

## CASE STUDY ON MUFY MATHEMATICS UNIT 2 STUDENTS: ANALYSIS OF PROBABILITY TEST PERFORMANCE IN FLIPPED AND CONVENTIONAL CLASSROOM

ANGIE NG WEE KOON

Monash University Foundation Year

Sunway College Kuala Lumpur

No. 5, Jalan Universiti, Bandar Sunway, 46150 Petaling Jaya, Selangor

Email: angie.ngwk@gmail.com

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### ABSTRACT

*The purpose of this study is to examine the effect of two different lecturing methods on student's test performance. Probability, which was one of the topics in MUFY Mathematics Unit 2 syllabus, was delivered to the students through flipped and conventional approaches. A group of 85 students was taught in a conventional classroom model (control group) and another group of 85 students was exposed to a flipped classroom model (experimental group). These students had to sit for the same set of test questions after learning the topic of probability. Analysis on the students' test results revealed that students from the flipped classroom had performed better than the control group by achieving a very high passing rate of 92.9% (with a mean test marks, 77.65%). In contrast, passing rate for the control group was only 81.2% with the mean test marks, 66.66%. Furthermore, students from the flipped classroom had obtained better grades. About 48% of them had graded as "High Distinction", which was equivalent to a test mark of 80% or above. In term of student's gender, data analysis revealed that there were no significant differences in the mean test marks and grades distributions between male and female students in the flipped classroom. Flipped classroom model managed to invert the traditional teacher-centered based learning to student-centered based learning. It had provided a more interactive learning environment where the students were able to engage more in the group discussions during class activities. Lecturers be the guidance or facilitators in the flipped classroom. Students learnt to be more responsible for their study and well prepare before class. Overall, the flipped classroom approach had a positive effect on the student's learning and achievement.*

Key words: Flipped classroom, conventional, test performance, gender.

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### Introduction

For Monash University Foundation Year (MUFY) Mathematics Unit 2 syllabus, there are four main topics to be delivered which are Sequence and Series; Probability; Probability Distribution and Statistics. Based on the previous experience, Mathematics Unit 2 lecturer found that most of the students were having the difficulties in learning the topic of probability. Students always claimed that the probability concepts were too abstract for them to understand and very difficult to link it to the daily life applications. An anxiety on probability always exists among the students, which has reduced their motivation in learning and consequently, has affected the students' achievement. This scenario has encouraged the Mathematics Unit 2 lecturer to look into a new teaching approach in order to overcome the students' phobia on probability. There is a need to motivate students to arouse and sustain their interest in learning this topic.

Since educational technology and online study materials are improving and expanding rapidly, lecturer has decided to adjust the teaching strategies by integrating more online learning concepts. Besides that, lecturer has redesigned the class activities in order to involve more students' engagement. Lecturer has incorporated the flipped classroom model to be part of the teaching strategies for the topic of probability.

For years, teachers have been the main speakers in class imparting their wisdom to students, and then assigning homework to reinforce the learnt concepts with minimal supports (King, 1993). Meanwhile, students are assumed as empty vessels, in which the teachers pour in the knowledge. There is only one-way communication in the learning process (King, 1993). For a conventional classroom lecture format, lecturers conduct the lecture during class time while students revise the lesson at home, and complete all the homework or tasks given out of class time. Due to this passive learning environment, students are not able to think critically or independently; and hence, they are not able to solve unexpected problems or complex issues. Interactive discussion between lecturers and students during class time are very limited due to the time constraint, as lecturers have to finish the entire syllabus on time.

Compare to conventional classroom, flipped classroom is a new pedagogical method, which has inverted the lecturer-centered based to students-centered based learning during class time. The flipped or inverted classroom is a form of blended learning in which events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa (Bishop & Verlager, 2013). In a flipped classroom model, learning is divided into two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom (Bishop & Verleger, 2013). The flipped classroom takes the form of web-based video lectures delivered at home, with class time allocated for problem solving, discussion, debates, case studies, and other activities (Bishop & Verlager, 2013). Lectures have moved out of the classroom and delivered online as a mean to free up class time for interaction and collaboration. The lectures are recorded for viewing outside

of class, and class time is dedicated to active and student-centered learning. Video lectures have been shown to be as effective as live lectures at presenting basic information (Bishop & Verleger, 2013).

