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# Redefining Quality in Engineering Education through the Flipped Classroom Model

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**Abstract**

The students in engineering institutes are expected to be tech-savvy and have an appetite for technology-based learning. Sadly, most of the courses in the current Indian engineering education scenario are taught using straight lectures where students are made to play a passive role while the teacher takes the center stage. The need of the hour is to get the students out of this passive mode of learning and bring them to the forefront in the teaching-learning cycle. Most often than not, teachers utilize the class time teaching technical intricacies that are crucial to solving problems which leave very little time to do anything else. Hence, the onus falls on the students to apply the learning in the class to solve problems on their own outside the classroom which is far from ideal. The flipped class is a model wherein much of the technical content is delivered outside the classroom via a virtual platform which in turn makes the classroom a congenial place for discussions, problem-solving and promoting active learning in the presence of the teacher. Through this paper, a study has been conducted to bring in this modern technology into engineering education. The objective is to analyze the power of technology in teaching courses that require significant work beyond class hours.

The flipped classroom model was applied on 32 final year Post Graduate students through the Android Mobile Application Development course. A fundamental topic was chosen that forms the base to build sophisticated Android Apps. Since it was very difficult to grasp the topic at one go, the class was flipped so that the students get ample time to go through the learning resources and come well prepared for the class. To begin with, the students were given the task of going through a lecture video from one of the NPTEL courses on Modern Application Development. However, the video shared was 22 minutes long and to simplify the learning experiences of students, a 3-minute Introductory video on the course content was shot and posted on the course website so that the students could first go through it before going into the actual learning material. During the lecture hour, an active learning strategy based on In-Class Teams was leveraged to drive home learning.

Practicing a disruptive tool like the flipped classroom model shifts the focus from the teacher to the students and assists in restoring the balance. By flipping the class, the students are expected to go through learning material employing self-study and then come prepared for the deliberations in the class. As students go through the gist of the course content in advance, it becomes

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easy for the teacher to turn into a facilitator and assist in students learning during the lecture hours. Through the assessment of student's interaction, preferences, and performance, the results of this study show that the students learn a whole lot better when technology is harnessed as opposed to the traditional classroom lectures.



*Keywords:* Engineering Education; Power of Technology; Flipped Classroom; Active Learning

## 1. Introduction

In an era of technological outburst, the methods of providing education, especially engineering education, to present and future generations need to be changed dramatically to make engineering graduates ready to tackle the challenges posed by a world which promotes rapidly accelerating changes.

The nagging question in front of all researchers in the field of engineering education is to find suitable measures to offer education to the millennial learners of today in a cost-effective and time-efficient manner. While some institutions have been able to provide a breakthrough in this area by bringing in digital tools into the classroom which leads to the promotion of hybrid mode of instruction that amalgamates in-class methodologies with learning on the go. However, extensive usage of digital technologies in engineering education teaching [1], a place where it could be considered inseparable, has evolved rather insipidly.

Most often than not, educational ecosystems that let students get highly actively involved with the learning course materials are most likely to have a telling impact in terms of the learning gains of the students. The existing research in the field of engineering education domain has proven that any teacher who practices active learning strategies to drive home learning tends to attain better results as opposed to traditional classroom-based lectures [2]. This encourages faculty members to design lecture materials that require students to get more actively involved in the classroom.

The main intention of this paper is to provide evidence-based recommendations to teachers having an affinity towards leveraging the flipped classroom model [3]. The recommendations provided are based on both the evidence gathered from the literature and pragmatic indications from a case study conducted by the authors. To begin with, the paper provides an understanding of the flipped classroom model followed by a literature review on its impact on the scenario of engineering education. In addition to it, an experimental case study showing the implications of using flipped class on a set of PG students has been discussed. The course in discussion progressed from a traditional lecture-based model through to the flipped class mode and that too multiple versions of it. The variations between these versions of the flipped classroom were limiting the length of the video and trying out a different activity in the classroom. Brief descriptions of each of the strategies are provided which includes the things the students were expected to do outside the classroom, the activities conducted during the lecture hours and the evaluation methodologies adopted which resulted in students being prepared for in-class interventions. The assessment of the flipped classroom was done by means of surveys at the end of the experiment. Based on the data gathered through the implementation of multiple versions of flipping the class, some plans are made available to teachers who are looking forward to using active learning methodologies in their own classroom by harnessing the power of technology [4].

