

## Application of The Flipped Classroom Method and Effectiveness in Learning Mathematics

Pardimin<sup>1</sup>, Siti Rochmiyati<sup>2</sup>, Zainnur Wijayanto<sup>3</sup>, MohRusnoto Susanto<sup>4</sup>

<sup>1</sup>pardimin@ustjogja.ac.id, <sup>2</sup>rochmiyati\_atik@ustjogja.ac.id, <sup>3</sup>zainnurw@ustjogja.ac.id,  
<sup>4</sup>rusnoto@ustjogja.ac.id

<sup>1</sup>Elementary Education Program Dikdas, Pasacsarjana UST Yogyakarta, Indonesia,

<sup>2</sup>Indonesian Language of Education Program, UST Yogyakarta, Indonesia,

<sup>3</sup>Education of Mathematic Program, UST Yogyakarta, Indonesia,

<sup>4</sup>Visual Art Education Program, UST Yogyakarta, Indonesia

### Abstract:

The effectiveness of traditional teaching and learning has been a topic of research for many years. Various studies were conducted to find out the approaches that focus on the learner's role and make them the center of the learning process. One of the learning models that has attracted the attention of many researchers and educators was the Flipped Classroom Learning Model. In this study, researchers want to investigate flipped classrooms' effectiveness in terms of students' academic achievements and student responses. The subjects who participated in this research were students of 8<sup>th</sup> grade in a junior high school in Yogyakarta, as many as seventy students. Selection of the research subjects by considering the research objectives. The participants were divided into two groups, the experimental group (flipped classroom) and the control group (direct learning). This study's findings indicate that most students showed greater preference for the flipped classroom than the direct learning model. Learning in a flipped classroom increases students' academic achievements. It reaches good student responses, including positive learning experience, quality group discussions, building motivation, understanding the topics, and desire to re-engage in the flipped classroom.

**Subjects: Educational Research; Education Studies; Effectiveness & Improvement; Teaching and Learning; Teaching Methods**

**Keywords:** flipped classroom, learning model, mathematics learning

### 1. Introduction

The effectiveness of traditional teaching and learning (in this case: direct teaching method) has been a research topic for many years (Davis, Hodgson, & Macaulay, 2012; Lane & Harris, 2015; Schmidt, Wagener, Smeets, Keemink, & Molen, 2015). In direct teaching method, an educator served to deliver curricula. It contradicts the constructivist teaching methods where students actively construct their understanding by reflecting on previous experience and knowledge (Smallhorn, 2017). Various studies were conducted to find out the approaches that focus on the learner's role and make them the center of the learning process. One of the learning models that has attracted the attention

of many researchers and educators was the Flipped Classroom Learning Model (Emine Cabi, 2018). Studies of the flipped classroom have been carried out in various disciplines (Davies, Dean, & Nick Ball, 2013; Kim, Kim, Khera, & Joan Getman, 2014; Yu Zhonggen & Wang Guifang, 2016; Zengin, 2017). What is Flipped Classroom and Why?

Flipped classroom is a method for educators to provide instruction by minimizing direct instruction in their teaching practice while maximizing their interactions (G. B. Johnson, 2013). The concept of a flipped class, which was previously done in class, is now done at home (Bergmann & Aaron Sams, 2012). It can be imagined as students generally learn in class, they do it at home and vice

versa. In the classroom, teacher acts as a facilitator and a server to design web-guided questions before the class (Neel Sharma, Lau, Doherty, & Harbutt, 2014). Students learn new material independently at home by reading or watching learning videos and by some problems as their home assignment while group-based problem-solving activities are carried out in the classroom (Bishop & Matthew A Verleger, 2013). Homework that is usually completed at home is completed at school. Flipped classroom learning model is focused on learning using video media at home and maximize class time with students (Bishop & Matthew A Verleger, 2013). The primary purpose of implementing the flipped classroom is to improve learning outcomes (Baepler, Walker, & Driessen, 2014; Bansal, Bansal, Ahmad, & Pandey, 2020; Davies et al., 2013; Malek Jdaitawi, 2019) and student motivation (Guan et al., 2020; Lanqin Zheng, Bhagat, Zhen, & Zhang, 2020; Suo & Xiuying Hou, 2017; Zainuddin & Halili, 2016; Zengin, 2017).

