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Paradigm shift in teaching methodologies - Improved knowledge of faculty and students.

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Abstract: The approach to science and engineering education in engineering colleges is slowly shifting its focus towards problem solving, innovation and creativity. Curricular and assessment methods are adapted that encourage critical thinking, open ended problem solving and creativity, which were previously built around teacher-centered lecture rooms that focused on information acquisition, memorization and regurgitation at closed book examination. This study examines the paradigm shift in teaching methodologies and analyses, the strengths and weaknesses in their implementation and also empowering the faculty with pedagogical methods.
Further, it strives to capture teachers' readiness to improve their professional skills and responsive practices as a form of accountability for their teaching and students' learning; the two aspects that are increasingly being judged by various stakeholders.
The overarching aim of introducing certain changes in teaching methodologies was to facilitate the development of faculty leadership in science and engineering education to introduce innovation and creativity into science and engineering education.

Keywords: Problem solving, innovation, creativity, paradigm shift, pedagogical methods.

1. Introduction

There is a need to take a fresh look at how engineering education is being run in India, with so many colleges existing and not adopting practices at the desired level that encourage critical thinking, open ended problem solving and creativity. The institutions continue to follow teacher-centered lecture rooms that focus on information acquisition, memorization and regurgitation at closed book examination. Consequently, the academic institutions have not produced suitable science and engineering graduates needed by industry to add value.

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Teaching students, the skills needed for employability, requires paradigm shift in teaching methods and assessment techniques. Simply putting, the roles of teachers and students are changing. Many of these changes are aiming at the development of higher order thinking skills
In an attempt to address the issues, MLRIT has established a centre for innovation in teaching and learning in association with IUCEE. In a phased manner, few of the faculty were trained by IUCEE in teaching pedagogies. The trained faculty in turn, trained the other faculty members to transform the teaching methods.
The changes were aimed to facilitate improved teaching content development that is geared towards students-centered content delivery, problem solving and creativity.
Introducing more creativity into the classroom and assignments can actually make it a lot more interesting and 'Nurture Creativity in Young People'. Teachers have a greater impact by creating lessons that "use the various types of intelligence in classroom activities". (V. Radhika , 2016).

For the first year students, the following changes were made in teaching, and the impact of these changes are studied.

- **ATLAS** – **A**ctivities of **T**eaching & **L**earning **A**ctive **S**trategies. Faculty have to teach at least one topic in every unit using active learning strategies in every subject and study their impact.
- **COTs** – **C**oncept **O**riented **T**utorial**s** were designed at analytical level (Bloom's level-4)
- Micro projects - Practising experiential learning.
- **COSHISS** – **C**onsortium **O**f **S**tudents **H**elping **I**mprove **S**peaking **S**kills

2. Teaching Methods:

(i) ATLAS – Activities of Teaching & Learning Active Strategies:

Active learning instructional strategies include a wide range of activities that share the common element of — "involving students in doing things and thinking about the things they are doing" (Bonwell & Eison 1991) .

At MLRIT, two faculty members from each branch of engineering underwent the IIEECP (IUCEE International Engineers Education Certification Program). The certified faculty members, in turn, trained the other faculty members, the strategies of active learning.

The faculty were asked to mention the obstacles which might stop them from using active learning strategies. Following are the most common concerns cited:

a. Syllabus completion in the given time might be effected.
b. It's difficult to implement active learning strategies in large classes (Size of 60 students).
c. Many of the faculty think of themselves as good lecturers, thereby they think that active learning strategies are not necessary.
d. Using active learning strategies involves risk of students failing in exams.

The faculty members were asked to teach at least one topic in every unit using active learning strategies in every subject and study the impact.

The challenges faced by faculty in implementing and the experience gained were recorded. This was compiled as a book (ATLAS) for the junior faculty to refer before implementing the activities.

Faculty have successfully overcome each of the major obstacles in the use of active learning strategies, and reduce the possibility of failure, by gradually incorporating teaching strategies that increase student activity level and also choosing an appropriate activity within the context of their discipline!

Fig:1 JIGSAW activity in progress

Though the classroom use of active learning strategies will always involve some level of risk yet the likelihood of success can be maximized by carefully selecting only those active learning strategies that are at a personally comfortable risk level.

Fig:2 Active learning strategies implemented

The impact of the active learning strategies was particularly measured and compared for 480 students. In six sections consisting of 60 students each, the activities were implemented and in other two sections traditional teaching method of chalk and talk only were used.

Pre/Post-Test Survey was conducted to assess student learning from the start of the course until the end. A pre-test survey was conducted across all the 480 students at the beginning of the semester to capture the extent of student knowledge and understanding about key course concepts they study in that semester. A follow-up post test at the end of the semester was conducted and the results were compared.