## 2. Background and Literature Review

In the traditional classroom, the teacher is the sole source of information and was famously termed as "sage on the stage" [5]. In this mode which is considered the most passive form of classroom, apart from the continuous lecture, there is absolutely no interaction between the teacher and the student. As shown in Fig 1, in such a classroom, information largely percolates from the teacher to the student. Although active learning strategies may be brought into the classroom to boost classroom interaction by means of trivial activities like think-pair-share which allow the students to discuss with their mates, most of the teacher's resist using these strategies owing to the noise that it could create in the classroom and the time it would take from their typical lecture hour.

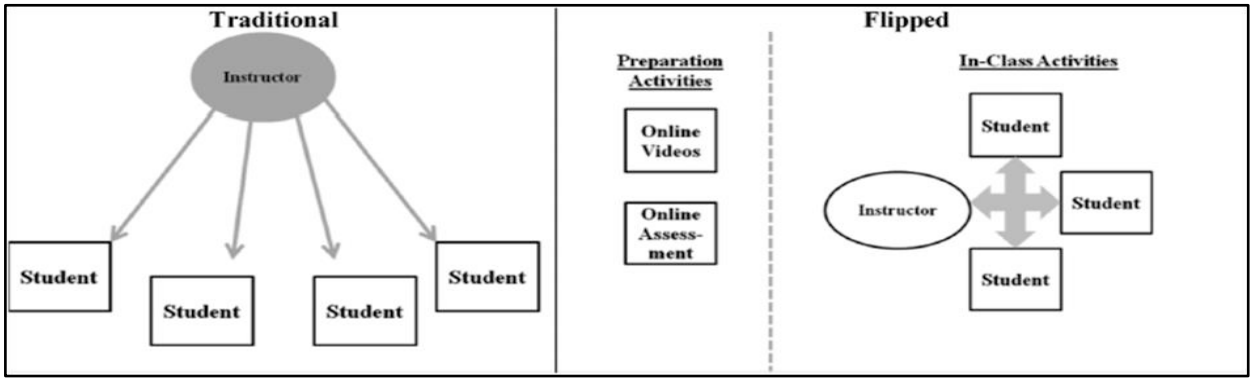


Fig. 1. Traditional vs Flipped Classroom

The right-hand side portion of Fig 1 depicts the flipped classroom model. In this approach, the students are expected to gain technical expertise by going through the online resources and complete online assessments which makes sure that the students are ready to actively take part in classroom deliberations. The activities to be conducted in the classroom may include solving nontrivial problems, discussions, brainstorming, design work and many more. Students are required to work collaboratively with their peers to perform the in-class activities while the teacher acts as a guide lending a helping hand in case of any difficulties. In cases where several students have similar problems, the teacher can then turn the attention of all students by discussing content pertaining to the common stumbling block, by making use of just-in-time teaching [6]. In all cases that involve flipping the classroom, the teacher becomes a facilitator instead of the so-called "sage on the stage". According to Baker [7], who was one of the pioneers in the work related to this area, the teacher must be a "guide on the side". Fig 2 lists out a set of characteristics of the conventional lecture approach as well as flipped classroom and provides a comparison between the two.

| Course characteristics | Traditional Lecture | Flipped |
|---|---|---|
| *Role of instructor during class* | Information provider | Guide |
| *Role of student during class* | Information recipient | Active participant in class |
| *Out-of-class activities* | Solving problems, reading textbook, projects, preparing for quizzes/exams | Watch online lecture or read assigned material (before class), complete problem sets & preparing for quizzes/ exams (after class) |
| *In-class activities* | Instructor-led lecture | Varies (i.e. problem solving, projects, discussion, brainstorming, field trips) |
| *Role of assessment* | Primarily summative in nature | Formative "gate checks" to ensure preparedness; Both formative and summative assessment |

Fig. 2. Comparison of traditional lecture and flipped classroom in engineering.

Chi [8] through his studies has proven the fact that the learning amongst students tends to grow manifolds as the instructional method shifts from passive to active, in which the students somehow find multiple ways to get involved in the activity and from active to constructive, in which students are expected to deliver novel outcomes that go way beyond the theoretical knowledge that gets presented to them during the classroom lectures. In his analysis of large samples of science students, Hake [9] discovered the fact that students who get to participate in more of active learning methodologies in the classroom made larger gains on any particular topic as opposed to students who undergo more of a traditional classroom delivery, advocating that the instructional methods indeed has an impact on the problem-solving skills of the students. Prince [10] conducted experiments to analyze the impact of active learning strategies and found that usage of substantial amount of active learning in the classroom results in an upswing in the learning abilities of students.