It frees up class time that would normally be used for learning. Because of using technology in learning to provide students with additional supporting learning materials that can be accessed online, the flipped classroom makes learning become more enjoyable (Natalie B. Milman, 2012). In a flipped classroom, the activities are based on constructivist principles where students act as researchers (Mahdi M. Alamri, 2019). The learning activities that traditionally occurred inside the classroom were taken outside, and vice-versa (Lage, Platt, & Treglia, 2000). Students spend a lot of class time discussing ideas in peer groups while learning from online materials provided by the teacher is done at home. Students' assignments are taken from manipulative learning materials, not from the workbooks and textbooks as in traditional learning. Besides, students complete their group tasks, not by their own (Findlay-Thompson & Mombourquette, 2014; Jeremy F. Strayer, 2012).

There are various definitions of a flipped classroom (Street, Gilliland, McNeil, & Royal, 2015). One of them said that a flipped classroom is a new method that provides learning videos and some problems as their home assignment while group-based problem-solving activities are carried out in the

Classroom (Bishop & Matthew A Verleger, 2013). Others said that flipped classroom is an approach that involves a teacher who acts as a facilitator and server to design web-guided questions before the class (Neel Sharma et al., 2014). Despite the varied definitions, the primary purpose of implementing the flipped classroom is to improve learning outcomes (Baepler et al., 2014; Bansal et al., 2020; Davies et al., 2013; Malek Jdaitawi, 2019) and student motivation (Guan et al., 2020; Lanqin Zheng et al., 2020; Suo & Xiuying Hou, 2017; Yilmaz, 2017; Zainuddin & Halili, 2016).

The use of technology in free and flexible learning because it provides additional supporting learning materials that can be accessed online, the flipped classroom makes learning more fun and supports a meaningful learning climate. In the context of the spirit of the Merdeka Campus Program (MBKM) which provides flexible and independent space for self-development that can be accessed through the implementation of the Merdeka Learning curriculum, the Merdeka Campus is very much in tune with using the Flipped Classroom approach, which is more class time that is usually used for studying. The question is how the application of the flipped classroom in providing a high level of effectiveness in learning mathematics and what specific findings can be ensured to increase the quality of the learning process that is effective, relevant, and enjoyable.

## 2. Method

### 2.1. Participants

The subjects who participated in this research were all students of 8<sup>th</sup> grade (as many as 2 class) in a junior high school in Yogyakarta-Indonesia, especially in mathematics subject as many as seventy (70) students. Selection of the research subjects by considering the research objectives: to investigate flipped classrooms' effectiveness in terms of students' academic achievements and student responses. The participants were divided into two groups, the experimental group, which was taught using Flipped Classroom model (FC), and the control group that taught by using the Direct Learning model (DL). The number of participants and research design overview can be seen in **Table 1**.

**Table 1. Design of the study**

Group	Participants	Pre-test	Post-test
Experimental (FC model)	35 students	Test	Test-interview-questionnaire
Control (DL model)	35 students	Test	Test

## 2.2. Design Research

This study was designed using a mixed-methods approach: qualitative and quantitative approach. Qualitative data approach aims to generalize the conclusions of a problem, while quantitative data aims to reveal data in detail (R. B. Johnson & Onwuegbuzie, 2004). The independent variables are flipped classroom and direct learning models, while the dependent variable are students' academic achievements and student responses. Data were collected by observation, interviews, documentation, questionnaires, and tests. This study also applied Forum Group Discussion (FGD) conducted by researchers and teachers to prepare the learning model to be developed.

The data in this study was in the form of (1) data of student responses after participating in flipped classroom learning that obtained by questionnaire and interview technique; and (2) data of student's academic achievements. Geometry test was conducted before and after the treatment to measure students' academic achievement. The data of student's academic achievements (geometry test result) and questionnaire were analyzed using an independent sample t-test by SPSS to identify statistical differences between experimental and control groups. In comparison, the interview results were qualitatively analyzed. The experimental and control group learning design are shown in Figure 1.

**Figure 1. The learning design for both of group**

In the learning process, both of groups were given the same topics with different teaching methods. In the flipped classroom model, video lectures are recorded and published to YouTube. Students are responsible for watching the video and asking any questions they have about the concept after watching the video, making a summary if they understand the lecture and have no questions, or doing practice of problem solving. Questions or summaries are used to stimulate class discussion.