In the flipped classroom environment, learning is an active social process in which the learners use the existing knowledge and prior experiences to build an individual understanding of new material (Brown, Collins, & Duguid, 1989). Furthermore, in this model, teachers act as facilitators, guiding students through the learning process while allowing them to shape their own understanding of the instruction (Rhodes & Bellamy, 1999). By doing so, students are able to construct knowledge in a meaningful manner that allows them to have better understanding on the learned contents.

As overall, flipped classroom model is a combination of few ideas, which involves online education concepts, students' pre-class preparation, cooperative learning in groups and active participation during class time. Before attending a class, students have to be more self-independent by studying the fundamental knowledge or concept of a particular topic at home. When students attend the class, they will deepen the subject knowledge again by participating in class activities. Class time is dedicated for discussions, hands-on problems solving or tasks completion. There will be more lecturer-students interactions as well as peer-to-peer interactions. Lecturers may assist in clarifying the concepts or resolving the problems. These changes of learning approach manage to enhance students' understanding and improve their learning achievement.

This study aimed to examine the effect of flipped classroom model on students' topic test performance. Two groups of students, which consisted of 85 each involved in this study. The topic of probability was delivered to these groups of students by using two different teaching models - conventional and flipped classroom. Students in the conventional group set as the control group while the students in the flipped classroom as the experimental group. Both groups sat for the same topic test by the end of the lesson and their test performance will be analyzed statistically. In this study, we hypothesized that students in the flipped classroom (experimental group) would get a better understanding on the topic of probability and perform better in their topic test compare to the students in the conventional classroom (control group).

#### **Objective of this study**

- (1) To examine any significant difference in students' test performance (mean test marks) between the control group (conventional classroom) and experimental group (flipped classroom).
- (2) To examine any significant difference in students' test performance (mean test marks) between male and female students in the flipped classroom.
- (3) To examine any significant difference in students' grades between the control group (conventional classroom) and experimental group (flipped classroom).
- (4) To examine any significant difference in students' grades between male and female students in the flipped classroom.

#### **Literature Review**

The flipped classroom, or sometime has been mentioned as inverted classroom refers to a learning model that inverts the conventional classroom lecture format and out-of-class self-study method (Lage, Platt & Treglia, 2000). In the conventional classroom model, lecturers teach the topics based on the schedules planned; students try to learn and understand the topics during class time, and complete all the tasks given out of the class-time. Due to the limited class time, lecturers are not able to attend all the misconceptions or doubts encountered by students. Interactions between lecturer-students are very limited.

In the flipped classroom model, there is a mutually swap of role of lecturers and students. It emphasizes more on students' self-preparation before class and active participation in classroom (Johnson et al., 2013). Before attending the class, students learn the topics or new fundamental of knowledge through the online materials. Students can access the materials easily and freely at anytime and anywhere, due to the improvement of the internet transmission speed. During class time, students can sharpen their knowledge and concepts again through classroom activities. In the flipped classroom model, class time is dedicated to more active problem-based learning where students work together for solutions. Students learn how to apply the knowledge learnt on solving daily life situations; and hence get a deeper understanding of the subject through group discussions (Johnson et al., 2013). Learning environment changes where the students will take the major role in class activities. The idea of the flipped classroom is to train students to be self-learners, to study concept before the class, and to dedicate more classroom time to learner-centered activities so that immediate feedback and assistance can be provided to the students (Vygotsky, 1978; Foot & Howe, 1998; Lage & Platt, 2000). Flipped classroom gives students an opportunity to explore the new topic content out of the class time, and then followed by time spent in class for more collaborative learning.

