Innovations in Teaching Methodologies to improve the results of core subjects at the First year level: A study under Autonomous scheme.

Dr Salumari Madhu[1], G Prabhakara Reddy[2]

[1]Professor and Head, Department of Mechanical Engineering, MLR Institute of Technology,
An Autonomous Institution, Affiliated toJNTUH, Hyderabad, T.S., India.
[2]Assciate Professor, Department of Computer Science and Engineering,MLR Institute of Technology,
An Autonomous Institution, Affiliated to JNTUH, Hyderabad, T.S., India.
[1]salumari@gmail.com
[2]guntakap@yahoo.com

Abstract: In the engineering education, the first year results of a student set the tone for the future and, indeed, whether a student decides to remain in the engineering program at all. Engineering programs around the country experience difficulty in assisting students with the transition from intermediate level to college level, and struggle with the delicate balance between supporting a student's transitional needs and maintaining academic rigor in a Competitive environment. The first year confronts students with a curriculum especially in core subjects that challenges their long held beliefs of "being good in math and science." Their first introduction to engineering education throws them into the realm of learning through experience and discovery. This at times can be overwhelming and challenging, on the way to achieving the goal of providing them with enough information to help them understand the breadth of the engineering profession. This paper elaborates upon three specific discussion points: Core subjects in which generally students score less at first year level, Methodologies and practices implemented to improve the scores in these subjects and the challenges faced in the implementation process.

Keywords: Engineering Program, Core subjects, Methodologies, Challenges and implementation processes.

1. Introduction

Many of today's engineering educators recognize the need to develop a first-year engineering curriculum that takes into consideration the diverse academic, social, cultural, and economic backgrounds of anincoming class of students. Generally speaking, many feel that today's students are more academicallyprepared, but areless prepared to be individually responsible for the largely self-directed study required in college.First year subjects like Mathematics, Physics and Chemistry are in general extension of previous years and hence students in general tend to understand them and do relatively well in the examinations. However subjects like Engineering Mechanics, Engineering drawing/Graphics and Computer Programming are relatively new and students struggle to understand the concepts and fare poorly in the examinations. A student needs to have verycritical thinking skills and different orientation to understand these subjects. This has given rise to a question "How do engineering educator's best prepare to teach first-year engineering students" .

The conventional teaching practices have proved to be less effective in terms of the effective delivery. All the accreditation bodies have shifted their focus on OBE which is emerging asa way forward for the academic community in addressing the challenges. In recent times, manyworkshops focusing the teaching methodologies for Engineering Education Transformations areconducted. Now the emphasis is on learning how to learn . There is a paradigm shift in teaching and learning. These shifts involve the adoption of a new outlook on the part of teachers in teaching methodologies.

In this context, the following Active Learning Strategies have been included as mandatory teaching methodologies in the class room:

1. Flipped Class Room
2. Think-Aloud-Pair –Problem Solving (TAPPS)
3. In-class Teams
4. Group Writing Assessments
5. Collaboration Learning

All the above have clearly defined Standard Operating Procedures and are discussed in details in the following sections:

2. Standard Operating Procedures for Teaching Methodologies:

2.1 Flipped Class Room:

Technology enabled knowledge transfer has led to a new method of delivering the content in the class rooms. To ensure that a student comes prepared to the class and participates actively in the problem solving and do other

related activities, online videos are shared before class to all the students.[1][2]

2.1.1 Objective:

i. To motivate students to learn concepts on their own.
ii. To aid students obtain timely information (via preliminary assessments) about their learning before class and thereby adapt learning style.
iii. Students come to the class with prior knowledge of the concepts and these concepts are reinforced in the class by solving some logical and critical thinking problems based on the topic.
iv. Esures long lasting retention of the concepts.

2.1.2 Procedure:

i. Provide student with the learning material - video link (handouts/video lectures/text book reference pages etc) of the topic to be covered through website(edmodo, canvas, Google classroom etc). Give students 2 to 3 days time to go through the link, ask them to take notes.
ii. On the day of the implementation (assessing the flipped class), students can be given a task of solving problems based on the learning material shared with them. Make sure the problems should be such that the student must apply the knowledge gained from learning material / video lecture to solve the problem. prepare as many questions as possible so that no adjacent student should get the same question.
iii. Role of the faculty is to facilitate the activity.
iv. Based on the complexity of the task, the duration can be ideally set to 15 to 20 minutes
v. Faculty should collect the papers from the students.
vi. Faculty should summarize the topic/concept and can also give answers to the questions.
vii. Faculty should correct these papers (not in the class room) and give constructive feedback.