The remaining classroom time was devoted to working on projects, readings, watching learning videos and other assignment that may otherwise be assigned for homework

to learn new subjects independently. Meanwhile, in direct learning methods, teacher plays a role in providing material and giving some problems for student to be solved as an exercise. It taken from the worksheets and textbooks, and students complete their tasks by their own. After class meeting, students doing their assignments at home as practice and problem solving activity.

## 3. Results dan Discussion

### 3.1. Results

#### How does the FC model affect students' academic achievement?

This study determines whether there is an effect of FC model implementation on

students' academic achievement. The homogeneity-test was conducted first. A homogeneity-test was performed to identify

any statistically significant differences between the two groups' pre-test scores (Kang & Fadhilah Yusof, 2012).

**Table 2. The Result of The Homogeneity-test**

Data	Levene Statistic	Sig.
Pre-test	1.858	.116

Based on the results of the homogeneity-test (see **Table 2**), it can be concluded that there were no statistically significant differences between the average pre-test score of the two groups (sig. 0.116 > 0.05). It can be stated that both groups are equivalent. It means that the data measurements are taken at a time with the same instruments and environments.

After determining the homogeneity of the

test, the mean and standard deviation of academic achievement scores were calculated to find out whether there is a statistically significant differences between means of academic achievement scores attributed to the teaching model variable. **Table 3** shows the mean and standard deviation values of the post-test scores of students in the experimental (FC method) and control groups (DL method).

**Table 3. Achievement Test Scores of Two Groups**

	Class	N	Mean	Std. Deviation (SD)	Std. Error Mean
Post-test	Flipped Classroom	35	80.8000	3.16971	.53578
	Direct Learning	35	62.6857	4.37084	.73881

Based on Table 3, the post-test mean score of students in the Flipped Classroom group (M=80.80) was higher than the Direct Learning group (M=62.68). This result indicated that giving different treatments can affect the students' academic achievement. Students who were treated using the Flipped Classroom learning model, obtained higher academic achievement results than students who were treated with the Direct Learning learning model. Another study showed that Flipped Classroom Group lead to higher students' academic achievement compared to Direct Learning Group (Day & Foley, 2006; Marcey & Michael E. Brint, 2012; Tune, Sturek, & Basile, 2013; Wilson, 2013). Furthermore, it can be seen that the standard deviation of the Flipped Classroom group (SD=3.17) was lower than the Direct Learning group (SD=4.37). It's demonstrated that the students' mean through Flipped Classroom learning model was more representative than direct learning. This analysis shows that there was statistically significant differences

between means on achievement test score (post-test score).

Next, an independent sample test (t-test) was conducted to determine whether there was a statistically significant differences in students' academic achievement (post-test score) between the Flipped Classroom and Direct Learning Group. Data analysis was carried out using SPSS at a 5% level of significance. In this case, hypothesis testing is carried out using inferential statistical analysis. In order to determine whether the null hypothesis is rejected or accepted, we need to observe the values of  $t_{cv}$  and  $t_{obs}$ , if  $t_{cv}$  (t-critical value) was lower than  $t_{obs}$  (t-observed), the null hypothesis would be rejected and vice versa. In analyzing using the t-test, the  $t_{obs}$  value needs to be compared with the  $t_{cv}$  value to find out whether the average scores of the Flipped Classroom and Direct Learning groups are statistically significant. Table 4 presents the results of the independent sample test (t-test).

**Table 4. Results of the independent sample test (t-test)**

		Levene's Test for Equality of Variances		t-test for Equality of Means			95% Confidence Interval of the Difference			
		F	Sig.	t	df	Sig.(2-tailed)	Mean Difference	Std.Error Difference	Lower	Upper
Posttest	Equal variances assumed	6.940	0.010	19.848	68	0.000	18.11429	.91263	16.29316	19.93541
	Equal variances not assumed			19.848	62.014	0.000	18.11429	.91263	16.28997	19.93860