Entwistle and Peterson [11] in their study, came up with an abstract structure that highlights the things that impact students learning. Out of all the factors that have an influence on the learning of students, one major factor was found to be the teaching-learning ecosystem that included the way in which teachers organize and present the course content in addition to how the classroom structure itself is designed. In one of the early literature, Entwistle [12] points out the fact that teacher-centered and syllabi-oriented perspectives to teaching which invariably aim at getting the information transmitted from teacher to student are highly likely to end up in students getting a limited understanding of the concepts taught. On the contrary, student-centered approaches to teaching where the teacher must play the role of a facilitator are likely to lead to students getting deeper insights into the concepts learned and contribute to lifelong learning of students.

Although most of the teachers do understand the benefits of the teaching-learning process that is student-centered, the reluctance among some of the teachers is quite evident when it comes to the actual delivery of concepts in the classroom. As Michael [13] discovered, one of the key misconceptions that teachers normally tend to carry is the fact that active learning requires a lot of class time due to which the coverage of the syllabus takes a hit, which is the most popular myth among teachers of engineering institutes.

The flipped classroom model generally involves flipping or reversing of the activities that are conventionally performed in class and outside the class. What it implies is rather than passively listening to lectures in the classroom, learners are expected to complete a set of preparatory work outside of the classroom, either at home or in the class itself during their free time. This preparatory work is usually in the form of an online or virtual resource that has been identified by the course teacher. Since the preparatory work is expected to happen outside the classroom [14], the lecture time in the classroom can be utilized by the teacher to mentor the students learning. The teacher is expected to lead the discussions in the classroom when the students collaborate in completing the set of activities assigned for a lecture hour.

The pilot work on the model of flipping the classroom was taken up by Lage and colleagues [15-16] which resulted in the invention of the famous catchphrase “inverted classroom”. Then onwards this methodology has blossomed to a great extent in both higher education [17-18] and engineering education.

In one of the initial experimentations of flipping the class, the teacher used a semi-technical variety of the method to allocate pre-class exercises and homework in an Electrical Engineering discipline [19]. The study was followed up by another set of teachers who experimented with a flipped classroom in order to teach a Software Engineering [20-21]. Soon after, a study was proposed that described the methodology to flip only a certain portion of the class [22-23]. This study ended up with the collection of data on the ways in which students utilize the shared video resources and the students take on the flipped classroom model.

Dollar, Steif and Ulseth [24] tried their hands at making use of the flipped classroom to teach Statistics by using an online system comprising of simulations and virtual laboratories that promote interactive learning.

## 3. Methodology

The case study was developed over the course of a semester in one of the Post Graduate programs in Computer Applications. The classroom was flipped multiple times during the semester and a study was conducted to analyze the flipping of the classroom.

The course that was chosen to implement the flipped classroom was Mobile Applications. As it is, the development of Mobile Applications is a technical and creative job; to add to it, flipping the classroom added more tech-savvy flavor to the already practical course.

Although much of the success of flipping the classroom could be attributed to the implementation, properly planning the classroom flip was also one of the most crucial factors. A lot of thought had to be given to zero in on topics to be chosen while flipping the class and resources to be made available for the students to go through.

### *3.1 Participants*

The participants chosen for this study were 32 full-time students pursuing the final year of their studies in the Post Graduate department in Computer Applications. Two teachers of the same department dealing with the course donned the role of facilitators during discussions.

### *3.2 Study Design*

In order to facilitate disruptions in student learning, the flipped classroom model was implemented 10 times out of a total of 45 classroom lectures which were delivered throughout the semester. Since the course was all about the development of Mobile Applications using Android, a basic concept was chosen in which the students had to develop user interfaces for a simple Mobile App. As the topic was slightly time-consuming to understand within one lecture hour, the flipped class model was brought in which would provide a considerable amount of time to students to go through the resources shared and participate in the classroom deliberations. The resources were shared using Canvas which is one of the widely used online Learning Management Systems.

During the first classroom flip, to assist students in learning, a lecture video from one of the NPTEL courses on Modern Application Development was shared on Canvas. Since the video resource shared was 22 minutes long which is slightly on the higher side, a 3-minute introductory video was shot and was shared with the students. The introductory video was developed in such a way that it would provide guidelines to the students on the usage of NPTEL video. The students were asked to go through the introductory video before the NPTEL video so that they could focus specifically on those parts of the video which would help them learn the course content better. During the class hour, an In-Class active learning strategy was utilized to facilitate students learning.

