

# Effectiveness of Mathematics Learning Devices Based on Flipped Classroom to Improve Mathematical Critical Thinking Ability Students

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**Abstract:** Involving students actively in the learning process is one of the ways that can be used in developing the learning objectives of mathematics which is to improve students' critical thinking skills. Students can be called have mathematical critical thinking skills if they have a way of thinking systematically, have an awareness in thinking, and have the ability to distinguish a truth from truth, and can provide arguments from a problem. In fact, students do not have the knowledge independently before the learning process begins so the students only expect new information at school. The lack of learning resources that are easy for students to understand makes learning still go in one direction and create passive learners. The impact is made students having difficulty in solving problems with varying level of difficulty due to insufficient time to finish it at school. These unsolved questions become independent tasks at home, and students become more difficult to solve it and caused students have not developed the ability to think critically mathematically yet. The purpose of this study is to create a product in the form of an effective learning video to improve students' critical thinking skills. The development model used is Model Plomp which consists of three phases, namely the initial investigation phase, the prototype development phase, and the assessment phase. The subjects of this study were class XI students and a mathematics teacher. Based on the results of observations during the learning process, students look active in discussions and can solve problems that are given systematically. The results of the final test of students' critical thinking skills, the students' mathematical critical thinking skills increased to 87.87%. It shows that students have good mathematical critical thinking skills after using flipped classroom-based mathematics learning tools. So, it can be concluded that the flipped classroom-based learning device is effective to improve students' mathematical critical thinking skills.

**Index Terms:** Learning device; flipped classroom; mathematical critical thinking

## **1. Introduction**

One of the subjects that played an important role in the advancement of science and technology is mathematics. So, the mathematics learning process should be done actively, that is by involving students and making the student become the centre of the learning process [1]. Then, the objectives of mathematics learning can be achieved optimally, especially students have good mathematical thinking skills [1]. However, in fact showed that students' critical mathematical thinking skills were still low. It can be seen from the results of the student's homework. The results of the homework mostly have similarities, both right and wrong. From the results, it was alleged that the students copied the work of their friends without re-understanding what they were doing. In addition, based on the midterm exam (MID) grade, the odd semester of students in class XI is still below the minimum completeness criteria (KKM) value that has been previously set.

Based on the results of observations in State High Schools in the City of Padang that learning has not focused on students. Basically, students have been able to understand the concepts of each material that is well taught but for the development of problems based on existing concepts students are still experiencing difficulties. So it can be concluded that there were low mathematical ability of students in mathematics learning process, especially critical thinking skills. A student can be called have mathematical critical thinking skills if they have a systematic way of thinking, can determine the

concepts that must be used, know the right strategies in solving problems, be able to provide arguments for the answers given, and be able to evaluate the evidence and decisions taken in existing problems [2, 3].

The time for learning in the classroom is more used by students to understand the concepts and provide examples of questions and exercises that are still classified as a matter of understanding concepts. So that for concept development questions or problem solving questions that require the ability to think critically mathematically students do at home [4]. Students have not been trained to work on questions that are classified as critical thinking skills in the class because of the lack of time to do it. Whereas the problem is the students had difficulties in developing mathematical concepts, especially mathematical critical thinking skills. Therefore innovation is needed in the learning process so that students can improve their critical thinking skills mathematically. Mathematical critical thinking skills can be improved with the help of educators and more emphasis on practice, in mathematics the practice means the student must do more exercising in solving the mathematics problem that has given [5, 6]. So that it is designed a learning device that fits the needs of students.

Learning that is felt to fit the needs of students is learning that uses media assistance in the form of learning videos. With the help of learning videos, students are required to understand the material independently through learning videos at home before the classroom learning process takes place. The aim is the students have more time to practice questions that vary in the level of difficulty with the guidance of educators in the class so that students' mathematical critical thinking skills can be increased. The learning process like this is commonly called flipped classroom based learning.

Flipped classroom is a learning process with reverse ideas, meaning that all activities of students who are usually done in class are reversed or exchanged with activities that are usually done outside the classroom [7, 8]. Bergmann and Sams are figures who re-popularized flipped classroom based learning [9] where learning minimizes the number of direct instructions and maximizes one-on-one instruction. Flipped classroom learning utilizes technology in the form of learning videos that contain explanations of material and sample questions so that students can easily access information about subject matter both online and offline [10]. It means that flipped classroom learning can be used for mathematics because it is in accordance with one of the goals of mathematics learning, namely using technology and adapted to the times [11], and facilitating students to learn independently in understanding concepts so that school students focus more on discussion activities to practice mathematical critical thinking skills.