Based on Table 4, it is known that the value of Sig. (2-tailed) is 0.000. It indicates that the observed level of significance was less than the standard alpha level (Sig. [2-tailed]=0.000 <  $\alpha=0.05$ ). In addition, we also need to analyze hypothesis testing ( $t_{obs}$  and  $t_{cv}$ ). It is known that the value of  $t_{obs}$  is 19.848 and the t-critical value for degrees of freedom (df) 68 is 1.99547 (Table 4). So,  $t_{cv}$  was lower than  $t_{obs}$  ( $1.99547 < 19.848$ ), therefore, the null hypothesis is rejected and the alternative hypothesis ( $H_a$ ) is accepted. It means that there is an influence of learning model on students' academic achievement. In other words, it can be said that there is a significant effect of the application of the Flipped Classroom learning

model on student achievement, where students in the Flipped Classroom group show better performance than the Direct Learning group.

### 3.2. How do students respond to learning using the Flipped Classroom Model?

The effect of the flipped classroom learning model implementation is also seen from the student's response to learning, not only from the measured academic achievement. A questionnaire was provided to investigate the student responses who are learning using the flipped classroom model. The results of the questionnaire were presented in Table 5.

**Table 5. Results of the questionnaire**

No.	Indicators	Mean	SD
1.	Encourage participation effectively in forum discussion	3.51	.51
2.	Discussions in the flipped classroom can be assisted students in understanding the topics	3.43	.50
3.	Encourage students to make efforts to search for topics on the internet to improve participation in learning	3.46	.51
4.	Provided a positive learning experience	3.43	.50
5.	Be able to learn from the topics well	3.69	.47
6.	Stimulate students to complete additional assignments on topics discussed in the course	3.51	.51
7.	The learning activities and assignments of this course are often found in everyday life	3.60	.50
8.	The flipped classroom course can achieve student learning expectations	3.06	.84
9.	The flipped classroom can improve students learning outcomes	3.37	.49
10.	There is a desire to take another flipped classroom courses in the future	3.09	.78

The results of the questionnaire showed a good responses in learning using flipped classroom ( $M > 3.00$ ). Most participants agreed that the flipped classroom learning model can stimulate students to complete additional assignments ( $M = 3.51$ ,  $SD = .51$ ). The learning activities and assignments are close to students' daily lives ( $M = 3.60$ ,  $SD = .50$ ). So, it could be provided a positive learning experience ( $M = 3.43$ ,  $SD = .50$ ). In addition, with the flipped classroom learning model, students are encouraged to be active in learning. Students make efforts to find topics on the internet ( $M = 3.46$ ,  $SD = 0.51$ ) and complete additional assignment on topics discussed in the course ( $M = 3.51$ ,  $SD = 0.51$ ) to increase their knowledge. Discussions in the flipped classroom can assisted students in understanding the topics ( $M = 3.43$ ,  $SD = 0.50$ ), they were able to learn using flipped classroom ( $M = 3.69$ ,  $SD = .47$ ), so it can improved students learning outcomes automatically ( $M = 3.37$ ,  $SD = 0.49$ ). The conclusion, they state that flipped classroom learning model can achieve student learning expectations ( $M = 3.06$ ,  $SD = .84$ ). They desire to take another flipped classroom courses in the future ( $M = 3.09$ ,  $SD = .78$ ).

An analysis of student responses based on the results of the questionnaire ( $n=70$ ) found that 93% of respondents stated that the flipped classroom learning model provided a positive learning experience (Table 5, point 4). Interviews ( $n = 10$ ) were conducted to clarify the results of the questionnaire. They commented that the flipped classroom model gave them the opportunity to ask questions in the forum both of peers and educators, challenged their understanding, and encouraged them to apply what they had learned. A student said: *Learning in this way allows me to understand the topic and applies what I have learned in my daily life in an environment where there is help available (both from other students and teacher). Learning math becomes more fun and*

*challenging.*

The questionnaire also revealed their group experience (Table 5 points 1 and 2). 85% of respondents said that learning in small informal groups was beneficial for their learning attributed to the contribution of group members. It could be increasing students' self-confidence, build teamwork, and exchange knowledge. Student a stated: *I am become confidently ask questions to other, debate about the topics, and doing interactions with each other during online discussions. Each of us often expressed an opinion. Usually, I'm fear of talking in front of my friends in the classroom. By small group discussion, I can focus on the topics so that I can understand the topics easily.*