It was observed that the duration of the video resource shared on the LMS plays an important role in the implementation of the flipped classroom. To study the impact of the length and quality of the shared resources, the classroom was flipped 9 more times during the semester. Each time the length of the video resource was varied, and introductory videos were shot to supplement the video resource. There were even a couple of instances when video resources were shared without an introductory video.

In each of the instances, during the physical lecture hour, the classroom was made as dynamic as possible by dividing the students to form In-Class Teams and have brainstorming sessions to drive home learning out of each classroom flip.

### *3.3 Team Formation*

Since the class strength was 32, teams of 4 members each were formed during every classroom flip. One of the team formation strategy followed was to divide the students into 8 teams of 4 students each (8*4=32) wherein:

- The teams would be chosen according to their University Seat Numbers (USN), sequentially. USN's 1-4 go into Team 1, USN's 5-8 to Team 2 and so on.
- The students would be made to sit according to their teams.

### 3.4 Data Analysis

During each implementation of the classroom flip, data was gathered with regards to the participation of students in discussions. The participation component included the student's participation on Canvas and during the lecture hour.

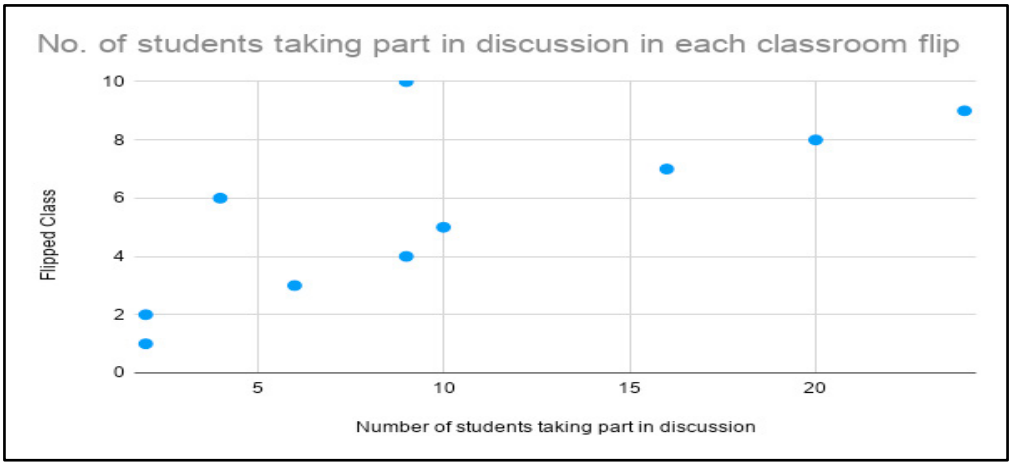


Fig. 3. Progression of student's participation during each classroom flip

As Fig 3 depicts, the participation was on the lower side during the first couple of occasions when the classroom was flipped. As it was later pointed out by students, the low participation was largely due to the newness of the flipped classroom model. Since they had never experienced it before, it took a while for them to realize the modalities of the classroom flip. Another factor impacting the participation of the students was the size of the video lecture. Since the length of the NPTEL video resource was on the longer side, most of the students ended up viewing only the 3-minute introductory video. As students became familiar with the flipped classroom, there was a gradual increase in the participation of the students as shown in Fig 3. The aberrations were due to the internal tests and festivities which impacted the participation on a couple of instances.

In order to gain clarity on the impact of bringing in technology to the classroom, a couple of classroom flips were assessed at the end of the lecture hour. As can be seen in Fig 4, the performances in assessment 2 were better than that of assessment 1. This is largely because the students got acquainted with the flipped classroom model the second time around and therefore performed better than the first time.

| I Assessment Marks | II Assessment Marks | Total Marks |
|---|---|---|
| 2 | 6 | 10 |
| 3 | 3 | 10 |
| 4 | 9 | 10 |
| 3 | 9 | 10 |
| 2 | 9 | 10 |
| 6 | 5 | 10 |
| 5 | 8 | 10 |
| 6 | 6 | 10 |

Fig. 4. Comparison of student's performances over multiple assessments

## 4. Results and Discussion

The primary aim of adopting the flipped class model to deliver a course was to ensure that the students are kept active through the course of a class. By employing a method that moves the lecture time out of the classroom, the duration of class time may be utilized to conduct several activities that would keep the students engaged. This study was conducted with a vision of discovering the preferences of students about the implementation of the flipped classroom. As the study went along, it was discovered that the refinements made to the implementation in terms of customizing and shortening the length of the video resources as well as varying the in-class activities result in positive feedback from the students [25].