2.1.3 Assessment:

viii. Number of students attended the video lecture / gone through the learning material before coming to the class. Faculty should ensure maximum students come prepared to the class otherwise it will be very tough to handle the class.
ix. Percentage of students who have completed the task successfully reflects the success rate of the activity.
x. Assessment Metrics: At least 80 % students must take part in the pre class activity i.e. video lecture / learning material etc. and at least 65% of students must be able to complete the task successfully.
xi. Faculty must try to improve these percentages in next flipped class room activity and improvement can be shown in a bar graph.
xii. Student feedback on the activity is a must

2.2 Think Aloud Pair Problem Solving (TAPPS)

As the name suggests, this involves students working in pairs. One student (the problem solver) is required to read the problem aloud and think aloud during the problem solving process, which includes verbalizing everything they are thinking and doing. Another student (the listener) attends to the problem solver's thinking and reminds him/ her to keep saying aloud what he or she is thinking or doing, while also asking for clarifications and pointing out errors being made. [4][6]

2.2.1 Objective:

i. To provide opportunities for students to meaningfully talk and listen, write, read, and reflect on the content and ideas.
ii. To have students actively engage in the learning process.
iii. To have students learn to identify relevant information and apply it in the solution of a problem.
iv. To have students learn and practice problem-solving strategies.

2.2.2 Procedure:

i. Before conducting the activity conduct a surprise test, where students have to solve one question individually. Make a note of the scores.
ii. Class of thirty students is best suited for the activity. 15 pairs are formed. It is suggested to have one good student paired with a dull student based on the scores of the surprise test. Prepare minimum 4 different set of concept oriented analytical questions.
iii. One student (the problem solver) is required to read the problem and think aloud during the problem solving process. Another student (the listener) attends to the problem solver's thinking and reminds him/her to keep saying aloud what he/she is thinking or doing, while also asking for clarifications and pointing out errors being made (if any).
iv. For the next question the roles should be interchanged and the activity be performed. The questions can be rotated among the pairs. Altogether each student needs to solve two questions.
v. Again conduct the test where the questions can be interchanged, but the students have to take the test individually. Compare the marks obtained before the activity and after the activity.

2.2.3 Assessment:

i. Prepare a comparative sheet of marks scored by the students before and after the activity
ii. Prepare a bar chart indicating no. of students showing improvement, No change, Negative change.

iii. If more than 60% of the students have shown improvement then the activity is assumed to be successful and completed. If 50-60% of students have shown improvement then the activity is assumed to be partially completed and revision is recommended. In these cases you can claim full variable amount. If less than 50% of students have shown improvement then faculty looses the variable pay amount.

2.3 In class Teams:

Compared to students taught traditionally, students taught in a manner that incorporates small-group learning achieve higher grades, learn at a deeper level, retain information longer,are less likely to drop out of college, acquire greater communication and teamwork skills, and gain a better understanding of the environment in which they will be working as professionals. [8]

2.3.1 Objective:

i. To encourage team work.
ii. To promote peer learning.
iii. Retention of concepts for longer period of time.

2.3.2 Procedure:

i. Faculty should summarize the prior material
ii. Team size should be 4-7
iii. Faculty should form heterogeneous groups of students
iv. The activity should be conducted for not more than 20 minutes
v. The activity can be solving a problem, brainstorming a list, justifying a statement based on the prior knowledge and peer interaction.
vi. Faculty should facilitate the activity
vii. Summarize the activity and eliminate any misconceptions.

2.3.3 Assessment:

i. Assessment is carried out using peer evaluation.
ii. If 70% of the groups have completed the task successfully, the activity can be considered as successful.
iii. Upon failure the faculty must identify the reasons of failure and take up corrective measures.
iv. It is recommended to study the progress of students in active learning and represent the same using a bar graph.

2.4 Group Writing Assignments:

In the academic world, all of us are likely to participate in some form of group writing—an undergraduate group project for a class or a collaborative/group research paper. Writing in a group can have many benefits: multiple brains are better than one, both for generating ideas and for getting a job done. However, working in a group can sometimes be stressful because there are various opinions and writing styles to incorporate into one final product that pleases everyone..