Recent studies have investigated various integrations of the pre-class self-study learning materials, such as watching videos, listening to podcasts, reading articles, and viewing slide presentations, as well as the in-class activities, such as hands-on activities, student presentations, discussions, and individual quiz (Clark, 2015; Herreid & Schiller, 2013; McLaughlin et al., 2014). Bergmann and Sams (2012) suggested that various activities, such as questions and answers discussion, project-based learning, inquiry-based learning and group discussions could be included in the flipped classroom.

The flipped classroom would become an innovative teaching model emphasized by higher education (Johnson et al., 2013), and rapidly move into the mainstream of educational research (Tucker, 2012). The literature has identified that the flipped classroom model is more effective, compares to conventional classroom model. A flipped classroom can stimulate students' critical thinking and increase teacher-students interactions. In terms of Bloom's taxonomy of learning, the flipped classroom has

students perform the lower levels of cognitive work out of the class time, and then the higher levels of cognitive work during class time (Brame, 2013).

Kathleen Fulton (2012) listed some of the advantages of the flipped classroom:

- (1) Students can learn the contents based on their own pace.
- (2) Class time can be applied for more effective and creative activities.
- (3) The use of technology is flexible.
- (4) Students swap from a passive learning to a more active learning process.
- (5) Solving problems in class gives teachers better insight into students' difficulties and learning abilities.
- (6) More interactions between lecturer and students, which will enhance lecturer-students relationship.

### Methodology

A sample of 170 students who had enrolled in MUFY Mathematics Unit 2 January 2016 participated in this study. A group of 85 students was studied in the conventional classroom as usual (control group) while another group of 85 students was assigned in the flipped classroom (experimental group). The mathematics topic that had been chosen to be delivered under this experiment was Probability, which took about three weeks to complete the whole topic. The students in both the control and experimental groups underwent the same learning topic, and they were given the same topic materials by lecturer. All of them had to attend weekly five-hour face-to-face class time. After completing the lesson, all students had to sit for the same topic test prepared by lecturer.

For the first week, students in both the control and experimental groups had to attend a 5-hour lecture in order to get the basic concepts and ideas of probability. After the first week, students from the experimental group will proceed to flipped classroom approach while the students in the control group will remain in the conventional classroom. For the second and third week, students in the experimental group attended a 5-hour session in flipped classroom with cooperative learning activities, including face-to-face lecturer-students interactions. Students had to be more self-independent by learning the new sub-topic's concepts at home or outside of the class time. They had to read the online materials or watch the video clips in relation to probability which were suggested by lecturer. During face-to-face class time, students were requested to sit in a four-member group to have their peer discussions. Each study group had to solve a set of four questions which was given by the lecturer during the beginning of class. All the groups were given a chance to present their ideas or solutions during class activities. In the flipped experimental group, classes were interactive and focused on questions and answers, the team cooperative learning, hands-on activities, and homework completion. Students were assisting each other when their group members had any doubts or queries on the topics. During class time, lecturer circulated around the classroom guiding the study groups that were having problems.

Meanwhile, for the full three weeks, students in the control group had to learn the lecture during their class time and to complete the tasks or assignments by themselves either at home or out of the class time. In the conventional classroom, lecturer was the main speaker and students were active in listening and taking notes. Cooperative learning and interactions in class were very limited. The design of two different learning groups of students was shown in Figure 1.

### Instrument

The instrument used in this study was the mathematics topic test, which was related to probability concepts. This test was given to both groups of students at the end of the lesson. A 30-minute of topic review and summary were conducted to both group of students before they went for the test. The topic test consisted of five multiple-choice questions and four short calculation questions, which contributed to a total mark of 100%.

### Results

Researcher used SPSS version 21.0 to conduct a basic descriptive analysis of students' demographic backgrounds. In addition, independent sample T-test, ANOVA and Chi-Square test were applied in order to achieve the objectives of this study.

