Effectiveness of Flipped Classroom Lesson on the Learning Environment for Collaborative Learning of Pre-University Mathematics

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ABSTRACT

This paper aims to investigate the effectiveness of the Flipped Classroom model in the teaching and learning of Mathematics in the Singapore Pre-university context. Although the Flipped Classroom model has been used in the United States of America, little is known about its use in the Singapore context, where it has been largely unexplored. The diverse profiles of students in junior colleges call for a need to maximize the time for teacher and peer collaboration as well as clarifying of

concepts during precious curriculum time, whist learning at their own pace at home though an interactive lecture video. This qualitative study explores the effectiveness of the Flipped Classroom model in the teaching and learning of Sampling Methods, an examinable topic in Pre-university Mathematics. A lesson study which consists of collaborative planning, the research lesson and discussion/revision of the research lesson was conducted with the final-year pre-university classes. Individual students' behaviours were observed which have provided an authentic learning experience that gave teachers the opportunity to monitor, reflect and act to improve their classroom instruction. A formative assessment was conducted to ascertain students' level of understanding of the content learnt. A post-study survey was administered in order to obtain qualitative feedback from the students. The survey includes data collection on students' perceptions of their experiences while participating in this Flipped Classroom model. The survey results indicate that the students appreciate learning the content at their own pace through the interactive lecture video, although some were still more comfortable with lecture-tutorial content delivery methods. They also agree that the student-centred learning activities during curriculum time were beneficial to their conceptual understanding of the topic. Students remarked that they become more self-directed by the end of the study. The positive responses reaffirm that Flipped Classroom model is indeed an effective teaching and learning model for pre-university Mathematics, at the same time developing self-directedness and increasing curriculum time for student-centricity.

Keywords: flipped classroom; on-line learning; lesson study; self-directed; collaboration

INTRODUCTION

It started with a simple observation: students need a teacher's presence to answer questions or to provide help when they are stuck on an assignment; they don't need a teacher's presence to listen to a lecture or review content (Bergmann & Sams, 2012).

The Flipped Classroom is a model that inverts traditional teaching methods by delivering lecture content online and moving homework and discussion into the classroom. This transforms a teacher's role from owner of information to facilitator and guide to learning (Barseghian, 2011). Through this model, students have the opportunity to ask questions and work through problems with the guidance of their teachers and the support of their peers - creating a collaborative learning environment (TechSmith Corporation, 2012).

The availability of video recording and editing software has now simplified the creation of professional-looking online lectures. Software available like Camtasia Studio allow teachers to create interactive videos that can include quizzes, subtitles, multiple views and voice-overs, all from just a click of a mouse. These online lectures can then be shared with the students through the school's online-learning platform. In Singapore, the Learning Management System (LMS) and Microsoft Learning Gateway (MLG) are among those used by schools.

Although the Flipped Classroom model is prevalently used for various levels of education in the United States of America, little has been documented on its use in the Singapore context. In Pre-University courses (Junior Colleges), the tight curriculum time and different learning needs of students call for a need to maximize the effectiveness of teacher-student interaction and student-student collaboration.

PURPOSE

This research aims to investigate the effectiveness of the Flipped Classroom model in the teaching and learning of Mathematics in the Singapore Pre-university context. This will be achieved by studying the students' level of engagement during tutorial lessons via learning activities and measuring their learning preferences and experiences through a perception survey.

METHODOLOGY

The cohort of 400 JC2 H2 Mathematics students was involved in this qualitative action research. They were between 17-19 years old. All the students were given a week to watch the online video lecture on the topic "Sampling Methods" on LMS, a 35-minute interactive lesson package that students are expected to watch and take down key notes on a set of hand-outs given earlier. The students' notes are checked for completion before they attended the 2 sessions of 50-minute tutorial lesson.

From the cohort, two classes of students of similar ability were selected as part of the lesson study. The team of researchers met together for a few sessions to plan and design a classroom lesson, which put strong focus on Bloom's Taxonomy to develop and assess the students' level of understanding. A tutorial group of twenty H2 Mathematics students were observed as the original lesson plan for the first lesson was carried out. When the teacher was teaching, all other researchers came, walked around and took careful notes about what the students were discussing and learning. Some photographs of the lesson were also taken. Immediately after that, the team of researchers convened to discuss the effectiveness of the lesson and revised the lesson plan. Another tutorial group of 25 students were then observed with the revised lesson plan carried out. A focused group discussion amongst the researchers was then carried out to determine the effectiveness of the revised lesson. They shared their observation of the students' level of engagement, specific student misconceptions and offered constructive feedback on the segments of the lesson that they felt required tweaking. Ultimately, the focus of the discussion was on the implementation of the lesson, not on the teacher who taught the lesson. A week later, all students sat for a written test as part of the formative assessment for learning. A sample of the lesson plan is shown in **Annex A**.