2.4.1 Objective:

i. Students will gain opportunities to collaborate effectively.
ii. Students have opportunities to see how other students view the same topic.
iii. Use assignment that has authentic purpose and audience such as creating Wikipedia entries or study guides for the course.
iv. An assignment with an authentic purpose and audience can increase students interest and commitment

2.4.2 Procedure:

i. Before conducting the Activity instruct the students about the rules and importance of Group Writing Assignments.
ii. This activity is best suited for 30 student's i.e. 10 groups and each group comprises 3 students. However it can be conducted for a class with 60 students.
iii. Divide students in to small groups (Maximum of four), Inform the student groups to bring textbooks/journals/handouts required for writing Assignment.
iv. After giving Assignment topics (probably different topics to different groups), ask the student groups to brainstorm and decide their roles (like who is writing and who is collecting info from books etc.)
v. These assignment questions should be of Blooms Taxonomy higher order verbs.
vi. Instruct them to write precise information about the topic. And we will use this as a study material for the class.

2.4.3 Assessment:

i. Prepare a comparative sheet of marks scored by the students both before and after the activity.
ii. Prepare a pi-chart including no.of students showing improvement, No change,Negetive change
iii. If more than 60% of students have shown improvement then the activity is assumed to be successful and completed .if 50-60% of students have shown improvement then the activity is partially completed and revision is recommended.

2.5 Collaborative Learning:

Collaborative learning is an instructional method in which students' team together on an assignment. In this method, students can produce the individual parts of a larger assignment individually and then "assemble" the final work together, as a team. Whether for a semester-long project with several outcomes or a single question during class, collaborative learning can vary greatly in scope and objectives. Cooperative learning, sometimes confused with

collaborative learning, describes a method where students work together in small groups on a structured activity. Students are individually accountable for their work but also for the work of the group as a whole, and both products are assessed.[10][11]

2.5.1 Objective:

i. To enhance problem solving, creativity and thinking skills in students.
ii. To understand team-based learning as an approach to collaborative learning
iii. To make students understand complex concepts.
iv. To develop oral communication skills, Fosters and develops interpersonal relationships

2.5.2 Procedure:

There are many collaborative techniques which include think-pair-share, jigsaw etc.,

2.5.2.1 Think-Pair-Share:

i. Think-pair-share (TPS) is a collaborative learning strategy in which students work together to solve a problem or answer a question about an assigned reading. This technique requires students to
ii. *Think*: Teachers begin by asking a specific higher-level question about the topic to the students. Students "think" about what they know or have learned about the topic for a given amount of time (usually 1-3 minutes).
iii. *Pair*: Each student should be paired with another student. Teachers may choose whether to assign pairs or let students pick their own partner. Students share their thinking with their partner, discuss ideas, and ask questions of their partner about their thoughts on the topic (2-5 minutes).
iv. *Share:* Once partners have had ample time to share their thoughts and have a discussion, teachers expand the "share" into a whole-class discussion. Allow each group to choose who will present their thoughts, ideas, and questions they had to the rest of the class.

2.5.2.2 Jigsaw Activity:

i. Divide students into 5- or 6-person jigsaw groups.
ii. Divide the day's lesson into 5-6 segments.
iii. Assign each student to learn one segment.
iv. Give students time to read over their segment at least twice and become familiar with it.
v. Form temporary "expert groups" by having one student from each jigsaw group join other students assigned to the same segment.
vi. Bring the students back into their jigsaw groups.
vii. Ask each student to present her or his segment to the group.
viii. Float from group to group, observing the process.
ix. At the end of the session, give a quiz on the material.

2.5.3 Assessment:

i. If 65% of the groups have completed the task successfully then the activity can be considered as successful.
ii. If 50-65% of the groups have completed the task then the faculty must identify the reasons of failure of activity and takenecessary measures.
iii. The progress of the students should be represented using a bar graph which shows improvement/failure.

