Flipped Classroom for Developing Higher Order Thinking Skills.

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***Abstract*— An objective of engineering education is to develop higher order thinking skills in students. This helps to improvise, innovate, design and develop product and services useful to the humanity.**

The traditional classroom teaching has little scope in developing these skills as major class time is spent in explaining topics which the student is listening for the first time. As there is hardly any change in the fundamentals of a subject, the teacher has to more or less repeat the same material to new students year after year.

With the advent of digital learning it is now possible for the teacher to create content in digital format and make it available to students before they come to the class. With the help of software the teacher observes the progress of students and knows which part of the topic is not understood by the students and plans accordingly to discuss the same in class.

In the classroom teacher conducts group discussions, role plays, assignments, innovative challenges in order to develop higher order thinking skills. This form of learning is termed as Flipped Classroom.

Keywords—flipped classroom, thinking skills, digital learning

I. FLIPPED CLASSROOM

Flipped Classroom changes the way traditional teaching and learning is conducted. In this model, teacher takes a different approach in which student gets first exposed to digital learning in the form of e-books, e-notes, presentations, mind maps, video lectures, films, animations, MOOCs or regular books on the topic prior to coming into the classroom

and the classroom or lab time is focused on processing this learning. In this mode, primary focus of the classroom or lab time is to assimilate, synthesize, analyze, apply, design and develop this knowledge with the help of their peers and teacher.

Barme [1], Berrett [2], and others have highlighted the importance of flipped classroom in improving student learning skills. Andrew Churches [3] in Bloom's Digital Taxonomy has illustrated the use of software tools to facilitate learning.

Bishop and Verleger [4] are of the opinion that active approaches like discussions, exercises, problem based learning (PBL), case based learning, practical work, peer learning etc. are more in-line with students centred pedagogies. Students are initially reluctant for this new method but after experiencing, they prefer it over the traditional lectures.

Day and Foley [5] have reported that there is a positive impact on students' attainment and studies show that grades have increased.

Scheel [6] has emphasised the importance of explaining to the students the need of flipped learning and why one should adopt this method of learning.

Many other researchers have shown the benefit of Flipped classroom. The authors feel that the campus can be transformed into a place of innovation, creation and critical evaluation if it adopts and follows Flipped classroom learning.

II. Challenges Faced by Traditional Model of Classroom

A. Challenge I

The amount of time students get to actively engage in peer interaction, interact with the teachers and get iterative and timely feedback for learning is very precious. Typically, this precious time is spent in doing things which can be more efficiently done outside the classroom, e.g.: reading from a textbook, watching a video, listening to a prepared lecture, etc. By taking this aspect of teaching outside of the classroom, there is an opportunity to address other challenges typically teachers face with regards to teaching a multi-paced class and adjusting to varying learning styles in a class. Some students may not understand the material in their first attempt, but may require multiple attempts to read, watch or listen to the instructional materials.

B. Challenge II

It is very difficult for teachers to efficiently gauge in a classroom the level of comprehension and understanding of the basic concepts taught via the instructional materials. Typically most of the class or lab time is spent in delivering the information validating student's comprehension in an ad-hoc manner and re-delivering the same content if it is not understood well.

This leaves hardly any time in the classroom and lab to focus on the higher level of learning of a subject, where students get an opportunity to process the basic facts and knowledge, putting this knowledge in a proper context, apply this knowledge to solve complex problems and eventually design or build or create something new. Traditionally this aspect of learning is left for students to do on their own via homework or assignments or projects, with very little opportunity for them to discuss debate, make mistakes, get feedback, correct mistakes, retry, and learn from each other in the classroom or lab.

This perpetuates a problem where teachers are frustrated, students feel helpless, assessments are used to filter and rank students rather than using them as an effective tool for gathering specific evidence of learning tied to the learning objectives, course outcomes and associated program outcomes.

The main challenge institutes and teachers face to develop higher order thinking skills as most of the effort is spent in the classroom accomplishing the lower order thinking skills of students i.e. remember and understand key concepts. This leaves very little time for the students to acquire higher levels of skills required by the industry where students are expected to apply, analyze, evaluate and create, rather than just recite what they know.