A survey was administered to obtain feedback from students about their learning experiences in a different classroom setting where lecture materials were moved out of the lecture environment through online delivery and moving "homework" to classroom. The questionnaire was designed based on the following themes: usefulness of the LMS interactive video with the online quiz, student enthusiasm to the collaborative learning activities conducted and the overall learning experiences. A sample of the survey is shown in **Annex B.**

DISCUSSION OF RESULTS

A total of 295 participants attempted the survey and some of the results are as follows:

Question	Disagree (%)	Agree (%)	NA (%)
I can learn at my own pace through video lectures.	1.35	98.65	-
I was engaged in my learning during the group discussion.	4.06	95.25	0.68
I prefer learning through the Flipped Classroom approach rather than the conventional lecture-tutorial system.	30.51	69.49	-
I learn more effectively through the Flipped Classroom approach rather than the conventional lecture-tutorial system.	31.86	68.14	-
The Flipped Classroom approach has made me a more self-directed learner.	14.58	85.42	-

From the survey results, about 75% of the participants agreed that the online video lecture was clear in the quality of information and explanations presented. One reported benefit was the inclusion of quizzes to apply concepts learnt and consolidate understanding. Almost all the participants (98.65%) indicated that they were able to learn the lecture content at their own pace by watching the lecture video. They were also engaged for learning during the group discussion (95.25%). As indicated by the mean ratings of 4.01 out of 6, majority of the participants preferred the flipped classroom approach as compared to the conventional lecture-tutorial system and expressed that they learnt more effectively as well. In addition, 85% of students also felt that they have become more self-directed through this approach.

The full survey results are shown in **Annex C.**

CONCLUSION AND RECOMMENDATIONS

From this lesson study, the flipped classroom model appears to be the way forward in the Pre-University context where tutors grapple with the limited curriculum time and diverse learning ability of students. In this section, we propose some improvements to our model and suggest how the flipped classroom model can be used for teaching and learning of mathematics in the future.

From our survey, a number of students faced technical difficulties which made viewing the online video lecture a frustrating experience. This could be due to high online traffic on the LMS and also the bandwidth of students' internet connection at home. One way to minimise this issue is to open up the computer labs in the college for the students to use to view the online lesson.

For the topic on Sampling methods, students had to watch the online video and simultaneously fill in the blanks in their lecture notes. From our survey and casual feedback, students commented that online video lecture should be created for short topics with minimal notes taking involved so as to make the learning more effective. We agree that the online video lectures should be created for more short topics for effective learning. Topics in the A level H2 Mathematics syllabus like Binomial Expansion, Maclaurin Series and Permutations and Combinations are easily digestible through online video lectures. With regard to the request for minimal note taking, there must be a system for tutors to effectively monitor whether the students have watched the video and digested the material before the lesson. This is achieved by getting students to fill in the lecture notes before the lesson. More autonomy can be given to students only if they exemplify self-directedness in learning.

Although our online video lecture has checkpoint quizzes, it does not allow students to clarify their doubts further at certain junctures of their viewing. This can be solved by opening up a discussion forum on the LMS alongside the video so that students

and teachers can participate actively to clarify doubts without waiting for the next school day or classroom lesson.

As for the collaborative learning activities which were carried out in the classroom, it was observed that some students participated at a superficial level while others participated more actively. For class time to be productive, the teacher need to structure the activities which are suitable for students to listen and engage them with the materials they have learnt. The team of teachers can develop various questions and suggest some questioning techniques to encourage more student participation.

As revealed in the open-ended responses, a flip classroom setting did make students more aware of the learning process and content, but some students commented that the two sessions of 50-minute lesson was not structured sufficiently to help them engage in deeper theoretical discussions and explore the implications of the concepts they were learning. They proposed for an additional tutorial lesson for doing "homework" in the classroom environment under the teacher's supervision and guidance, which can be done by restructuring the scheme of work.

In summary, the effectiveness of the flipped classroom approach depends greatly on the commitment level of students. Learning in an online environment requires discipline and self-motivation on the students' part. The teacher can then come in to facilitate and provide the necessary support for the students learning.

