Flipped Classroom as a Reform Approach to Learning Mathematics in Pandemic COVID-19

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Abstract

This research aimed to develop Flipped Classroom Mathematics Learning model. The second aim is to determine the effectiveness of flipped classrooms as a reform approach to learning mathematics in pandemic COVID-19. The type of research is research and development (R&D) with the Analysis, Design, Development, Implementation, Evaluation or ADDIE method. The effectiveness testing of flipped classroom implementation used an experimental design. The subjects who participated in this research were teachers and students of 8th grade in 10 junior high schools in Central Java and Yogyakarta-Indonesia. Research data analysis techniques used qualitative and quantitative descriptive analysis. The result of the study finds a flipped classroom-based mathematics learning model. There is an increasing test score for geometry using the flipped classroom model. The post-test score for the geometry of the flipped classroom group (79.40) was higher than the direct learning group (67.31). The impact of the flipped classroom learning model is also seen through student responses, not only by measurable academic achievements. An analysis of student responses based on the questionnaire results stated that the flipped classroom learning model provided a positive learning experience. The student commented that the flipped classroom model allowed them to ask questions in the forum both of peers and educators, challenged their understanding, and encouraged them to apply what they had learned.

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1 Introduction

As a result of the COVID-19 outbreak, teaching and learning activities faced obstacles and could not run well (Wang et al., 2020; Rundle et al., 2020). No direct contact is allowed in this provision. The regulations that require the community to carry out social distancing cause students to be unable to attend school, and teachers cannot provide lessons to students. School principals and teachers continue to look for effective and efficient learning models to use in these conditions with these conditions. To continue educational activities, especially in Indonesia, teachers can use technology as a medium.

Online teaching is the only choice that schools have to make. The traditional practice of face-to-face learning must be transferred to online learning and virtual education (Dhawan, 2020). Several online teaching modes to choose from include online live teaching, autonomous learning and flipped learning, and synchronous online teaching (Zhu & Peng, 2020).

However, whatever mode of teaching is adopted, the effectiveness of online teaching and learning during the epidemic is a significant concern. It makes school principals and teachers think hard about what to do so that education services continue to run well. A particular form of online learning is blended learning, and one of its types is the flipped classroom (Abeysekera & Dawson, 2015). Flipped classroom combines online and face-to-face learning (Hahessy et al., 2014). In practice, students will learn the core content through audiovisual media outside the classroom and then the interaction between student-teachers in the classroom to discuss and develop material (O'Flaherty & Phillips, 2015; Awidi & Paynter, 2019).

One model that can be used during a pandemic is a flipped classroom. The flipped classroom is a learning model in which students, before studying in class, study material at home following the assignments given by the teacher (Rochman & Pertiwi, 2020). The teacher can video what he teaches and give it to those who do not attend the class. Before discussing the material to be taught, the teacher gives assignments to students to study the material in the learning media. This learning model requires students to be more independent because they study the material first before a class meeting (Betancourt et al., 2022). This model also makes students more active because their curiosity drive is also higher. The positive side of this outbreak is the emergence of a sense of comfort and more activeness for students who tend to have passive characteristics during offline teaching (Hidayat et al., 2020).

To meet the challenges and to prepare for teaching and learning after COVID-19, a flipped classroom is an excellent choice for teachers. The basic idea behind a flipped classroom is to deliver lessons via online videos before a face-to-face session to give students more time in class to engage in active learning (Lo & Hew, 2017). Students in a flipped classroom engage in prior learning online to prepare for learning activities in the classroom with their teachers and peers (Reidsema et al., 2017).

The flipped classroom model is in line with the development of science and technology in Industrial Age 4.0. This change in learning models certainly requires the training and readiness of teachers, education staff, and education officials in designing learning implementation plans and learning media that are compatible with current technological developments (Rochman & Pertiwi, 2020).

The flipped classroom method is becoming more prominent because it allows videos to be easily accessed on a unique site, on YouTube, or downloaded to a device (Agarwal & Pandey, 2013). Students watch online videos of lessons as homework and then work on the questions during class time. Students can watch videos

of their own accord. They can pause, replay, and review the video if they are still confused. Then they apply what they have learned from the video lessons to the problems they solve in class.

Mathematics and science are naturally suited to the flipped classroom method. With this model, students do not need to attend school every day (Wei, et al., 2020). Students will do assignments at home. This model is suitable for optimizing limited class time and will also train students to manage time well. Flipped classrooms as an alternative learning model during this pandemic are considered appropriate because this learning model can combine internal learning in class with distance learning at home (Pakpahan, 2020).

The concept of the flipped classroom model, namely learning activities that are usually completed in class, can now be completed at home, and learning activities that are usually done at home can now be completed in class (Bergmann & Sams, 2012). Students read the material, watch learning videos before they come to class, and start discussing, exchanging knowledge, and solving problems with the help of other students and teachers. The flipped classroom model can equip students with critical thinking, collaborative, communication skills, and creative thinking well. Teachers do not dominate class time. The interaction between the teacher and students is getting better and more enjoyable.

This research is focused on the actions of mathematics teachers in using video and the use of technology in learning activities. The teacher's action here is the teacher's understanding of the concept of learning at home and how the teacher uses the flipped classroom method to carry out online-based learning activities. This study explored approaches to manage the flipped classroom in an Indonesian context and designed an approach to improve the mathematical learning performance. In a flipped classroom teaching and learning, students took notes while watching videos at home, and then the teacher utilized the notes for in-class discussion. This study aims to determine the implementation of flipped classrooms in mathematics learning during the COVID-19 pandemic (Cheung & Slavin, 2013; Zengin et al., 2012). This study also determines the effectiveness and impact of implementing flipped learning on improving students' mathematical competence. This study also determines the effectiveness and impact of implementing flipped learning on improving students' mathematical competence.