III. Flipped Classroom Requirements

A. Empower students to have access to topics in digital or print form.

The teacher lists or creates digital and or print content related to the topic to be discussed in the class and uploads on the institute server or cloud. It may be in the form of e-books, e-notes, presentations, self videos, videos from other universities sites that will enrich the understanding of the topic. Software monitors the content accessed by students and also assesses the understanding level of the student.

It is important to present the first exposure learning content in such a way that it is engaging, and encourages the students to spend their time to review the information before coming to class.

B. Encourage students to come prepared for the class.

Proper mechanism should be in place to make sure this effort is taken by students before coming to the class or a lab. Typically this is done by tracking their activity and having students submit evidence of their attempts to learn and demonstrate their level of success in accomplishing the learning goals. Some portion of the internal assessment is typically tied to this activity which impacts student's grades and thus motivates them to invest their time in this activity.

C. Use of efficient assessment tools to measure students' learning before the class begins.

Telling students to review material on their own, and engaging in the classrooms to perform high level of learning does not work well unless there is a mechanism to ensure that certain level of learning has taken place before coming to the class. If there are areas which are not well understood by the majority of the class, teachers get an opportunity to focus on the common misconceptions before starting the higher level of learning activity to apply the knowledge they have learnt.

Having efficient assessment tools to gather evidences of learning and quickly identify the gaps which need to be filled before proceeding further is an important aspect for making flipped classroom model successful.

D. Dedicated Faculty that is ready to adapt the change.

As per Lenz's Law any system resists change. This applies to the traditional teaching learning process. In order to adopt the flipped classroom concept faculty plays a key role. Unless the faculty is ready to accept the change then only the system will work. It is observed that the young generation uses mobiles, tabs, computers etc. with ease. However, some teachers sometimes are not comfortable with these modern tools. Creation of digital content also requires great effort and the process is slow. Tech savvy professors have created digital content and put on internet through MOOCs. Faculty need to carefully compile the material as per the requirement of the curriculum and the gaps or improvised version can be created by them.

Dedicated faculty can bring out the higher order thinking skills of students.

E. Developing Higher order Thinking Skills.

Most of the classroom and lab time should be spent by students to engage in active learning, interacting with their peers and teachers to use the knowledge and analyze, synthesize, apply their knowledge to evaluate, build, design and create new things.

IV. Using Software for Flipped Classroom

Well designed software can help institutes to implement the model of flipped classroom effectively.

The software should be accessible to teachers, students and administrators from any place, at any time, from any device, using any of the industry standard browsers.

Teachers can clearly define course outcomes, instructional materials and lesson contents required to accomplish these course outcomes.

As per the academic calendar, the software should help the teachers to enable a portion of the lesson content for assessment before the class. Lesson content can be their own content or the contents which teachers consider most appropriate to accomplish the learning objectives. Teachers can link to the open educational resources on the net, uploading the learning contents ranging from PDFs to videos with voice-over to sites with simulations and animations which explain the concepts (Fig.1).

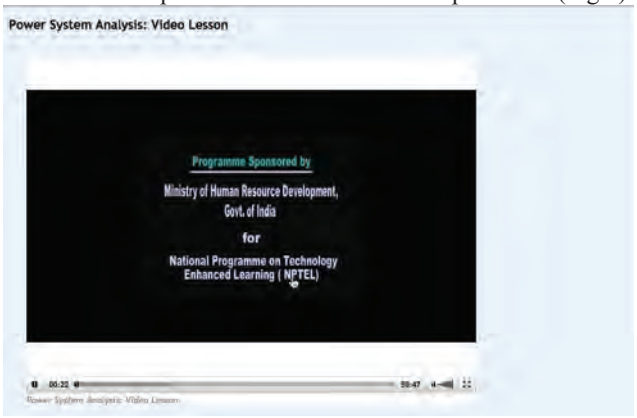

Fig. 1 Video posted on YouTube (NPTEL)

Students have the opportunity to discuss around this content, and teachers can moderate this discussion even before coming to the class.