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Date : 2 Apr 2012

Class:

Time:

Teacher:

I.   **Background information**

      Goals of the Lesson Study Group:

      o   To develop students' ability to learn independently and confidently.

      o   To encourage collaborative learning in the classroom.

      o   To provide opportunities for active engagement in learning and encourage students to assume responsibility for shaping
          their own learning tasks.

      o   To use a student's thinking and experience as a resource in planning instructional activities for more effective classroom
          teaching.

II.   **Lesson information**

      A. **Topic**: Sampling Methods

      B. **Objectives of the research lesson**: At the end of the lesson, students will be able to

          1. understand the concepts of population, sample and random sample;

          2. understand the appropriate use, advantages and limitations of the 4 sampling methods (random, stratified, systematic
              and quota samples) in practical situations.

C. Process of the research lesson:

Steps of the lesson: *Learning activities, key questions and time allocation.*	Student activities/expected student reactions or responses	Teacher's response to student reactions	Goals	Observation Notes
Introduction (15 mins) Activating students' prior knowledge of the topic **Materials Required:** a) 1 x activity board set b) 1 x card set c) 6 x markers d) 5 x butcher paper	T welcomes Ss and get them to settle down in 5 groups (numbers to be roughly equal). T informs Ss that there this is a series of 2 classroom lessons on Sampling Methods. T to inform Ss that lessons will be activity based and Ss should actively participate in the activites. T to set up the 5 coloured boards equally spread out on the whiteboard with Ss help. T to distribute at least 1 card each per Ss. T to introduce activity to Ss: Do not start until all instructions are given out. Go to the board and place the card under the correct headings. All to gather around	- Each group is to discuss and place each card in the correct category on the charts. -Students ask questions and clarify or debate confusion when working in small groups	Teacher circulated the class to keep students on-task and to monitor progress.	Create opportunities for students to exhibit memory of previously-learned materials by recalling facts, terms and basic concepts.	○ Students were able to get into groups quickly and be ready for the lesson _____ _____ ○ Level of engagement _____

e) 10 x rough paper f) 5 x Question 1 - 5 each g) 25 x Question Set	the board to check and debate the placing of cards. T can facilitate by asking Ss questions like 'why do you think this should be placed here?' or 'Are there any other possible places to put this card?'				
Lesson Development (10 mins) Follow-up process and misconception checks through oral questioning	When the activity has ended, T to check if the cards are placed under the correct headings. If not correct, T to explain quickly why incorrect and place the card under the correct header. If correct, T will congratulate the Ss for doing a good job and ask Ss if they have any questions**. **T asks relevant questions to specific Ss to discourage chorus answers as well as to stimulate thinking. T can ask Ss to discuss in pairs / threes the following: 'Which sampling method is the clearest to me? Which do I still have some	- Students are expected to listen with understanding and posing questions to clarify doubts at strategic points	-Teacher uses students' explanation as a form of error analysis to identify gaps of understanding. Possible questions: 1. Choice of placement of cards 2. Any misconception that they want to raise	- Illustrate the need to translate thinking in a clear and orderly manner so that it can be understood. - Students to articulate their thinking.	o Students not paying attention/not interested

	misconceptions about?' T will then ask one Ss from each group (if time permits) to answer the question. T to acknowledge the question to be a good question and clarify any doubts. T to thank Ss for their lively participation and inform Ss that they will now move on to the next activity.				
Problem solving and presentation of solutions (15 mins)	T to introduce Ss to the next activity. T to ask Ss to listen to instructions carefully. T to instruct Ss the following: 1. Each group will be given a Sampling Method question (each S from the same group will have a copy of that question), a piece of butcher paper, rough paper and a marker. 2. Ss are to spend the next 15 minutes to plan and solve the problem. Ss are encouraged to plan on the rough paper first before writing on the			-Students to apply the concepts learnt to A-level questions. -Teacher illustrates that students' presentations can be improved on to make them more comprehensible.	o Any "slack-off" students? o Any "struggling" students? o Some misconceptions? o Constructive discussion taking place?

	butcher paper.				
	3. Ss can use the information on the coloured boards done in the first activity or their lecture notes.				
	4. Ss should write legibly and large. Every Ss should contribute actively.				
	5. Their solutions will be used for the next activity in the next lesson.				
	T to inform Ss that they can start now.				
	T to walk around to facilitate and encourage. T can provide hints if Ss are stuck, or point Ss to sections of the lecture notes or coloured boards for information.				
Closure (5 mins)	T to stop discussion and inform Ss on what to expect for the next lesson: 1. T to inform Ss to hand in their butcher paper. 2. T to distribute question set to Ss. Inform Ss that these are the 5 questions prepared				

	by their fellow Ss. Ss should read the questions and be prepared to contribute to their Ss solutions in the next lesson. T to end the lesson.				
Lesson 2					

