Shift towards student-centered learning in Engineering Physics Lab

-A case study.

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***Abstract*— Physics being the parent subject for many engineering branches, a strong foundation needs to be laid. We stress on a hands-on experience for our students in the Engineering Physics Laboratory in our college to get their basics right, so that, the underlying theory taught in the class room is better understood. Transformation from the traditional teacher centered approach of demonstration and explanation, to the student centered approach of learning and assimilation has successfully happened in our Engineering Physics Laboratory. Fresh entrants enrolled for the course volunteered to participate in a sample survey. The average effectiveness deduced from the survey favors the shift. The survey analysis and scope for further improvement are discussed in this paper.**

***Index Terms*—Student-centered, multimedia content, virtual lab, demonstration**

I. Introduction

Engineering education in India has undergone significant change in recent years, thanks to the influences of overseas demands and our ability to compete globally, in information technology and allied services market. It is imperative that we teach our budding engineers at the entrance level, to equip themselves to this change. The traditional method of demonstration was followed in our Physics laboratory, till last semester. The teacher played an active role of lecturing and imparting information about the experiments to the students. The students in turn, played passive roles as listeners. There were at least fifteen students crowding around instruments trying to learn what was being shown. The demonstration of all the experiments was carried out completely during the first contact hour, at the beginning of the semester. The syllabus consists of ten experiments and sequenced on a weekly basis as one experiment a week. There were instances when the teachers had to repeatedly demonstrate the experiments, as the students tended to forget it over a period of time. During the allotted two hours, teachers had to demonstrate, check and troubleshoot faults, grade the observation and evaluate the record books while continuously monitoring the students' performance and rating them. Thus there was a time constraint for any teacher to carry out the continuous internal evaluation more efficiently. To effectively address these constraints, we introduced a methodology which essentially consisted of multimedia content presentation in our Laboratory. In addition to this on-campus coaching, as flipped class room [1] pedagogy, the multimedia content was made available to students through virtual laboratory which the college website hosted.

II. Methodology

- The first cycle of experiments, consisting of a measurement laboratory and four experiments was recorded as multimedia content [2]. It contained the text from the Physics laboratory manual, still-images of instruments used for measurements, audio visual recording of procedure, the formulae, tabular columns and other information such as pitfalls to avoid in carrying out the experiment.
- Frugality was our watch-word. We used the camera in our mobile phones and free tools for video-taping the demonstration of experiments, without incurring any cost.
- The multimedia presentation was shown to all the students taking the course, in the laboratory during the first week, during their allotted lab hours.
- A part of the content was uploaded in the web site of the institution and was made available online, under the menu, virtual lab.
- Learning is not imitation or regurgitation. Hence, our students were given an introduction to an open ended experiment, design, creation and study, the

equipment availability and its scope of application as an audio visual presentation.

- The video files pertaining to the demonstration are made readily available in the PCs of Engineering Physics Lab for the students to view. Also the students are encouraged to go through the recording whenever they have any questions or doubts. Thus an asynchronous learning environment was created.
- A benchmark of any teaching learning process is a favorable feedback from the learners through any survey. We conducted one to find out the initial response of students and to iron out any teething problems or hiccups.

III. THE SURVEY METHOD AND OBJECTIVES

Objective: Our aim is to find out whether the student-centered learning introduced in Physics laboratory is
(i) Beneficial from the students' point of view,
(ii) Shifting towards their active learning,
(iii) Resulting in outcome based education.

Scope: The population, namely, the number of registered students for Physics cycle of course is about five hundred and eighty, every semester. The random sample consists of eighty two first year under- graduates registered for our course. Care was taken, while adopting the random sampling technique, that all types of students in the population were represented. The survey covered three batches of students, randomly selected from Electronics engineering from sections named F and G and Mechanical engineering from section named D, to quantify its success. Their opinion about the new pedagogical method was collected by means of questionnaires containing 10 questions.

Design: The questions were carefully chosen to find their feedback about clarity of the content, awareness of virtual lab, involvement in doing an open ended experiment, flexibility in their approach to learn the lab content, their idea of self-learning and active learning [3]. The data are tabulated and analyzed. The normal distribution pattern and the average effectiveness thus deduced, have encouraging values. The eight professors teaching the course with the lab as its integral part were also quizzed about the transformation. The students felt that they are into active learning while the teachers felt that there is enhancement in the performance of the students when compared to earlier semester. Their encouraging response was also a motivating factor for us as a go ahead.

