***
Avoidant	6
Participative	17
Competitive	12
Collaborative	19
Dependent	30
Independent	16

Table II: Student distribution based on learning styles

Desai et al. [10] used multiple performance metrics to evaluate activity based teaching learning. In this work, Student feedback, Course end survey and Course attainment results are used to assess the effectiveness of the proposed pedagogic change in teaching learning.

A. Student feedback

Student feedback was collected based on the parameters listed in Table III. Students rated the parameters on a 5 point scale ([5] Excellent; [4] Very good; [3] Good; [2] satisfactory

[1] average). The feedback was collected through an Enterprise resource planning software suite. The identity of the students were not revealed to the teacher, so that students are indepen- dent to express their opinions on the teaching learning process.

Feedback Questions	***Average Mark***
Satisfaction of syllabus coverage (5)	4.40
Class room ambience and interaction with course teacher (5)	4.20
Achievement of COs defined (5)	4.60
Overall rating for the understanding of the course (5)	4.40
Effectiveness of lecture delivery - black board and /or visual aids (5)	4.60
Efficiency of assessment methods (5)	4.60
Overall Avg Mark	4.47
Percentage	89.33

Table III: Student feedback

From the feedback scores in Table III, it is evident that students expressed high degree of satisfaction for the parameter 'Effectiveness of lecture delivery - black board and /or visual aid' with a score of 4.60. This parameter is directly correlated to the innovations employed in teaching learning paradigm

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B. Course end survey

After the completion of course, a survey was conducted to analyse the degree of attainment in learning the 'CommunicationEngineering' course using course outcomes. Students rated the attainment of course outcomes in a 5 point rating scale ([5] Excellent; [4] Very good; [3] Good; [2] Average;[1] Below average) .

The innovative practices for each course outcomes is listed in Table IV.

Course outcome	*Innovative teaching*
CO1	Peer
CO2	Collaborative
CO3	Technology enabled
CO4	Participative
CO5	Conventional

Table IV: Innovative practices-Outcome mapping

The chart in Fig 4 reveals that majority of the students rated high degree of attainment for CO1,CO2 and CO4. Hence it is clear that students respond well to peer, collaborative and participative learning. Conventional learning method used in CO5 and technology enabled learning in CO3 received a less response because of their monotonous and time consuming nature.

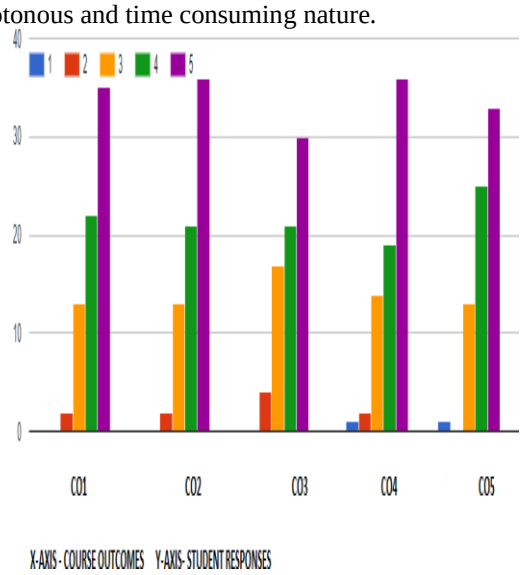

Fig. 4: Course end survey

C. Course attainment

Course attainment is calculated for each student by taking weightage of 50% from continuous assessment and 50% from end semester examination. The course attainment for the course outcomes with different learning styles and innovative practice employed is tabulated in Table V

Course outcomes	*Innovative practice*	*Learning style*	*Students with attainment above 60%*	*% of students with attainment above 60%*
CO1	Peer	Avoidant	0	0
		Participative	5	42
		Competitive	9	100
		Collaborative	10	77
		Dependent	8	40
		Independent	7	64
CO2	Collaborative	Avoidant	0	0
		Participative	8	67
		Competitive	9	100
		Collaborative	13	100
		Dependent	10	50
		Independent	11	100
CO3	Technology enabled	Avoidant	0	0
		Participative	10	84
		Competitive	9	100
		Collaborative	13	100
		Dependent	3	15

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		Independent	11	100
CO4	Participative	Avoidant	0	0
		Participative	11	92
		Competitive	9	100
		Collaborative	13	100
		Dependent	10	50
		Independent	11	100
CO5	Conventional	Avoidant	0	0
		Participative	11	92
		Competitive	9	100
		Collaborative	13	100
		Dependent	5	25
		Independent	11	100

TABLE V: Course attainment for different learning styles

From the table, it is inferred that students with competitive, collaborative, independent and participative learning style exhibits high course attainment scores irrespective of the innovative practice used in teaching learning. However, students with and dependent learning styles show significant improvement in attainment scores using participative (50%), collaborative (50%) and peer learning (40%) respectively. Students with avoidant style of learning does not respond to any pedagogic change (0%).

V.CONCLUSION

In this work, innovative methods in teaching learning pedagogy such as collaborative learning, peer learning, technology enabled learning and participative learning strategies for students are incorporated. The impact of employing the innovative methods is assessed using students feedback, course end survey and assessment results with different learning styles. A significant improvement in the student performance claims the effectiveness of proposed techniques to improve the quality of graduating engineers.

The future scope involves employing active learning strate- gies, flip classrooms, developing video lectures to enhance teaching quality and analyse the effect of these techniques using student feedback and statistical correlation analysis.

The proposed innovative teaching pedagogical change may help in improving the teaching learning, thereby helpful for the society in producing high quality engineers with good technical and problem solving skills

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