Steps of the lesson: *Learning activities, key questions and time allocation.*		Student activities/expected student reactions or responses	Teacher's response to student reactions	Goals	Observation Notes
Introduction (5 mins) **Materals Needed:** a) Butcher paper with solutions b) 2 sets of colour post-its. c) worksheet (1 per student) d) thumbtacks	group leaders to put up their butcher paper on around the classroom (recommended: 1 in middle of whiteboard (use magnets), 1 each on the green boards) T to welcome Ss and get them settled down into their original groups. T to give a brief recap of the previous lesson: 'Last lesson, we took a look at the various sampling methods. Then, in groups, you have written the solutions to one question on butcher paper. Today we will take a				

(16) + bar magnets (4)	look at what your fellow classmates have done and you will give your inputs and suggestions on their solutions.'				
Lesson Development (20 mins) Gallery Walk	T to give instructions on gallery walk. T to inform Ss to listen to instructions carefully before you give the go ahead to start. 1. each group to choose an expert. The expert will be stationed with the group's butcher paper. The expert will explain the question and solution to visiting groups. All Ss to bring a pen along with them. 2. 4 minutes per station. At each station, each Ss should listen carefully and read the solutions. 3. there will be post-its at each station. Ss visiting the stations will pen their suggestions, comments or questions on a post-it and paste the post-it on the				

	butcher paper. 4. when they hear an alarm / chime / bell, they will move in a clockwise direction to the next station. T to stop the activity after 20 minutes. T to ask groups to take down their butcher paper and return to their table to be seated.				
(10 mins) Collate feedback	T to inform Ss to listen to instructions carefully before they start. 1. T to inform Ss to spend a few minutes to look at the comments / suggestions / questions. Ss to discuss in their groups about whether they should modify their solutions. 2. T to inform Ss to rewrite the solution onto a piece of paper and submit to T in 10 minutes. T to inform Ss to start the activity. T to walk around and facilitate by asking questions like: a) 'why do you think this				o

	person commented this way?' b) 'what do you think of this suggestion?' c) 'have a vote in your group whether your group should adopt this suggestion?' 3. T to stop activity and collect back solutions. 4. If the solutions are good, T to pass the solutions to Maths Rept and inform Ss to get the solutions printed from the bookshop to keep a copy. 5. if the solutions require improvements, T to inform Maths Rep to collect the solutions from T later on in the day so that they can send to the bookshop for printing. 6. T to congratulate Ss for a job well done, and inform them that they will now move on to the next activity.				
(10 mins) Consolidation worksheet	T to distribute worksheet to each Ss. T to give the following instructions:				

	1. now, individually, attempt the question on the worksheet. You have 10 mins to do so. Write your name and submit the worksheet by the end of 10 mins. You should try not to refer to your notes as far as possible. 2. T to collect back worksheet and inform S to look out on the LMS for feedback on the solutions (selected solutions will be used to point out common mistakes and learning points). 3. T to inform Ss that all worksheet will be returned after the weekend. 3. T to inform Ss of the FA in 1 week's time (the same tutorial the following week) T will then end the lesson.				

Survey questions on flipped classroom Scale 1 - 6

Survey Questions on Video and Online Quiz

1.   The video helped me to explain the concepts clearly
2.   I can learn at my own pace through video lectures
3.   The quiz put at the end of section 1 helped me to consolidate my understanding of what was covered.
4.   The quiz put at the end of the video helped me to consolidate my understanding of what was covered.
5.   The process of watching the video was smooth.
     Yes   No
6.   Please elaborate if you answered 'No' to Q5.

     _____

Opening Activity – Card Matching

1.   I like the cards activity.

2.   The questions on the cards stimulate my thinking and allow me to relate the materials learnt previously via online video lesson to the activity.

3.   There was adequate thinking time.

4.   The cards activity serves as a quick check for my understanding of the basic concepts of the topic.

Group discussion and Presentation of Solutions

1.   I was more engaged in my learning during the group discussion.

2.   I was able to clarify concepts during the gallery walk activity.

3.   The collaborative learning activities have enhanced my reasoning skills.

4. Were you a presenter of your group's solution?

Yes   No

If yes, please answer the following question

I was encouraged to explain my thinking and group solutions to my classmates.