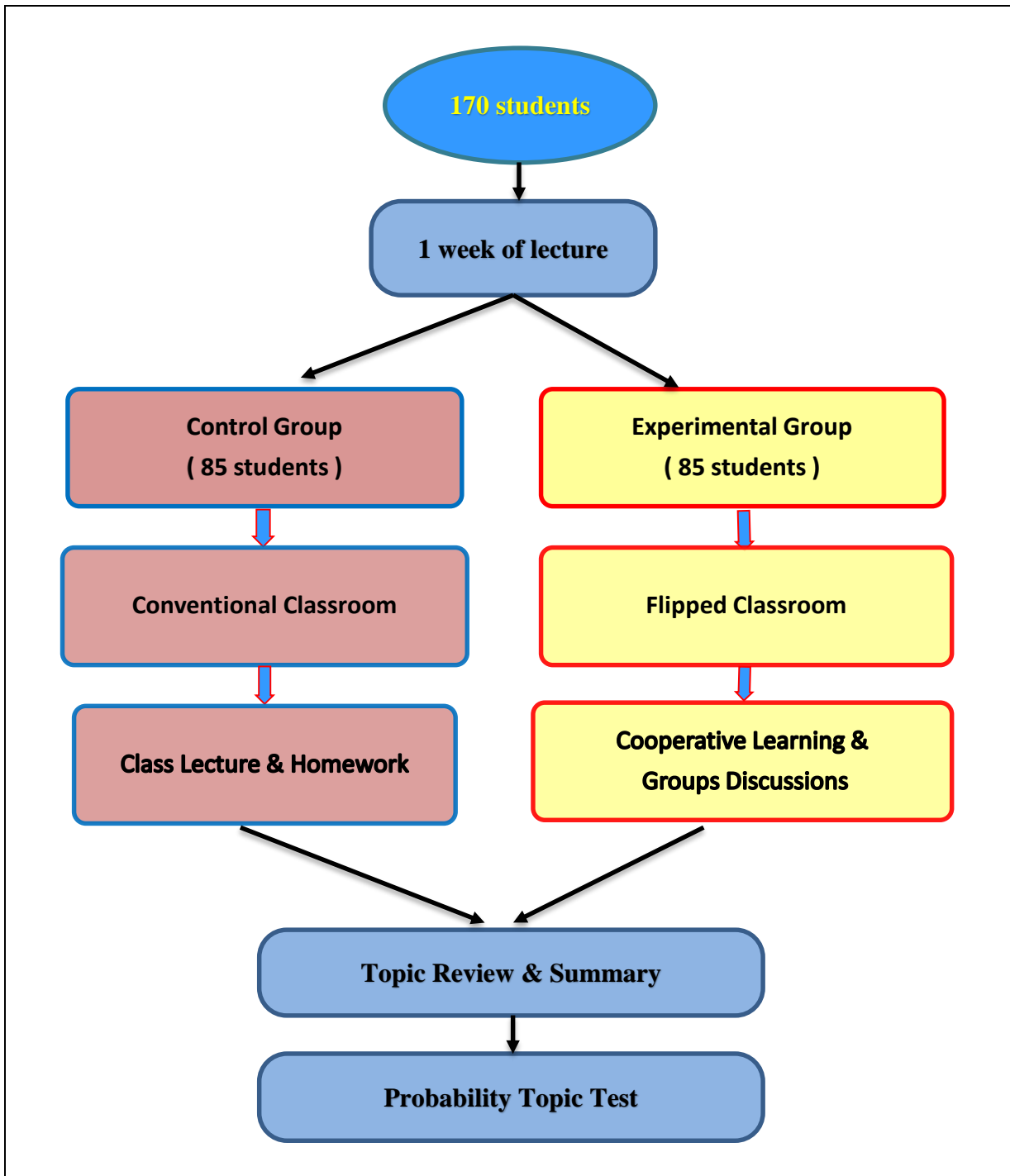
### Descriptive Analysis – Demographic background

A total of 170 students participated in this survey with 49% (n = 83) of them were male students and 51% (n = 87) were female students. In order to avoid sample size biased, these 170 students were divided equally into control (conventional) and experimental (flipped) groups. Each group were having 85 students. Table 1 showed a summary of the students' demographic details (gender and age) for both of the two groups.