Monitoring can be done by overlay quizzes on top of the video content which can be paused at a certain pre-defined point and seek engagement from the student before proceeding further (Fig. 2). This increases student involvement with the

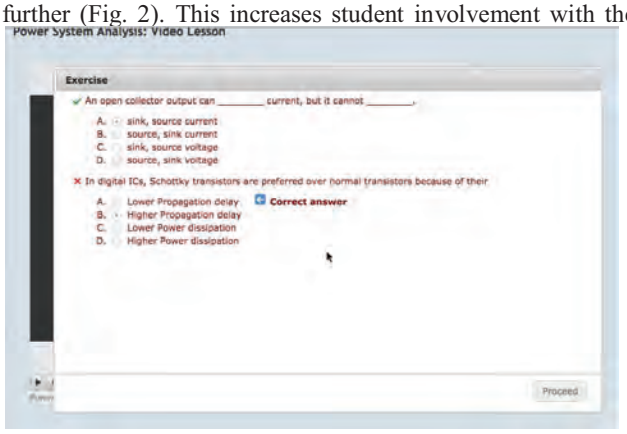

Fig 2.Example of an Overlay Quiz.

content, and also gets powerful analytics back to the teacher to evaluate the level of understanding while watching the video content. Teachers can view a report to see which students have watched the video content and gauge their level of understanding demonstrated before they come to the class (Fig. 3).

Fig 3. Performance of students before attending class.

Assessments are linked to the relevant lesson content to get deeper insights into the level of student understanding, and more importantly, quickly identify common misconceptions they may have, before they come to the class.

Once students go over the pre-class learning content and do the assessments linked to this content, classrooms or labs can engage in face to face interactions to cultivate higher level of thinking and design, build or create new things.

In many cases, students can be split into smaller groups to work as teams and engage for some period of time doing projects. Software makes it easy for the teachers to create virtual pods of students as project teams and allow them to continue their collaboration even after leaving the walls of the classroom or lab. Teachers can continue to monitor their collaboration and provide timely feedback to make sure the group continues to build higher level skills while applying the knowledge.

V. Case Studies on Flipped Classroom

A. Case Study I

Students of the First Year engineering were divided into six groups. Each group was assigned one unit of the course.

The group had to collect related learning material from books, websites, videos, their peers, from industry or any other source. On the stipulated date the group had to present a poster or working model on the topic.

The following observations were made:

- Students collected lot of material on the said topic. However, they need a guidance from the faculty and senior students to prepare the poster or model.
- About 60% of the students were able to defend the poster effectively.
- Students who created model were able to demonstrate effectively the working principles with fundamental understanding (Fig. 4).

Fig. 4 Model created by First Year students.

- Students exhibited team work.
- In a rare case a student offered his case to conduct the class substituting the teacher and presented the topic in a very effective manner which was appreciated by the teacher to a great extent.
- The qualitative performance of the students improved drastically.
- Sometimes teachers had tough time to solve the queries of students when conducting their traditional class.
- Students appreciated the learning methodology.
- It was a learning experience for the faculty too.

B. Case Study II

Students enrolled in a Microbiology class were expected to do around 25 laboratory experiments in a course. Laboratory time was relatively expensive because of the use of costly lab materials and time spent by the supporting staff to prepare all the agents for the students. Although lab manuals contains the basic information of the terms, their definitions, concepts, and theory related to the experiments, students showed varied levels of understanding before coming to the laboratory. This resulted in frustration for the teacher in the lab, frustration for the students not able to see the results they expected, and waste of time and resources as students repeated some of these experiments for better results. A lot of time was wasted repeating some of the basic information and terms in the lab, instead of using lab time to do things at a higher level of learning by applying the concepts and putting them in the right context. Teachers realized that they were wasting so much of lab time in rehashing and revisiting the basic information students are expected to remember and understand before coming to the lab. This reduced the time they could spend with the students to develop and refine higher-level skills and techniques in the lab.

In the intermediate course outcomes (Fig. 5), it is very clear that there is a need to take steps to improve student attainment ratio for the course outcome of laboratory techniques.

Fig. 5 Immediate Course Outcome Report

Software was used by the teacher to publish focused lesson material for each experiment with associated video demonstrations, concepts, theory and procedures (Fig.6).

