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## Flipped Classroom: Enhancing Mathematics Achievement and Investigating Critical Thinking Skills of Grade 11 Students

Nitthawat Leelawatthanapan<sup>1</sup>, Chaweewan Kaewsaiha<sup>2</sup>

<sup>1, 2</sup>International College, Suan Sunandha Rajabhat University

### Abstract

The purposes of this classroom action research on using flipped classroom approach were: 1) to enhance students' achievement and 2) to investigate students' critical thinking skills in learning 'Derivative of Functions'. Thirty Grade 11 students were purposively selected and served as the participants of this study. They studied in the special program and took the additional mathematics course in the second semester of the academic year 2017. The research instruments consisted of learning management plans for 12 periods, achievement test and critical thinking skills tests. The research design was one group pretest-posttest based on the flipped classroom approach in learning content and investigating on critical thinking skills. The statistics used in data analysis were Effectiveness Index (E.I.) and the percentage. The results showed that the E.I. was 0.6384, which was higher than the acceptance criteria of 0.50 or 50%, which concluded that the flipped classroom approach affected increasing students' achievement by 63.84% compared to their previous knowledge. In addition, the percentage of number of students showed critical thinking abilities in each component from the highest to the lowest as follows: 1) Recognition of assumption (86.46%), 2) Deduction (83.12%), 3) Inference (81.04%), 4) Evaluation of arguments (63.96%), and 5) Interpretation (56.67%).

**Keywords:** Flipped Classroom, Mathematics Achievement, Critical Thinking Skill

### Introduction

Mathematics is used as a basic tool to build knowledge and innovation in various disciplines for critical thinking and problem solving. For human development, mathematics develops analytical, synthesis, and critical thinking (Makanong, 2009). In learning mathematics, the process of solving mathematics problems involves thinking levels that students can solve the problems by understanding the problems before planning problem solving. They have to read the problems and collect data to obtain the information logically by validating, analyzing, and connecting the data which requires the use of critical thinking to help in every step in order to solve the problem successfully (Krulik & Rudnick, 1993, pp. 4–5).



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In light of enhancing students' achievement and engaging students to solve the mathematics problem critically, the researcher focused on using classroom action research. This type of educational research can be defined as the process of studying about how to improve teaching and learning practices or resolve problems in classrooms through systematic multiple cycles of planning, acting, observing, and reflecting. Before starting classroom action research, the teacher should collect about the several recurring difficulties that students often encounter in successful completion of lesson or topic they have learned. These difficulties are problems of teacher and students that need to be solved. In addition, the teacher conducts the action research in the classroom as a researcher to solve problems that occur in the classroom and bring results to improve learning, teaching, and promoting the development of learners to be better in order to maximize the benefits for learners and it is conducted by the teacher while teaching and teacher focuses attention on a problem or question about his or her students (Mettetal, 2012; Wongvanich, 2003).

The flipped classroom approach is one of innovative learning centered pedagogies that can support "Teach less, Learn more" policy because the flipped classroom approach takes less time in the classroom but focuses on self-learning outside the classroom. Students study the content at home in advance from the provided video, while doing homework, learning activities and exchanging ideas in classroom. This learning approach changes the main focus in the classroom from the teacher's teaching to students' learning (Bergmann & Sams, 2012).

The main idea of "Flipped Classroom" is a reverse of traditional teaching strategy that students can study the content and pre-recorded lectures from video lecture or other instructional materials by themselves and study in advance at home, and then the teacher will use activity in classroom to reflect students' learning by asking them questions and discussing in a group, while teacher's roles as the facilitator to advice and answer students' questions. In addition, teacher manages class time more actively learning to engage students participate in applying concepts and creativity in subject matter (Piehler, 2014).