IV. THE ADVANTAGES ENVISAGED

The advantages of student-centered approach to demonstration methods in the laboratory [4] were the key motivational factors for us to shift towards this new process. The following benefits were envisaged and the random sample survey conducted helped us to check the learning outcome of our lab course:

Better clarity: During traditional demonstration, a motley group of students crowded around the apparatus while a teacher explained about the experiment. This over-crowding sometimes led to misconception in the students' minds and lack of clarity about the procedure. In contrast, the multimedia presentation captivates the audience who are comfortably seated in the laboratory in front of the screen where the demonstration video is projected. When the demonstration is carried out with an audio visual aid, the students find it lucid, simple and understand the concepts better.

Addressing slow learners: The heterogeneous background of the students who enter the college at under graduate level makes our task of teaching very challenging. Some students are over confident while some of them feel diffident. Some are slow paced learners and yet another set are weak in their fundamentals. Conventional demonstration method was leveled at an average student. In contrast, our new teaching aid caters to every category of students. It is convenient for student as they can watch it at their leisure. Those who have difficulty in learning or understanding important concepts will have the opportunity to view the content repeatedly and learn it at their own pace.

Availability of content through the college web site: Anyone who wants to prepare in advance for conduction of experiment or anyone desirous of finding the application of the experiment in their own projects can do so by browsing through the online content. The ease of use of e-learning tool by budding engineers is also a main advantage.

Avoidance of errors: Mistakes often made by students can be pointed out in our presentation so that they need not have to learn them, the hard way. The don'ts if clearly spelt out in the audio visual demonstration will go long way in avoiding errors. Otherwise this would be very subjective of the individual demonstrator.

Open-ended Experiment (OEE): An open-ended Experiment is optional for the first year under-graduates. As the course is very rigorous and 14 weeks of time allotted for the Physics Lab at the rate of two periods per week is insufficient for teaching an open ended experiment not to mention the fact that it becomes a burden on the teachers. There are motivated students who are eager to perform those experiments and can manage doing them during the semester. Our teaching aid helps them to channelize their efforts into performing one. In their higher semesters, when they start learning their core engineering subjects, our open ended experiments will help them to grasp the concepts better.

Learning curve can be made steeper: Any active learning method has its edge over passive listening and our expectation to make the learning curve steeper can be met.
Increased evaluation time for the teacher: As the role of teacher has become only that of a facilitator, the time for evaluating every student has enhanced, making the continuous evaluation process better.
Benefit to a larger population: The virtual laboratory is a boon to any student, who yearns for more knowledge in fundamentals. It is not restricted to just first year under graduates.

V. Discussion

Freshly commencing students enter our college with a lot of enthusiasm about fulfilling their dreams. If the course has deep approach in it, then a meaningful learning happens. As a first step towards this, the students' response to the multimedia presentation was very rewarding. Over eighty percent of the students were in favor of visual media, reinforcing our opinion that engineering student are visual learners than verbal learners. They also liked to recommend the online content to their colleagues studying in other colleges. The fig (1) is a bar diagram which shows the number of students preferring the multimedia manual over conventional method and wanting to recommend it to their counterparts in other colleges.

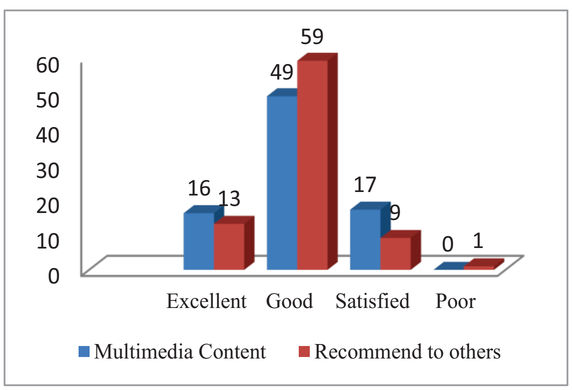
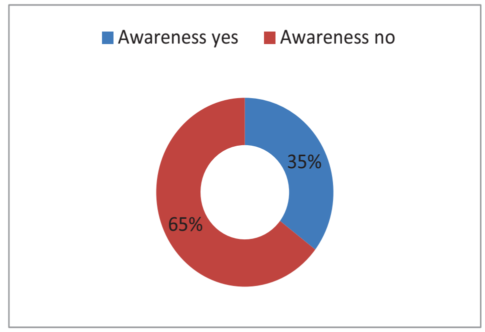


Fig (1): Response to Multimedia presentation

Statement	Mean	Median	Mode	Variance
Flexibility	69.21	68	66.54	198.91
Active learning	65.55	67	63.86	251.43
OEE	62.2	62	63	434.36

Fig(2): Normal distribution parameters.