As more and more classes were flipped, most of the students started to view the video resources shared, thereby obtaining the technical know-how required to learn the course. Since the videos were available on Canvas, the students could watch them any number of times until they cleared up their misunderstandings. Most of the students even admitted that they re-watched videos since they were distracted, the first time they watched it. Some of the comments from the students showed that they found the flipped environment quite easy to clear their doubts which could be an uncomfortable business in a traditional setting.

It was also discovered that students prefer to utilize class time to interact with peers and solve problems instead of listening to straight lectures. This gave them the opportunity to learn technical content on their own at their own space [26] which would mean they would be ready to take part in deliberations during the class hours.

The analysis performed on the data gathered indicated the trend in the participation and performances of the students during the classroom flips. As the semester progressed and more classes were flipped, the students gradually got into the groove. The participation of students, both online and offline, increased with the number of classroom flips. Similarly, the performances of the students were found to be better in the second assessment due to the familiarity factor [27].

Further, to gauge the student's impression on the execution of the flipped model, a survey was conducted towards the fag end of the semester. The students were asked to rate both the traditional classroom approach and the flipped approach to teaching. As the graph depicted in Fig 5 shows, the students rated the flipped approach higher than the traditional classroom. Even the feedback given at the end of the semester gave an indication of students liking towards the flipped classroom model.

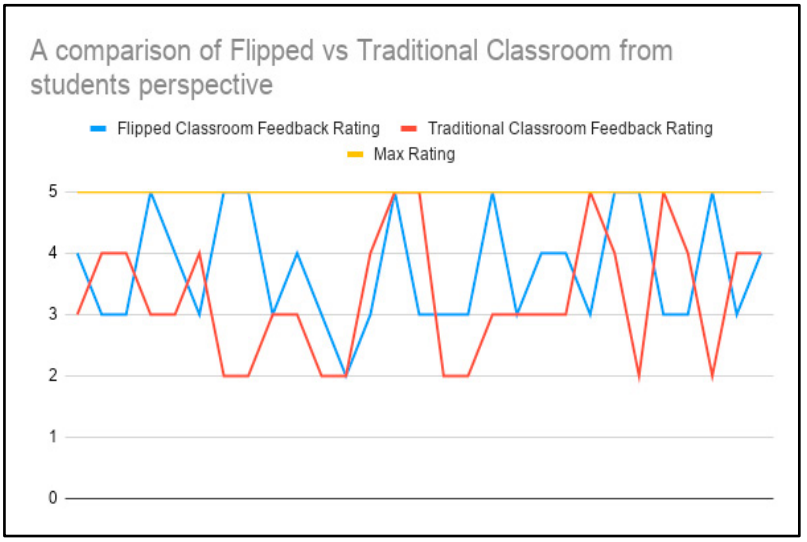


Fig. 5. Comparison of flipped vs traditional classroom from the student's perspective

## 5. Conclusion

Typically, the teachers associated with engineering education face two specific challenges while dealing with any course that they teach. The first challenge is to have a coverage of course content that is good enough for the students to prepare for the term-end examinations. Secondly, the teacher is also expected to make the classroom active enough so that the students could interact with their peers about the technical content learned and be able to apply their learning in the real world. Unfortunately, most often than not, both the above challenges are found to be mutually exclusive wherein the lecture time is to be utilized to cover the course content which in return, leaves the students to comprehend the learning on their own.

An ideal way of dealing with this deadlock situation is to have the students acquire the learning resources through a virtual mode, which would then allow the teacher to make use of the lecture time to let the students discuss and apply the learnings. The analysis shown in the paper clearly indicates the students prefer operating in the flipped mode as it provides them the flexibility to acquire new technical acumen on their own time while getting an opportunity to interact with peers and teachers during the lecture time. The study points out that flipping the class allows students to turn into active learners with the help of a variety of activities that could be performed in the physical classroom. The flipped classroom also allows the teachers to have flexibility in delivering their courses. The teachers get the freedom to carefully examine their course objectives and design in-class activities that best suit their needs on a case to case basis.

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