In this research, Flipped Classroom means organizing learning activities that consist of 2 parts: learning outside the classroom and learning inside the classroom. Learning outside the classroom is learning from video media and guided notes (used as the study guide), describing the basic knowledge content, prepared or selected by teacher via the internet. In terms of learning inside the classroom, it will be a place where students can practice the accuracy of the content by doing assignments or practicing skills through activities that focus on students as the center of the learning process and give them opportunities to interact with other students in class, learn together and help each other. For a teacher, he/she will act as



a motivating force or a facilitator to support students learning as well as listening to their problems.

Critical thinking is an advanced and complex thinking process, starting with issues, arguments, or uncertainty by relying on personal knowledge, ideas, and experiences in understanding through the process of gathering and linking existing information carefully before deciding what should be believed or should be done to help judge the situation correctly and act or not act. Critical thinking has to go through the steps or processes for making a rational conclusion (Ennis & Millman, 1985).

In this study, the researcher reviewed Watson-Glaser Critical Thinking Appraisal measurement tools which provided to assess students' critical thinking to get objective data that benefits teachers to improve students' thinking skills and their academic achievement as categorized in five parts (Watson & Glaser, 2002): (1) **Inference** (identify and determine the probability of a conclusion whether it is true or false); (2) **Recognition of Assumption** (identify text, whether which one is the basic agreement); (3) **Deduction** (find a reasonable conclusion from the given claims by using logic); (4) **Interpretation** (give the weight of information or evidence in order to determine the possibility of a conclusion); and (5) **Evaluation of Arguments** (judge, classify the reasoning whether which one is reasonable).

### Research Objectives

1. To enhance Grade 11 students' achievement in learning topic on 'Derivative of Functions' using flipped classroom approach
2. To investigate the critical thinking skills of Grade 11 students being taught by using flipped classroom approach

### Research Methodology

#### Participants

The participants in this study were thirty Grade 11 students studying in the second semester of the academic year 2017.

#### Content

The contents used in this study were 'Derivative of Functions' indicated in the Basic Core Curriculum B.E. 2551 (A.D. 2008), i.e., (1) The definition of a derivative in the form of a limit.; (2) The basic formula for derivative; (3) The derivative of composite functions; (4) High order derivative; and (5) Application of derivative;

### Variables

1. The independent variable was learning management activities of ‘Derivative of Functions’ using flipped classroom approach.

2. The dependent variables were students’ achievement and critical thinking skills by using flipped classroom approach in studying ‘Derivative of Functions’.

### The duration of this study

This study was conducted in the second semester of the academic year 2017. The time allocation of teaching and learning activities was 12 periods with 50 minutes in each period.

### Research Instruments

The instruments used in this study were as follows:

1. Lesson plans consisted of 6 plans (12 periods) on ‘Derivative of Functions’ topic by using ‘Flipped Classroom’ approach to enhance students’ mathematical achievement and investigate students’ critical thinking skills. All lesson plans covered systematic multiple cycles of planning, acting, observing, and reflecting through five cycles: Cycle 1: Derivative of function in the form of a limit, Cycle 2: Basic formula of finding derivative, Cycle 3: Derivative of composite functions, Cycle 4: derivative, and Cycle 5: Application of Derivative..

2. Achievement test consisted of 20 multiple choices with illustrating reason to assess students’ achievement as Pretest and Posttest, before and after using ‘Flipped classroom approach’ on the ‘Derivative of Functions’ topic for Grade 11 students.

3. Critical thinking skills test on ‘Derivative of Functions’ consisted of 12 selected response items and 8 items of selected response test with illustrating reasons of selected.

4. Videos and guided notes with contents validity for learning outside the classroom and discussion in the classroom for each cycle of action research on ‘Flipped Classroom’ approach was used to enhance students' mathematical achievement and investigate critical thinking skills.

Figure 1 and Figure 2 illustrate video and guided note that was used in this research.