Table 1: Descriptive statistics of demographic background

	Control Group	Experimental Group
Number of students	n = 85	n = 85
Age	19 years old	19 years old
Gender	33 Male (39%); 52 Female (61%)	50 Male (59%); 35 Female (41%)

Figure 1: Models in this study



#### Analysis on Topic Test Performance

Students from the control and experimental groups sat for an-hour topic test on the same day. The test paper consisted of five multiple-choice questions and four calculation questions, which contributed to total marks of 100%. In this study, researcher compared the mean test marks and grades obtained by students from both of the two groups. On overall, students from the experimental group which had undergone the flipped classroom activities performed better than students from the control group. In experimental group, the mean and standard deviation were 77.65% and 17.337% respectively (as shown in Table 2). This group of students managed to obtain a higher mean with a smaller standard deviation value.

Table 2: Basic analysis on topic test

	Control Group	Experimental Group
Mean (%)	66.66	77.65
Standard deviation (%)	19.265	17.337

**Objective 1**

In further, researcher used independent sample T-test to examine whether there was any significant difference in mean test marks between the control and experimental group. Results shown in Table 3 revealed that, there was a significant difference in mean test marks between the control and experimental groups with  $p$ -value = 0.00, at 5% level of significance.

**Objective 2**

There were 50 male students and 35 female students in the experimental group. Did the gender affect the students' mean test marks in the experimental group? ANOVA test was applied and the  $p$ -value obtained in this analysis was 0.269 (as shown in Table 4). This indicated that there was no significant difference in the mean test marks between male and female students in the experimental group.

**Objective 3**

Students' test performance can be evaluated also by categorized them into grades categories. In MUFY, the grades responding to marks scored are displayed in Table 5. Students who score within 80% to 100% are graded as "High Distinction"; score within 70% to 79% are graded as "Distinction"; score within 60 to 69% are graded as "Credit"; score within 50% to 59% are graded as "Pass" and those score less than 50% are graded as "Fail". Table 6 showed the overall passing rate and grades distributions for both two groups. As overall, students from the flipped classroom performed much better by achieving a higher passing rate of 92.9%. In addition, the number of students managed to score at least 80%, which graded as "High Distinction", were more than double of the students in the control group. Figure 2 gave a visual comparison of grades obtained by students in the conventional and flipped classroom. A *Chi-Square* test was conducted with the result of  $p$ -value = 0.000 (<0.05) indicated that there was a significant difference in the grades between the two groups (as shown in Table 7).

**Objective 4**

This study also looked into the effect of gender on the grades obtained by students in the experiment group. *Chi-Square* test results showed a  $p$ -value of 0.186 (>0.05) which indicated that there was no significant difference in the grades between male and females in the experimental group (as shown in Table 8).

Table 3: Independent samples T-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% Confidence Interval of the Difference	
									Lower	Upper
Test marks	Equal variances assumed	.349	.556	-3.91	168	.000*	-10.988	2.81	-16.538	-5.438
	Equal variances not assumed			-3.91	166	.000	-10.988	2.81	-16.538	-5.438

\*Significant at 0.05

Table 4: ANOVA result for mean test mark and gender

		Sum of Squares	df	Mean Square	F	Sig.
Test marks*Gender	Between Groups	(Combined) 370.626	1	370.626	1.236	0.269
	Within Groups	24878.786	83	299.744		
	Total	25249.412	84			

Table 5: Grades categories

Grades	Range of marks (out of 100%)
High Distinction (HD)	80 - 100
Distinction (D)	70 - 79
Credit (C)	60 - 69
Pass (P)	50 - 59
Fail (F)	0 - 49

Table 6: Grades distributions based on two groups

	Control Group		Experimental Group	
Overall Passing Rate	81.2%		92.9%	
Grades (number of students)	HD	20	HD	48
	D	19	D	14
	C	21	C	6
	P	9	P	11
	F	16	F	6