For each student who participated in all the activities, to evaluate the total change in learning after the implementation of active learning strategies, we calculated the total points obtained for each activity and converted them to a percentage (up to 100). Using these percentage scores we calculated a normalized change (c) value for each student. The normalized change value is the ratio of the observed change to the total possible change (Marx and Cummings 2007). Each individual c value was calculated as follows:

c = (post-pre)/(100-pre); if post > pre
c = (post-pre)/pre; if post < pre
c = 0; if post = pre
drop; if pre = post = 0 or 100

The value of c ranges between −1 and 1. A positive c value indicates a gain, a negative value indicates a loss and a zero value means no change.

With the individual c values for each student, we calculated the overall average normalized change (c_{ave}) for students.

On average, students learning improved within a single semester. While activities were administered to 360 students during the study period, we analyzed data from a total of 341 students who completed all activities over the course of a single semester. Total 246 students (72%) improved (positive c value).

(ii) **COTs** – **C**oncept **O**riented **T**utorial**s** to improve Higher Order Thinking Skills (Bloom's level- 4&5)

It is possible to identify, from both anecdotal sources and more defined evidence, that deficiencies continue to exist in the teaching of problem solving skills, and that the traditional model of teaching used in engineering education may not provide sufficient motivation for engineering undergraduates (Chu and Lai, 2002; Felder, 2006). It is also argued that engineering educators tend to focus on teaching content rather than method (Wankat and Oreovicz, 1992).

COTs activity was aimed at developing the critical and analytical skills where students are expected not only to understand what they read but also pick it apart, analyze, evaluate and assess.

We piloted the COTs in diverse classroom settings (e.g., different class sizes and student levels) in different courses. Following is a sample of the questions asked in the tutorials

Bridget surveyed the price of petrol at petrol stations in Cape Town and Durban.

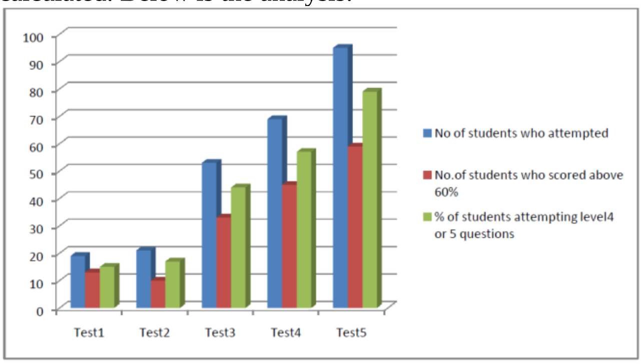
Cape Town	3,96	3,76	4,00	3,91	3,69	3,72
Durban	3,97	3,81	3,52	4,08	3,88	3,68

The data, in rands per litre, are given below.

1. Find the mean price in each city and then state which city has the lower mean.
2. Find the standard deviation of each city's prices.
3. Which city has the more consistently priced petrol? Give reasons for your answer.

Fig:3 Sample copy of Concept Oriented Question

The analysis was done in engineering physics subject where the COTs was implemented in two classes consisting of 60 students each. In the final exam, from every unit, one analytical question was asked and the percentage of students attempting and scoring above 60% marks was calculated. Below is the analysis:



	No of students who attempted	No. of students who scored above 60%	% of students attempting level 4 or 5 questions
Test1	19	13	15%
Test2	21	10	17%
Test3	53	33	44%
Test4	69	45	57%
Test5	95	59	79%

Fig 4: Statistics indicating the improvement of results

The nature of the problems, the grouping of students and the follow-up lectures are the major contributing factors that improved the students' performance.

(iii) Micro projects - a shift from "learning by listening to learning by doing"

The idea of micro projects was a subtle one. The aim of micro projects was to make a connection between activities and the underlying conceptual knowledge that students had to foster.

Ted Lewis (2007) declared that mathematics and science curricula alone might not be able to produce the kind of authentic representations that characterize and necessitate ill-defined and creative work (Ted Lewis , 2007)

Adapting university curriculum and instructor teaching styles may prevent the loss of struggling students who are intellectually capable of succeeding (Fazarro & Stevens, 2004).

In PBL the student role changes from "learning by listening to learning by doing" (Stauffacher et al., 2006).

Micro Projects are a small version of project based learning focussed on the application, and possibly the integration of previously acquired knowledge. Projects were carried out in small groups.

Students work in groups of 4-5 for the micro projects. Students choose a project from a list that the faculty has prepared. Each project group is assigned a faculty advisor. Faculty member supervise three to five project groups as well as teaching coursework in their specialty area.

Micro projects incorporated a good deal of student more autonomy, choice and responsibility than in the case of traditional instruction.