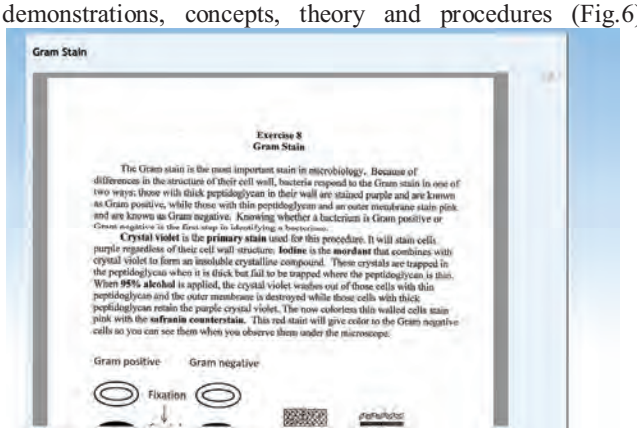

Fig. 6 Lab Manual Open Course Library Resource (Microbiology) (Creative commons)

For each of the lab session, the teacher enabled a Pre-Lab Quiz which students were required to finish before entering for the lab session. This helped students prepare well, any time before coming to the lab, from any place of their preference and from any device of their choice. They could see the videos and read materials as many times as they wanted and had the ability to test their knowledge of the terms, procedure, concepts and theory (Fig.7).

Fig. 7 Video on Gram Staining Procedure by Amrita Vlab (Creative commons)

The teacher was able to spot most common misconceptions in the students' minds before they entered the lab, and was able to use the HotSpot analysis (Fig. 8) of the data to efficiently allocate a small amount of time to remove some of these common misconceptions before students started their lab work.

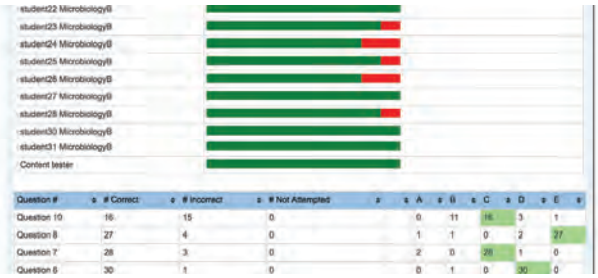

Fig. 8 HotSpot Analysis.

Students and teachers were able to go beyond the remembering and understanding level, and spend more time with actual experiments to apply their knowledge, make mistakes and learn from those mistakes in the lab with their peers and teacher present to help them. By letting students learn outside the classroom, teachers are able to create more opportunities in the classroom/lab to help students try out newer things, develop curiosity to take on interesting projects, discuss how all of this applies to the real world, e.g. with the spread of viruses like Ebola in Africa and E-Coli in a local suburb. They had time to discuss ethical issues surrounding some of the decisions being made about who gets the limited vaccine and drugs, economic implications of other nations helping or not helping the spread of deadly viruses and micro-organisms etc.

The teacher provided incentive to the students to finish the Pre-Lab reading, viewing and assignments by making this activity an important part of their internal assessment for the lab work. Software makes it easy for teachers to get a dashboard view on who has watched the videos, read the announcements and learning content, and how well they have understood the material via interactive quiz report and HotSpot analysis report for the Quiz.

This approach is helping a teacher effectively use Software based learning platform to flip the model and empower the students to take initiative and learn basic concepts, remember terms, visualize procedures, understand the theory on their own, BEFORE coming to the class. This allows teachers and students to make their lab experience more engaging, productive, interactive, collaborative and efficient, which in turn allows students to develop higher order skills and the institute to increase the student outcome attainment levels at the same time.

VI. Conclusions

Flipped Classroom model can develop higher order thinking skills of budding engineers and scientists which is required by the stake holders especially industry and enterprise.

It can be successful only if:

- Teachers create content that is easily accessible to students and are dedicated for developing higher order thinking skills in the class.
- Classroom time is systematically planned.
- Software support for content creation and assessment is working 24X7 and is available to students and faculty members.
- Feedback analysis be properly evaluated and corrective measures taken for improvement of content.
- Teacher updates the knowledge continuously and uploads and discusses with students.
- The organization provides infrastructure such as self learning places, project rooms, resource facilities on and off the campus

Preliminary and anecdotal findings indicate that implementing flipped classroom model has helped teachers and students improve outcomes and create more opportunities to develop higher level thinking. These observations encourage us to expand the implementation more broadly and explore this area further to gather more data for quantitative analysis of Flipped classroom model implementation.

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