5. Overall, the whole flipped classroom lesson

(a) has promoted active learning in class;

(b) Is useful for conceptual development.

o   What are the strengths of the whole lesson?

_____

o   What are some suggestions for improvement?

_____

Survey Questions to ask for Lesson Study observation on the learning experience

1. I prefer learning through the Flipped Classroom approach rather than the conventional lecture – tutorial system. [Student learning preferences]

2. I learn more effectively through the Flipped Classroom approach rather than the conventional lecture – tutorial system. [Effectiveness of student learning]

3. The Flipped Classroom approach has made me a more self-directed learner. [Development of C2015 competencies]

Survey Title: Survey on Sampling Methods Flipped Classroom (Updated)

Group: H2MATH

Total Users: 295
Date Generated :6/25/2012 9:21:28 AM
Generated By :Lin Furong

RATING QUESTION

1. Please answer all questions in this section.

Section	Question	Not Attempted(%)	Strongly Disagree (%)	Disagree (%)	Somewhat Disagree (%)	Somewhat Agree (%)	Agree (%)	Strongly Agree (%)	N.A. (%)
1	A. The video helped me to understand the concepts clearly.	0%	0.34%	1.69%	2.03%	18.31%	54.92%	22.71%	0%
1	B. I can learn at my own pace through video lectures.	0%	0.34%	0.34%	0.68%	11.19%	41.02%	46.44%	0%
1	C. The quiz put at the end of Section 1 helped me to consolidate my understanding of what was covered.	0%	0.68%	1.36%	2.37%	20.68%	51.19%	22.71%	1.02%
1	D. The quiz put at the end of the video helped me to consolidate my understanding of what was covered.	0%	0.68%	1.02%	2.03%	22.37%	52.20%	21.02%	0.68%
1	E. Overall, the process of watching the video was smooth.	0%	1.02%	0.68%	2.71%	14.92%	49.15%	31.53%	0%

1. Please answer all questions in this section.

Section	Question	Not Attempted(%)	Strongly Disagree (%)	Disagree (%)	Somewhat Disagree (%)	Somewhat Agree (%)	Agree (%)	Strongly Agree (%)	N.A. (%)
2	A. I like the opening cards activity.	0%	0.34%	3.73%	7.46%	24.75%	46.44%	15.93%	1.36%
2	B. The card activity allows me to recall what I have learnt via online video lesson.	0%	0.34%	3.39%	2.71%	21.69%	52.20%	18.98%	0.68%
2	C. The card activity stimulates my thinking.	0%	0.34%	2.37%	3.73%	20.34%	52.54%	20%	0.68%
2	D. The cards activity serves as a quick check for my understanding of the basic concepts of the topic.	0%	0.34%	1.36%	1.69%	19.32%	52.88%	23.73%	0.68%

1. Please answer all questions in this section.

Section	Question	Not Attempted(%)	Strongly Disagree (%)	Disagree (%)	Somewhat Disagree (%)	Somewhat Agree (%)	Agree (%)	Strongly Agree (%)	N.A. (%)
3	A. I was engaged in my learning during the group discussion.	0%	0%	2.03%	2.03%	19.66%	49.49%	26.10%	0.68%
3	B. I was able to clarify concepts during the gallery walk activity.	0%	0%	3.39%	3.05%	19.32%	52.54%	20.34%	1.36%

2. Answer this question only if you were the presenter of your group's solution.

Section	Question	Not Attempted(%)	Strongly Disagree (%)	Disagree (%)	Somewhat Disagree (%)	Somewhat Agree (%)	Agree (%)	Strongly Agree (%)
3	A. I was encouraged to explain my thinking and group solutions to my classmates.	46.10%	0%	1.69%	1.69%	15.59%	28.81%	6.10%

1. Please answer all questions in this section.

Section	Question	Not Attempted(%)	Strongly Disagree (%)	Disagree (%)	Somewhat Disagree (%)	Somewhat Agree (%)	Agree (%)	Strongly Agree (%)
4	A. I prefer learning through the Flipped Classroom approach rather than the conventional lecture â€" tutorial system.	0%	3.73%	12.20%	14.58%	31.19%	25.42%	12.88%
4	B. I learn more effectively through the Flipped Classroom approach rather than the conventional lecture â€" tutorial system.	0%	3.39%	9.83%	18.64%	30.17%	27.46%	10.51%
4	C. The Flipped Classroom approach has made me a more self-directed learner.	0%	1.36%	4.41%	8.81%	35.93%	33.90%	15.59%