A number of 92% of respondents state that they were highly motivated in the experiment class. Most of the students expressed that they made an effort to study. Student D said: *"...I prefer to study through audio/video record, online assignments & material, and search for topics from various sources on the internet"*. The highest percentage on level of students' satisfaction is easier to understand the topics. Almost all students said that they were able to learn the topics well. Student B said: *"I have more time to discuss with others (student) and teacher. So I can understand the topic better than usual (direct learning)"*. The number of 74% of respondents wishes to reuse the flipped classroom learning model. Student C commented: *"I want this learning to be done in other disciplines as well."* These results are supported by the other studies, which had a positive impact on student's attitudes toward the class and teacher as well as on students' performance in the class (Mason, Shuman, & Kathleen E. Cook, 2013; McLean, Attardi, Faden, & Goldszmidt, 2016; Wilson, 2013).

There were problems encountered by students when learning using the FC model. The problems were categorized under two major themes (see **Figure 2**).

**Figure 2. Problems encountered by students**

Four students stated that they had content problems. The topic that has been chosen is difficult to understand and feels boring. Geometry is considered difficult to understand for students who do not have good visual abilities. Three students encountered learning problems related to time constraints. They commented that they were difficult to schedule time to watch the online video. They couldn't manage their time well: "*..... it's difficult to manage time at home to watch the learning videos and understand the topics given by the teacher*". At the same time, the other twenty-eight students did not have any problems.

This flipped classroom has been used in various subjects and is intended to increase interaction and communication between students and teachers (Uzunboyulu & Karagozlu, 2015). It exchanges learning inside and outside the classroom at the same time. It is expected to result in positive and significant changes in students' comprehension. One of the reasons for the flipped classroom's growing popularity is a desire for student involvement. The flipped classroom modifies the traditional sequence of in-class and out-of-class activities. In the flipped classroom, traditional classroom content is presented to pre-class students through videos, simulations, or other electronic means. As a result, students arrive familiar with the content rather than being introduced to new content in the classroom. The remainder of the class period will be devoted to discussions, explorations, collaboration, and additional examples to improve student comprehension.

We recommend that classroom teachers build on the literature when designing flipped classrooms. The researchers' voices will aid flipped educators in avoiding future problems in the classroom. We might consider changing the classroom culture to emphasize the exchange of mathematical ideas with consistency and precision and to demonstrate

the variety of approaches (M.-T. Lo, Chen, & Lin, 2017). While the students' final performance has improved, more research could help determine what aspects of the classroom contributed to this improvement (Larriane Collins, 2018). The flipped classroom seeks to improve learning by involving students in non-traditional educational activities. Over the last decade, flipped classrooms have grown in popularity and have become a topic of discussion in teaching and learning forums. Through a flipped-down approach to the classroom, students' performance improved, and they understood concepts better. Evidence also indicated an increase in learner involvement (Khan & Rashmi Watson, 2018).

Teachers with varying technological comfort and teaching experience levels improved their practice by broadening their community and tools. The flipped classroom tools helped them improve their practice and make it more student-centered (Goodnough & Murphy, 2017). One of the appeals of flipped instruction for many teachers is engaging students in a wide range of learning activities in a setting where they and the students' peers are readily available to assist and collaborate. Teachers who reported relatively high levels of behavioral engagement in their flipped classrooms followed a few best practices. Students were only required to watch the assigned video and complete all ancillary tasks. There was an increase in thought, learning lessons, and quantitative thought due to the flipped classroom. These are satisfactory, but there is room for improvement (Lawson, R, & Son, 2019). This study supports (Clark, 2015) findings on the flipped model of instruction on student engagement and performance in the secondary mathematics classroom. She observed that students were initially resistant to the implementation. The teacher can use this approach in other math

classes to achieve even better results (Buch & Warren, 2017).

The study has implications for other teachers thinking about implementing a flipped-down approach in the classroom, particularly in terms of the time commitment required. In this study, implementing a flipped approach to the classroom included a carefully designed program in which students were given clear guidance, appropriate resources, and dedicated teacher support. Teachers who consider such an approach should consider the time commitment that teachers may be required to make (Muir, 2018). Teachers who flip or are thinking about flipping may benefit from meeting with colleagues or technology specialists who have experience flipping before teaching their first flipped lesson. A teacher of experienced flippers planning and preparing in-class activities could foster growth in selecting appropriate and engaging classroom time activities. Given the significance of adequate class time in flipped learning, school administrators should routinely observe flipping teachers and provide ongoing feedback on the delivery of in-class activities and strategies used to facilitate learning, interactions between students and the teacher, and the use of scaffolding and assessment (Graziano & Hall, 2017).