Figure 2: Grades by two groups

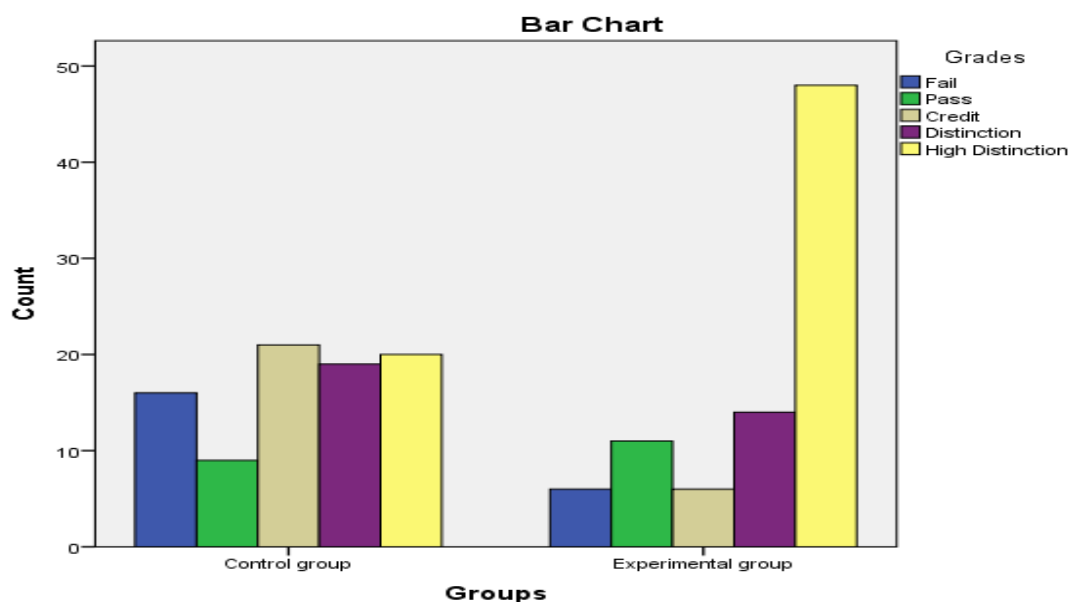


Table 7: Chi-Square test for grades by two groups

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	25.366	4	0.000*
Likelihood Ratio	26.383	4	0.000
Linear-by-Linear Association	13.595	1	0.000
Number of Valid Cases	170		

\*Significant at 0.05

Table 8: Chi-Square test for grades by gender in experimental group

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.187	4	0.186
Likelihood Ratio	8.385	4	0.078
Linear-by-Linear Association	1.383	1	0.240
Number of Valid Cases	85		

As per finding, there was a significant difference in students' test performance between conventional control group and flipped experimental group. Instead, students from flipped classroom performed better than students in conventional classroom by achieving higher mean test marks and passing rate.

### **Feedback from Students in the Experimental Group**

After the experiment periods, researcher had an informal sharing session with students in the flipped classroom. The following were some of the positive feedbacks from students.

- We had better ideas on probability concepts.
- We managed to learn something new from our peers during the group discussions.
- We had improved our problem solving skills through the group works.
- We had improved our communication skills through the discussions.
- We learnt to respect our peers' opinions or suggestions.
- Learning process was interesting.

### **Discussion**

In the experimental group, the prior class online reading materials suggested by the lecturers allowed students to have their self-reading or self-preparation on the topics of probability. They learnt the fundamental concepts or formulas in relation to probability before attending classes. By studying the lecture beforehand, scheduled class time is made available for collaborative activities. During class time, students would have their active collaborative learning through the group work. Questions or tasks related to probability were given to students as their group assignments. Students could sharpen their probability knowledge and concepts again through the problems solving. Working as a group, students had to recall the concepts, and to justify the most appropriate techniques or skills to solve a particular question. These activities had encouraged the students to think more critically. Besides that, there would be more students' interaction during class time. Students were given more opportunities to express their ideas, and to communicate with their peers. At the same time, students were helping or guiding each other in the group activities when they came across to any difficulties. Interaction among students made the classroom-learning environment be more cheerful and interesting.