Fig(3): Awareness of virtual lab.

Learners vary in terms of learning style, background, prior knowledge, motivation levels and their confidence or the lack of it. Their conviction about flexibility and convenience, active learning, their impulsive response against self-learning together with their enthusiasm to perform open ended experiments followed a normal distribution curve, with the central tendencies, mean, median and mode coinciding. The standard deviation, variance and coefficient of deviations are analyzed and tabulated, in fig. (2), considering these uni-variate data.

The students' awareness about the virtual lab was lacking as the link which our college web site hosted became functional only a week prior to the survey process. Fig (3) depicts the percentage of students' knowledge about the virtual laboratory as only about 35%. We sincerely hope that the awareness will spread and more students benefit from the virtual lab [5]. Flexibility to the ever-changing technological environment and appreciation of the deep approach are the desired characteristics of the students and the teachers [6]. The pace of slow learners and fast learners are different and there is no way of identifying it, in a conventional method. In our new pedagogical approach, we were successful in finding out how many slow learners watched the video repeatedly till they understood and were satisfied. They have given a positive feedback about the convenience with respect to time and pace.

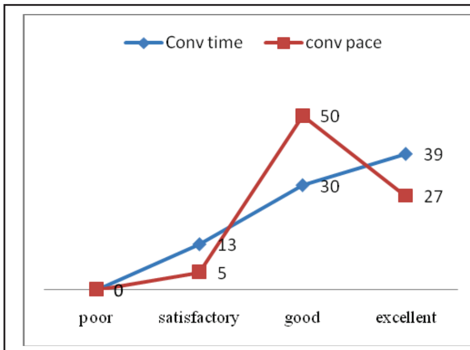


Fig (4): Advantages of Multimedia presentation.

Fig (4) shows the number of students who are able to appreciate the advantages of the audio visual learning tool. 80-90 % of the students categorized this e-learning method as good or excellent. Our first baby step towards technology assisted pedagogy has a heartening response among student community and it can only become bigger and stronger.

The use of any e-learning material can only be warranted by its application. It also opens many avenues towards meaningful learning and ways to improve its quality. The video presentation about the open ended experiment was shown to the students. It contained guidelines like defining the content, establishing objective, reading and building foundation, taking the facilitator's guidance, time management, and finally communicating what has been learnt by them by way of a report.
All the active learners, belonging to sections named D,F and G consisting of mainly the electronics engineering and mechanical engineering students like to do open ended experiments as the fig(5) explicitly shows. They have indicated a desire to perform open ended experiment and we are planning to call the students during the holidays and facilitate them in this regard.

To test the level of enthusiasm among student community for doing open ended experiment, one tailed test was conducted and the null hypothesis that, "about 50 % liked to learn open ended experiment", was rejected as the test statistic calculated is more than the critical value at 1% level of significance. Right tailed test allowed us to feel happy about the fact that majority of our students, about 56% are active learners.