The use of project-based learning (micro project) as a key component of engineering programs should be promulgated as widely as possible, because it is very clear that any improvement in the existing lecture-centric programs would be welcomed by students and faculty alike.

Fig:5 Students participating in Micro Projects

(iv) **COSHISS** – **C**onsortium **O**f **S**tudents **H**elping **I**mprove **S**peaking **S**kills:

Emphasis of requiring strong communication abilities for engineering graduates has been shown in several studies across engineering disciplines (Milke, et al. 2013, Nicometo, et al. 2010). In fact, ABET curriculum requirements ensure that institutions teach those skills to their graduates .

Lack of opportunity for engineering students to practise communication skills is one of the weaknesses that can impact significantly on an engineer's communication skills.

There are shy students in every classroom. How do you help these students step out of their discomfort zones and participate in class, was the main idea for including seminar hours every week to improve oral communication skills. But it was observed that many students find seminar presentation is traumatic and used to skip the classes.

In an effort to help students overcome the trauma, an activity named COSHISS - pronounced as "koshish" (the hindi meaning of KOSHISH being TRY / EFFORT) was rolled out.

The entire class of 60 students is made into 3 batches, each consisting of 20 students. Again a group of 4 students was formed (from the 20 students group) and topics for presentation were declared in advance. The students had to ensure that every member of the team gives an oral presentation of the topic.

Students teaming up to share and ensure their team members present the topics revolve around a complex series of interactions between team members over a time and improves the skill of communication, apart from planning and team working.

Below is a sample copy of implementation of COSHISS.

TOPICS for COSHISS (Seminar presentation)

1. **Topic :** COSHISS
   Student1: What is happening to engineering graduates after they are graduating? Unemployability.
   Student2: What is the real cause – Is it lack of Technical skills or Language skills?
   Student3: What MLRIT was doing so far?
   Student4: The concept of COSHISS.

2. **Topic :** Demonetization policy
   Student1: What is Paper currency? Who and how it gets its value?.
   Student2: What is the real cause for demonetization?
   Student3: When and what happened during demonetization?
   Student4: What is e-transaction?

3. **Topic:** GST bill
   Student1: How was taxing system in India – Direct and Indirect taxes'
   Student2: Need for GST Legislation?
   Student3: What is CGST, SGST?
   Student4: Impact of GST - Positives and Negative.

4. **Topic**: Digital India
   Student1: When was Digital India Program launched and what is it?
   Student2: Services under digital India.
   Student3: Milestones achieved by Digital India Programme.
   Student4: Pros and cons of digitization.

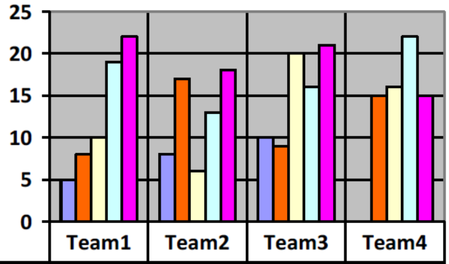
5. **Topic**: E-waste
   Student1: What is e-waste? Causes and Effects?
   Student2: The environmental impact of the processing of different electronic waste components
   Student3: Can e-waste be recycled? Methods.
   Student4: What can be done to reduce e-waste.

Fig 6: Sample copy of topics for COSHISS

The goal is to try and give them topics that make them feel that they are contributing to the seminar presentation and feel connected to other students encouraging them to interact with other students.

The assessment was done twice. Firstly each student was assessed for their individual presentation. Later 4 members were teamed and were asked to give a group presentation. The below graph along with the data indicates the improvement seen in all the 4 teams after COSHISS was implemented.

The COSHISS has encouraged and enhanced the interpersonal skills apart from improving the communication skills.



	Team1	Team2	Team3	Team4
Student 1 marks	5	8	10	0
Student 2 marks	8	17	9	15
Student 3 marks	10	6	20	16
Student 4 marks	19	13	16	22
Group marks	22	18	21	15

Fig:7 Statistics indicating improvement in the speaking skills

Conclusion:

Few students claimed to have felt under pressure during active learning classes but majority of the students claimed that these activities enabled them to analyse, search and think of different solutions.

It can be concluded that the activities encouraged the students to think out of box and stimulate thought process. In most of the cases we observed positive results. Even faculty were supportive of the idea of infusing active learning strategies into the teaching.

The COSHISS adapted in classes, was effective in terms of increasing communication skills and improved student participation. The paradigm shift in teaching methodologies facilitated the development of faculty in nurturing the skills of the students.

Curricular and assessment methods can be modified that encourage critical thinking, open ended problem solving and creativity, which are previously built around teacher-centered lecture rooms.

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