Both teachers and students found the flipped classrooms to be motivating. For teachers, what was once a more unidirectional approach to teaching in the classroom is being replaced with one that emphasizes student-centered discovery and inquiry. It also extends the out-of-class learning cycle, giving students more time to think and experiment in class, enhancing their problem-solving abilities (Song & Kapur, 2017). However, it has been demonstrated that this strategy has improved retention and comprehension (Zengin, 2017). In the flipped classroom, students have a more optimal learning experience and a higher level of commitment. Students highlight their learning by highlighting their peer loyalty, being noticed, feeling safe, teaching relationships, a physical learning environment, interacting with peers, and using videos to learn new content. When students focus on learning in flipped classrooms, student participation's emotional aspect is especially noticeable (Anna Therese & Foldnes, 2018).

Jang & Kim, (2020) in their research on

the flipped classroom and traditional classroom found that the reverse classroom had a considerable impact on various student learning outcomes. According to the findings, the flipped classroom had a more significant impact on affective and interpersonal outcomes than cognitive outcomes. The flipped classroom features that encourage active engagement and learner-centered interaction can explain this result. Instructors and other educational leaders may seek training to redesign and support flipped classrooms' implementation as an effective pedagogical practice. This approach has been shown in studies to help with mathematics education. Students' qualitative responses also indicated that they benefited from a flipped-classroom approach. It is consistent with the research approach used by (C. K. Lo & Hew, 2017) to improve under-performance and high-capacity student achievement in mathematics.

Roehling, (2017) discovered mixed results for flipped classrooms' efficiency, which were moderated by student characteristics and familiarity with previous online or flipped courses. The flipped classroom instruction effectively increased student interest in the subject and promoted problem-solving discourse. The flipped classroom paradigm is an equally effective method of teaching core mathematics concepts to students (Scott, Green, & Debra Lynn Etheridge, 2016). According to this study's findings, a flipped learning classroom would be ideal for learning mathematics concepts through the strategic use of video content concepts.

The flipped classroom must incorporate both face-to-face and online learning. Online learning is carried out through the use of learning videos, which students can easily access and download from anywhere and allow them to learn it whenever and wherever they want. After studying independently, students can use the videos to assess their abilities by working on some questions and practice questions. Students are also aided by media, which can be used outside of the classroom to ask teachers and other students online if any material has not been understood. Face-to-face learning is accomplished by assigning tasks discussed in groups, and some games can make learning more enjoyable. At the end of the lesson, the teacher can administer a written test to

determine how well students understand the flipped classroom material.

#### 4. Conclusion

The findings of this study indicate that the majority of students showed greater preference for the flipped classroom rather than the direct learning model. Specifically, the results of this study show that, learning in a flipped classroom increases student's academic achievements and reach a good student response, include positive learning experience, quality group discussions, build motivation, easier to understand the topics, and desire to re-engage in the flipped classroom. The flipped classroom learning model can stimulate students to complete additional assignments. The learning activities and assignments are close to students' daily lives. So, it could be provided a positive learning experience. In addition, with the flipped classroom learning model, students are encouraged to be active in learning. Students make efforts to find topics on the internet) and complete additional assignment on topics discussed in the course to increase their knowledge. Discussions in the flipped classroom can assisted students in understanding the topics, in other words they were able to learn using flipped classroom. Flipped classroom model can improved students learning outcomes automatically and can achieve student learning expectations. Learning with flipped classroom is very fun for students. This can be seen from their desire to take flipped classroom courses in the future. It is crucial for future research (other research) to examine the efficacy of flipped classrooms with larger sample sizes, various disciplines, and various levels of education. The flipped classroom learning model concept is when students do learning as always in the classroom at home, and homework generally done at home is completed at school. In this model, students learn new material by reading or watching learning videos independently (at home), and then in class, the lesson is brought to discussion or discussed again. However, this model is learning with the help of video media and how to optimize class time with students.

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