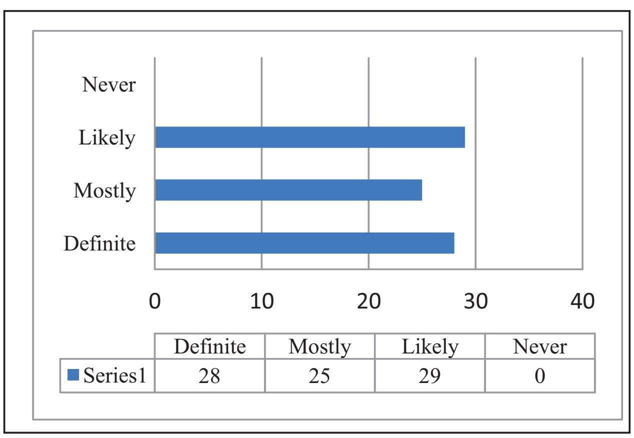


Fig (5): Enthusiasm towards Open ended Experiments

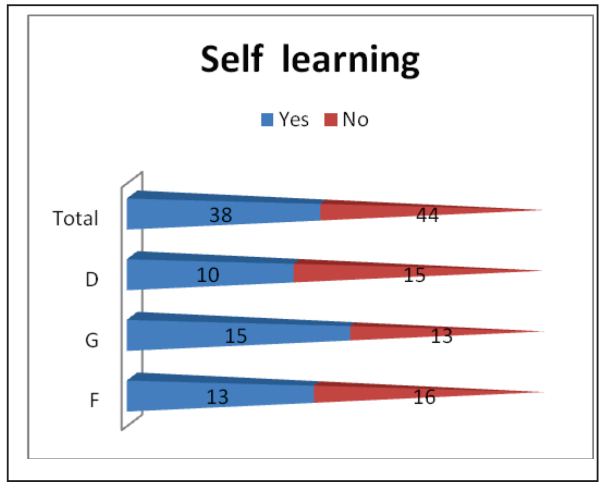


Fig (6): Fraction of students against self-learning.

The six levels for learning outcome based on Bloom's taxonomy [7] contrasts the long term deep approach to short term surface approach. It is but natural that the students being just out of school atmosphere did not favor self-learning. The university education has the professors playing the role of facilitators. It only reinforces the traditional practice of teaching-assisted learning.

A one-tailed test with a large sample size was done to check how popular the concept of active learning among the first year engineering students is. The test statistic calculated is more than the critical value 2.33 in the critical region, at 1% level of significance. This right tailed test allowed us to conclude that more than 61% of students felt they benefited from active learning.

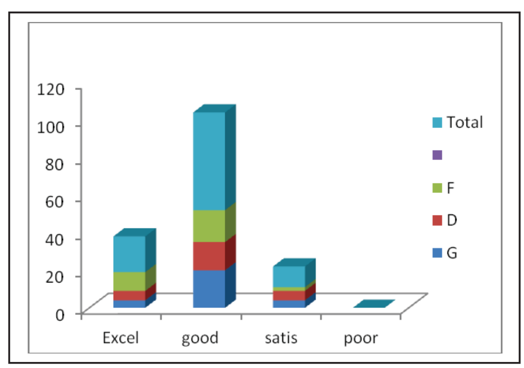


Fig (7): No. of students opting to active learning.

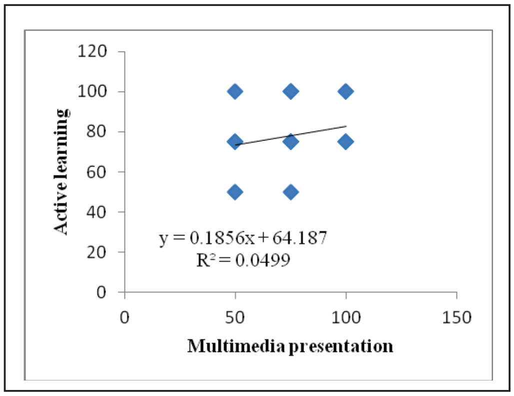


Fig (8): Positive correlation between Lab & active learning.

To be intelligent is to be open-minded, active, memorised and persistently experimental. In this sense, the level of active learning confessed by the students is grouped batch wise in the three sections, D, G, F and consolidated as total. The stratified bar chart in fig (7) measures the success rate. In all the three sections F,G and D, the number of students rating active learning as "good" are more than any other category.

The degree of causative relationship between the active learning and their liking of multimedia presentation about the open ended experiment is found out and the positive correlation coefficient is 0.23 as predicted by the graph given in fig(8).

VI Scope

A small step taken toward the student-centred approach [8] has opened numerous avenues for us. Firstly, there is scope to improve the content by incorporating the theory on which the experiments are based. As the lab course is integrated with the theory taught in the class room, student satisfaction can be better if they understand the physical phenomenon involved, its type, the working principle, derivation of the formula used and such. Secondly, the students' involvement can be enhanced by adding their content about the open ended experiment in the virtual lab. Attentions of the students have been caught, but we need to work towards building their confidence, realising the relevance of OEE, doing it and getting the sense of accomplishment. This will sustain their interest in the course. Thirdly, we can improve student-faculty interaction by introducing forum and creating threads to address their issues. In short, it can function like any open online courseware.

VII Conclusion

Our laboratory course in its new form has caught the learner's interest. The students categorically vouched for its benefits through the survey conducted. The multimedia presentation aided them in their initial step towards active learning and bridged the gap between passive pre-university education and the active approach in university education and evened their path to a smooth road towards their desired goal. We are hopeful of a favorable learning outcome after their lab assessments and exam results to quantify it. It has enormous scope for us, the facilitators, to take this pedagogical approach to a higher plane towards realizing personal gratification.

Acknowledgment

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