Video	QR code
	

Figure 1: An Example of Video on Definition of the Derivative

Source: [https://www.youtube.com/watch?v=-ktrtzYVkJ\\_I](https://www.youtube.com/watch?v=-ktrtzYVkJ_I)



<p><b>Guided note:</b> Finding the derivative of a function using the definition of a derivative in the form of a limit</p> <p>1. Find derivative of <math>y = f(x) = x^2 + 3x</math> compare to <math>x</math> at <math>x = x_0</math> when</p> <p>1.1 <math>x_0 = 2,</math> <span style="float: right;">1.2 <math>x_0 = -4</math></span></p> <p><math>y_0 = f(x_0) = (x_0)^2 + 3(x_0)</math>  <math>y_0 + \Delta y = f(x_0 + \Delta x)</math>  <math>= (x_0 + \Delta x)^2 + 3(x_0 + \Delta x)</math>          .....  <math>\Delta y = f(x_0 + \Delta x) - y_0</math>          .....  <math>\frac{\Delta y}{\Delta x} = \frac{f(x_0 + \Delta x) - f(x_0)}{\Delta x}</math>          .....</p>	<div style="border: 1px solid black; padding: 2px; text-align: center; font-size: small;">Write your questions and thoughts here!</div> <p>derivative of <math>y = f(x)</math> compare to <math>x</math> at <math>x = x_0</math> is .....</p> <p>1.1 when <math>x_0 = 2,</math> Value of derivative is .....</p> <p>1.2 when <math>x_0 = -4</math> Value of derivative is .....</p>
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Figure 2: Guided Note

### Data Collection

The researcher collected the data to support research objectives as follows:

Objective 1: To enhance students' mathematical achievement of Grade 11 students who have been taught by using 'Flipped Classroom' approach on the 'Derivative of Functions' topic

The 'Pretest' and 'Posttest' with the same set of questions concerning the contents of 'Derivative of Functions' was used to collect the data from students' test scores to determine students' achievement

Objective 2: To investigate students' critical thinking skills consisted of 5 components: 'Inference, Recognition of Assumption, Deduction, Interpretation, Evaluation of Arguments.

### Data Analysis

The researcher analyzed data for Objective 1 and Objective 2 in the following details:

Objective 1: The researcher analyzed data by calculating the E.I to show the development of students' mathematical achievement. As shown in the following formula:

$$E.I. = \frac{Post - Pre}{Total - Pre}$$

Where: *E.I.* is Effectiveness Index

*Post* refers to the sum of all students' posttest scores

*Pre* refers to the sum of all students' pretest scores

*Total* refers to the sum of all students' full score

The criteria for acceptance of the value of E.I. is above 0.50 or 50% (Kidrakan, 2002).



Objective 2: The researcher analyzed data by using mean and percentage on five skills of critical thinking of students such as (1) Recognition of assumption, (2) Inference, (3) Deduction, (4) Interpretation, and (5) Evaluation of arguments.

## Results

For objective 1, the researcher calculated E.I. to illustrate the percentage of students enhance mathematical achievement after using 'Flipped Classroom' approach in learning activities.

Table 1: Effectiveness Index (E.I.) of Students' Development in Mathematical Achievement

N	Total of Full scores	Total score of students		E.I.	Percentage
		Pretest	Posttest		
30	600	159	455	0.6642	66.42

From Table 1 shows the Effectiveness Index which indicates 30 students' achievement enhance on 'Derivative of Functions' topic after being taught through 'flipped classroom'. The sum of full scores of total students is the product of the number of students ( $N = 30$ ) and the total of full scores of the pretest (20 scores) is 600. The total scores of the 'Pretest' and 'Posttest' score of 30 students gained are 159 and 455, respectively. The E.I. is equal to 0.6642, which means that the achievement of students increases from the previous knowledge of 0.6642 or 66.42%.

For objective 2, the researcher investigated the students' critical thinking skills and calculated in percentage development in each component of critical thinking skills from their test scores. The results were listed in Table 2.