The advantage of applying flipped classroom based learning based on Bergmann and Sams research [12] is in accordance with the current activities of students where all activities of students are very dependent on smartphones, helping students who have many activities, helping students who have learning difficulties, learning videos can be paused according to needs, educators can distinguish the level of ability of each student, and educate parents to monitor their children while studying at home. The only weakness lies in how to force students to want understanding the videos that educators have prepared for the provision of learning at school.

Learning by applying flipped classroom based learning can improve learning outcomes, sense of responsibility, and independence of learners [13]. Another perceived benefit is that students can maintain interest in learning so that the academic ability of students increases [14]. It caused by the students have been provided with learning videos that require them to understand before entering the class, so that when they arrive in class students are ready to exchange information with their friends. The task of educators is to oversee the course of the discussion and provide assistance when students feel the need so that educators have considerable time in interacting with students [15].

Flipped classroom based learning will also help students to improve their critical thinking skills mathematically. Critical thinking is the activity of training or incorporating careful assessment, in mathematics such as the ability to use concepts that have been understood before, the use of appropriate strategies by doing mature reasoning activities, and being able to argue properly in solving mathematical problems so that the results obtained are correct and can accounted for [16]. In school, students are divided into small groups to actively exchange ideas in solving problems that are already available.

Research conducted by Lamsa et al [16] concluded that active learning processes can create productive learning and better learning outcomes. So it is very important to apply flipped classroom based learning with the help of learning videos as a learning resource that is easy for students to understand. The application of flipped classroom learning will help teachers streamline the time used to explain material in class. The teacher will only repeat or provide reinforcement and explain the most difficult part of the material. Thus, students will be assisted by the teacher for a longer time than the usual learning model.

Flipped classroom learning can improve learning outcomes, a sense of responsibility, and influence students' independence learning [13, 17, 18]. This is because before entering classroom learning, students are required to understand the material and watch learning videos independently. So, when participating in classroom learning, they already have the initial knowledge regarding the material being studied. In the classroom learning process, the teacher equates students' perspective by conducting questions and answers and discussion, then answering various questions according to the subject matter at that time.

## 2. Material and Method

This type of research is development research (R & D). Development research is a process and steps to develop a new product or perfect an existing product [19].

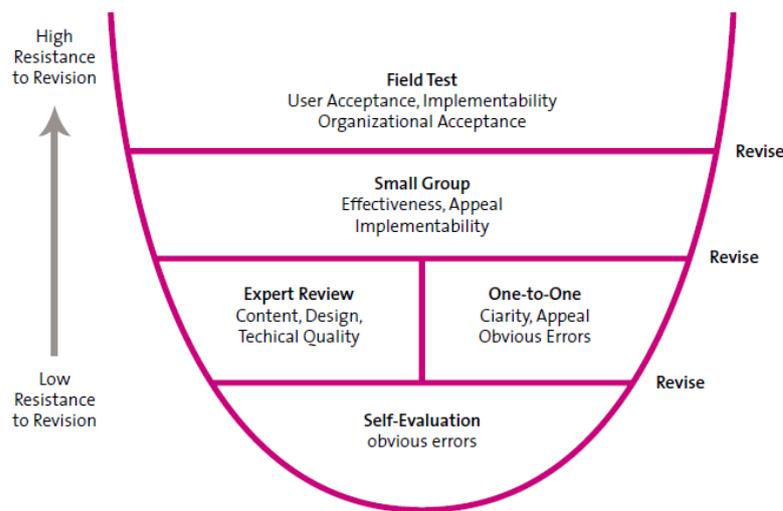


Fig. 1. Formative Evaluation Layer

The development model used is the Plomp model which consists of three phases, namely preliminary research, development or prototyping phase, and the assessment phase [20, 21, 22]. Previous study has reported the result of preliminary research and prototyping phase [23], therefore this study conducted a test that aims to measure the level of effectiveness of the device learning on students' mathematical critical thinking skills. The subjects of this study were class XI students and a mathematics teacher. Students involved 33 students in one different class which was used as the subject of testing for flipped classroom based learning in the field test stage. In this article which is discussed in detail, the effectiveness of the learning device developed.

The instrument used to see the effectiveness of learning devices in data collection in the form of observation sheets and tests of mathematical critical thinking skills. Data collection techniques by means of documentation, analysis of observations of the implementation of the learning process, and analysis of the ability of critical thinking mathematically. The effectiveness of mathematics learning tools can be seen from the results of students' mathematical critical thinking ability tests with a percentage exceeding 75% of students get a minimum score of 80 on a scale of 100. Increased students' critical perception can be seen from student learning outcomes at each meeting through discussion and the value obtained.