Research indicated that compared to those in traditional lecture-based classes, students in active learning environments showed an improved retention and better conceptual understanding of learned material (Sezer, 2010). This was proven in this study, when the students from the flipped classroom managed to perform better than the conventional group in their probability test. Analysis on students' test performance indicated that flipped classroom approach had a significant positive impact on students' learning and achievement in the topics of probability. Students in the flipped classroom obtained a higher mean value with a higher passing rate in their test. In term of grades distributions, more than half of the students in flipped classroom obtained "High Distinction". By contrast, students in the conventional classroom showed an average test performance. The grades distributions among students were almost equal balance. On overall, the flipped classroom approach was effectively in improving students' academic performance and their interpersonal skills. Students had positive perceptions and feedbacks on flipped classroom model. They enjoyed the learning process and class activities.

In a traditional classroom model, lecturer will give the lecture during class time and students have to try their best to capture the points said by the lecturer. Sometimes, students may miss out some important points since they are not able to catch up lecturer's pace of instructions. Furthermore, they need more time to understand what is being said during lecture. This is even more challenge to the students especially when they have to learn those complicated and difficult mathematics topics. Students need to have good understanding on the fundamental concepts of mathematics before applying them on the problems solving. Listening to the lecture without hands-on practices are not helping students in the learning process.

By contrast, in a flipped classroom model, putting the lectures online allows the students to control their pace of learning. The use of video and other pre-recorded media puts lectures under the control of the students (Kanuka, 2005). They can watch, rewind, and fast-forward the lesson at any time as needed. There are plenty of video clips available online freely, which related to mathematics questions and solutions. Students can view the lectures and sample problems solving at their own preferable time. The use of technology to transfer the knowledge, helped to break through the temporal or spatial constraints, which enable the self-directed learning outside of class (Johnson et. al, 2013). This flexibility of learning is beneficial to students especially for those slow learners.

Furthermore, flipped classroom model makes the class activities be more interesting and joyful. It has created a more dynamic learning environment. There are more interactions among students, and between lecturer and students (Johnson et. al, 2013). The timely and appropriate interaction between lecturers and students is very important (Swan, 2003). When students encounter any problems in their learning, the feedback provided by lecturers can guide students to reexamine their learning process, overcome their weakness, and seek for the methods to solve their problems (Winne & Hadwin, 2010). Through the interaction, lecturers will know well about their students' learning styles and pace of study (Bergmann & Sams, 2012; Gannold et al. 2008; Gerstein, 2012). This will give lecturers some ideas in designing the class activities.

Group discussions in the flipped classroom provide more opportunities for questions and answers clarification. It encourages students' engagement in the problem-based learning, which will help them in improving the critical thinking and problem-solving skills. Collaborative learning in groups is incorporated through flipped classroom as well. Interactions during class

activities had a positive effect on students' learning achievement (Gannold et al., 2008). Students were given opportunities to handle or solve different level of problems.

The changing in the role of lecturer and students happened in a flipped classroom. Lecturer became a facilitator in student's learning process by providing a timely feedback and assistance during class time (Bergmann & Sams, 2012; Gannod et al., 2008). Meanwhile, students be more active and self-responsible in gaining the new knowledge by doing a lot of pre-class preparation. Students had trained to be more self-learners and problem-solvers.

In summary, flipped classroom method effectively enhances the students' level of focus and commitment, and hence, promotes a higher-level achievement. It has the opportunity to cause a significant shift in the way instruction is delivered in class. Using technology, teachers are now able to provide an alternative to traditional lecture-based models by implementing a blended learning method that combines the benefits of direct instruction and active learning to engage students in the learning process.

## Conclusion

On overall, students in the flipped classroom achieved better results in their topic test compared to students in the conventional class. Quantitative data showed that there were significant differences in students' mean test marks and grades distributions between the flipped classroom and conventional classroom. However, there were no significant differences in mean test marks and grades distribution between male and female students in the flipped classroom. Gender was not an issue in affecting students' test performance. As a conclusion, the findings in this study did support the initial hypothesis, and in hope that, these findings will serve as a reference for lecturers or educators in their future planning of teaching strategies.

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