Table 2: The Percentage Scores of each Component of Students' Critical Thinking Skills in Learning 'Derivative of Functions' Using 'Flipped Classroom' Approach

Elements of Critical Thinking skills	Percentage Score	Mean ( $\bar{X}$ )	S.D.
Recognition of Assumption	86.46	13.83	2.09
Inference	81.04	12.97	2.40
Deduction	83.12	13.30	2.17
Interpretation	56.67	9.07	3.29
Evaluation of Arguments	63.96	10.23	3.06



The results in Table 2 show that the percentage of thirty Grade 11 students after studying through the 'Flipped Classroom' can develop the critical thinking skills in five elements ranking from the highest as follows: Recognition of assumption 86.46%, Deduction 83.12%, Inference 81.04%, Evaluation of arguments 63.96%, and Interpretation 56.67%.

In addition, the results in Table 2 demonstrate that the critical thinking skills of thirty Grade 11 students falls within each component different by mean ( $\bar{X}$ ) and standard deviation ( $S.D.$ ) in the following: (1) Recognition of assumption with  $\bar{X} = 13.83$  and  $S.D. = 2.09$ ; (2) Inference with  $\bar{X} = 12.97$  and  $S.D. = 2.40$ ; (3) Deduction  $\bar{X} = 13.30$  and  $S.D. = 2.17$ ; (4) Interpretation with  $\bar{X} = 9.07$  and  $S.D. = 3.29$ ; (5) Evaluation of arguments with  $\bar{X} = 10.23$  and  $S.D. = 3.06$ .

## Results and Discussion

This action research using 'Flipped Classroom' approach aimed to develop thirty Grade 11 students' mathematical achievement and to investigate students' critical thinking skills in mathematics in learning 'Derivative of Functions' topic.

The results of using 'Flipped Classroom' approach for thirty Grade 11 students indicated that this approach had the effect on the enhancement of students' achievement in learning 'Derivative of Functions' topic which affirmed the study of lamumnuaisuk's (2013, pp. 72–73) using the flipped classroom teaching approach and illustrating that improve student's achievement. Moreover, using online videos with guided notes as part of tools in learning outside the classroom allowed students to spend most of their times engaged in learning. In the classroom, the students expected to be corrected misconceptions or errors from the teacher and classmates. Also, using video as instruction media via online resources provided more control over their learning could help students to be more personalized, cooperative groups fostered critical thinking through the 'Flipped Classroom' approach (Baker, 2011).

Considering of the results of the critical thinking skills of thirty Grade 11 students, after using 'Flipped Classroom' approach had an effect on Recognition of Assumption, Deduction, Inference, Evaluation of Arguments, and Interpretation. The fact that students must interpret the concepts learned to answer questions in the guided notes, which are questions about the details of the concept via watching the video outside the classroom. It helps students practice *Interpretation* and *Deduction*. In-classroom students listen to the reason of others in the group and consider it reasonable will help students practice *Evaluation of Arguments*. Teachers set issues to allow students to ask questions, discuss content, ask questions for students to review, bring knowledge gained from watching videos from discussions, summarize knowledge through



participation, and do exercises in the classroom. Students are trained to consider various environmental conditions and to predict what is possible. Students must summarize the possible answers and give reasons to support why the answer is a reasonable answer to help students practice Inference. Allowing students to think of possible conditions for the desired results to help students practice Recognition of Assumption. This finding is consistent with Sinthapanan (2009) that the development of critical thinking abilities of students can be done by organizing activities that emphasize systematic thinking processes, allowing students to think and interpret what they have learned and then expand the results of what you think.

### Recommendation

‘Flipped Classroom’ approach for teaching mathematics on ‘Derivative of Functions’ topic is recommended as the alternative approach with its benefits to develop students’ mathematics achievement and mathematical critical thinking skills for further work as follows:

1. Teachers should prepare a variety of materials for students to self-study outside the classroom that is necessary to be successful in learning and allow students to choose the materials such as videos that more suitable for them to understand;
2. Teachers should provide formative tests to assess the knowledge of students what they have learned both outside and inside the classroom and/or suggest the previous tests for the students to practice more.
3. Teachers should design the tests to measure students’ mathematical thinking skills applying different types of tests such as ‘Critical Thinking Skills Test’, ‘Reasoning Skills Test’, ‘Interpretation and Communication Skill Test’, and so on.

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