### 3. Results and Discussion

Flipped classroom based learning that is applied is a cooperative activity where students interact with each other to solve problems that are already given, while educators are only as facilitators who help solve problems that they consider difficult and cannot be solved. Learning that is carried out forms an intensive and good interaction between fellow students, or between educators and students. Based on research conducted by Velegol [21] it is known that by implementing flipped classroom based learning can increase the active role of students in acquiring new material.

Before testing the effectiveness of learning devices, first the learning device must be valid and practical in its use. Assessment carried out to test the effectiveness of flipped classroom based learning devices is to look at the daily values of students at the time of the field test and the value of the final test results of mathematical critical thinking abilities of students given after being applied flipped classroom based learning.

Based on the results of observations during the field test, it was seen that students' critical thinking skills both oral and written increased every meeting. It was seen that during the discussion students were more confident to express their opinions, active discussion processes and seemed to live. In accordance with Muir's research [24] which shows that students are motivated in achieving the goals of mathematics learning because they feel helped in understanding the material with the learning video and can develop self-confidence for discussion in the classroom. Steen's research [25] shows that the affective dimension of student involvement is very prominent when the learning process applies flipped classroom learning.

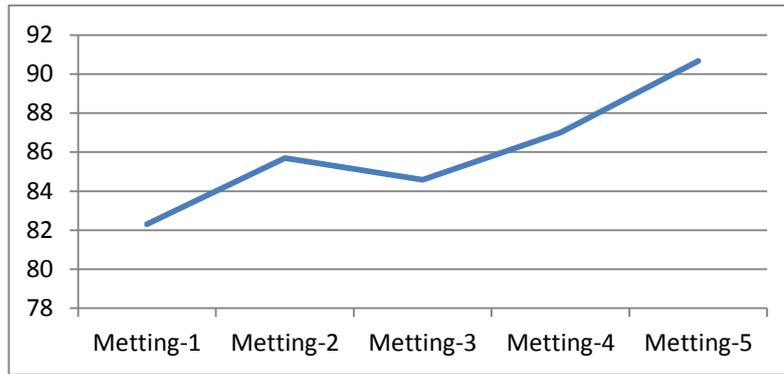


Fig. 2. The average value of student at Field Test

Based on the Fig 2, it was concluded that the average value of students had increased, except that there was a decrease in meeting 3 of 1.1 when compared to the previous meeting. When reviewed again, it is known that the decline occurred because at the meeting 3 the material discussed was a geometric transformation with a rotation title. Students have a little problem in determining trigonometric values that have previously been studied [26]. But the reference is meeting 1 so that when compared to meeting 1 and meeting 3 there is still an increase, which is equal to 2.3. So it can be concluded that there is an increase in students' mathematical critical thinking skills when viewed in terms of field tests. It means that flipped classroom-based learning devices have been effective in improving students' mathematical critical thinking skills in class XI based on field test analysis.

The next effectiveness assessment is to look at the final value of the students' mathematical critical thinking skills. The type of questions used are four item essays. Each question is a question that is indicative of mathematical critical thinking skills.

Table 1. The Sum of Student per Each Item of Mathematical Critical Thinking Test base on the Gain Score

		Question's Number			
		1	2	3	4
Score	1	0	0	0	1
	2	0	2	9	5
	3	3	13	20	8
	4	30	18	4	19
Sum		33	33	33	33
Completeness Percent		97.727	87.12	71.212	84.09

Based on the Table 1, it showed that students are able to solve the number one critical thinking skills with indicators determining the concepts used in problem solving with the acquisition of scores 3 and 4. In question number 2, it can be seen that students are quite capable of determining the right strategies to solve problems. For question number 3, the indicator gives an argument or reason in solving the problem students experience difficulties so that only four out of 33 people are able to provide arguments correctly. Students also got difficulty in evaluating evidence or decisions that have been taken. This is evident from the question number 4 obtaining an average value of 84.09%.

Based on the results of the merger, 29 out of 33 students or 87.87% had scores above the previously established KKM, which is 80. It means that the flipped classroom-based learning devices that were developed had been effective to improve students' critical thinking skills in class XI based on the final test analysis.

**4. Conclusion**

The results showed that the average score of students always increased at each meeting. Based on the results of the mathematical critical thinking test, it was found that more than 87.87% of students scored above 80. It shows that students have good mathematical critical thinking skills after using flipped classroom-based mathematics learning tools. Thus, the flipped classroom-based mathematics learning tool has effective in learning that is focused on seeing students' mathematical critical thinking skills. The development of this device can also make mathematics learning that takes place in the classroom more effective and efficient.

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