2.6 Results and Discussions:

It is ensured that at least one activity out of the above five mentioned activities is conducted per month and the outcomes are compiled in the following tabular form:

Table 1: Outcome of the Active Learning Strategies

Sl No	Name of the Faculty	Subject	Section	**Outcomes Verification (FC/PC/NC/ND)**				
				Activity 1	**Activity 2**	**Activity 3**	**Activity 4**	**Activity 5**

Legend: FC (Full Compliance): 80%-100% of SOP requirements have been met
PC (Partial Compliance): 60% -79% of SOP requirements have been met.
NC (Non Compliance): < 60% of SOP requirements have been met.
ND (Not Done)

Activity 1: Flipped Classroom; Activity 2: TAPPS; Activity 3: In class team; Activity 4: Group Writing Assignment ; Activity 5: Collaboration Learning

The mentors will discuss the outcomes with those faculties whose outcome is PC/NC/ND. The mentors will provide the guidance and training to the faculty so that there is an improvement in the next activity.

When all the above activities as per the SOPs are implemented with all the seriousness, the following observations were made with respect to the results of the Core Subjects of the First year:

Table 2: Results (in %) of the First year Core Subjects based on the Active Learning Strategies:

Subject	**AY 2015-16**	**AY 2016-2017**
Engineering Mechanics	64.6	78.42
Engineering	62.11	89.73

Graphics		
Computer Programming	51.06	60.36

2.7 Conclusions:

From the above results, it can be concluded that innovative teaching methodologies active learning methodologies mentioned in the discussions are not only very effective in creating interest to a student but also making a student understand the concepts very well. Also increase in the confidence levels of student is observed after the activities are conducted which has resulted in the increased performance of results in terms of examinations.

However, the following challenges were encountered while implementing these active learning methodologies:

Table 3: Challenges faced by various classroom activities

Sl No	Activity	Challenges	Remarks
1	Flipped Classroom	40% of students were not coming prepared to the classes.	Continuous monitoring and motivation, has yielded positive results.
2	TAPPS	Since students are of different calibre, paring has become the toughest task,	Over a period of time, students of equal calibre were indentified and grouped.
3	In class team	Since the group was heterogeneous, everyone could not complete in time.	By changing the group members, there was a considerable improvement in the output.
4	Group Writing Assignment	Opinions differed and coming to common solution was the challenge for a heterogeneous group.	Students of equal calibre could overcome this challenge.
5	Collaborative Learning	Assembling a larger assignment has become the bottleneck.	Proper guidance from faculty had led to very good results.

References

1. Farrell, Stephanie, et al. "A Virtual Community of Practice to Introduce Evidence-based Pedagogy
2. 2. Bergmann, Jonathan, and Aaron Sams. Flipped learning: Gateway to student engagement. International Society for Technology in Education, 2014.
3. http://oncourseworkshop.com/interdependence/think-aloud-pair-problem-solving/
4. MacGregor, J. (1990). "Collaborative learning: Shared inquiry as a process of reform" In Svinicki, M. D. (Ed.), The changing face of college teaching, New Directions for Teaching and Learning No. 42.
5. Lochhead, J., and Whimbey, A. (1987). "Teaching analytical reasoning through thinking aloud pair problem solving" In Stice, J. E. (Eds.), Developing critical thinking and problem-solving abilities, New Directions for Teaching and Learning No. 30.
6. Millis, B. J., and Cottell, P. G., Jr. (1998). Cooperative learning for higher education faculty, American Council on Education, Series on Higher Education. The Oryx Press, Phoenix, AZ.
7. Slavin, R. E. (1995). Cooperative learning: Theory, research, and practice (2nd ed.). Boston: Allyn& Bacon.
8. R.M. Felder & R. Brent. (2003). “Learning by Doing.” Chem. Engr. Education, 37(4), 282–283. <www.ncsu.edu/felder-public/Columns/Active.pdf>. The philosophy and strategies of active learning
9. http://writingcenter.unc.edu/tips-and-tools/group-writing/
10. https://www.umass.edu/writingprogram/jy/collaborative%20assignments.html
11. http://www.ryerson.ca/content/dam/studentlearningsupport/resources/types-of-writing/Efficient%20Group%20Writing.pdf

12. Prince, Michael J., and Richard M. Felder. "Inductive teaching and learning methods: Definitions, comparisons, and research bases." Journal of engineering education 95.2 (2006): 123-138.
13. Felder, Richard M., and Rebecca Brent. "Effective strategies for cooperative learning." Journal of Cooperation & Collaboration in College Teaching 10.2 (2001): 69-75.
14. R.M. Felder and L.K. Silverman, "Learning and Teaching Styles in Engineering Education," Engr. Education, 78(7), 674-681 (1988). Presents the original learning style model and strategies for addressing a variety of learning styles.