2 Materials and Methods

The concept of a flipped class is that which is traditionally done in class is now done at home, and that which is traditionally done as homework is now completed in class (Bergmann & Sams, 2012). Flipped classrooms are feasible to implement because they integrate technology in their implementation with current student habits in accessing the internet. In flipped classrooms, students are more active, and classes are easier to manage because class time is used for direct activities or working in small groups. The free time available in the classroom is used for discussion and exploration to improve students' understanding (Hodgson et al., 2017). The flipped classroom improves teacher-student and student-student interactions. Students can see their teachers as mentors, friends, and experts.

Flipped classroom transforms traditional classroom learning from "pre-teach teaching" to "pre-teach learning." This teaching model changes the traditional teaching model of teachers who are very concerned about transmitting information and teaching knowledge, realizing the concept of learner-centered education (Yang et al., 2016).

Wolff and Chan (2016) introduced the flipped classroom as a learning strategy that uses instructional video material. The flipped classroom model is a learning method in which students must complete necessary reading or watch lecture videos at home before or after class. Discussions, problem-solving, questions, and answers, work assignments, or teaching materials regarding difficulties that the students do not comprehend are employed in classroom teaching and learning activities. Estes et al. (2014) emphasize the necessity of providing activities in the flipped classroom that encourage students to use higher-order thinking skills.

The existing teaching paradigm must shift, and it is past time to promote an innovative learning framework based on the flipped classroom instructional approach. The flipped classroom is a strategy that enhances the number of active learning activities and allows students to apply their knowledge in the classroom while being guided by the teacher (Veres & Muntean, 2021). Flipped learning is a pedagogical strategy in which the lecture's content is given home through video, and the classroom work is dedicated to the application of the knowledge by the students, guided by the teacher.

The flipped classroom is an approach that aims to improve lesson efficiency by transferring knowledge to students via videos, as well as through discussions, group work, and applications conducted during class (Milman, 2012). The flipped classroom is a blended learning instructional model in which students acquire new knowledge after watching a video or studying documents, materials posted on websites, and engaging in at-home understanding activities. During classes, they engage in activities in which they are actively involved in the deepening of knowledge under the guidance of the teacher.

The use of video media in a flipped classroom can increase students' interest because they can simultaneously listen and see the illustration of the material. Students study the subject matter at home in a flipped classroom by watching videos, making summaries, writing down important points, and discussing with friends online. Saputra and Mujib (2018) examined the effectiveness of the flipped classroom model using mathematics learning videos. The flipped classroom model effectively applies in mathematics learning by using learning videos. Gallagher (2020) states that giving assignments to students to do research and video recording and presenting the results in a virtual classroom will lead to more meaningful, effective, and enjoyable learning during a pandemic.

The flipped classroom is a cutting-edge educational approach that has the potential to revolutionize mathematics education. The study of Cevikbas and Kaiser's (2020) findings revealed that in a flipped classroom, the instructor's tasks, the applied discourse, teacher feedback and scaffolding, and the teaching-learning environment were all altered. Although teaching mathematics in a flipped classroom caused specific challenges for instructors, the findings show that teachers may increase students' mathematical potential through the flipped classroom. The flipped classroom is a cutting-edge educational approach that has the potential to revolutionize mathematics education (Mishra et al., 2020; Rao & Patel, 2013).

The theory of constructivism supports the implementation of online learning. The constructivist approach views students constructing their knowledge from individual experiences and reasoning about these experiences (Windschitl & Andre, 1998). As a result, teaching from a constructivist perspective becomes a question of facilitating an individual's private knowledge creation.

The core of constructivism philosophy is that students must independently uncover and change detailed knowledge, check for new information using existing rules, and change the rules if they are no longer applicable (Trianto, 2007). Students have the freedom to seek knowledge and organize their studies through online learning. When addressing problems, students are no longer aided by the teacher face-to-face; instead, they are encouraged to explore and solve difficulties on their own, or issues are provided independently (Song et al., 2004; Hung et al., 2010).

The behaviorist learning theory explains changes in behavior in learning (Farooq & Javid, 2012). Online learning also provides a stimulus for the students to be actively involved in the learning process. The virtual space is a place for learning activities where all involved are digitally connected. Adopting online learning to supplement face-to-face learning will accelerate, and schools will prepare themselves more systematically (Daniel, 2020). The flipped classroom is a fantastic choice for teachers to deal with issues and prepare for teaching and learning after COVID-19.

Various teachers, particularly mathematics teachers, are concerned about learning methods from face-to-face to learning through the network. According to the results of the Fakhrunisa & Prabawanto (2020) survey, mathematics teachers have a good attitude about the use of online learning. Meanwhile, online learning has several benefits, including encouraging students to learn more independently, allowing students to be more creative when completing projects, and allowing students to search for lesson references.

Methods

The type of research is research and development (R&D). Model development using Analysis, Design, Development, Implementation, and Evaluation (ADDIE). The research phase begins with a survey of mathematics teachers and students. The complete stages of research are: 1) analysis: preliminary survey results on mathematics learning practices; 2) design: good practice, flipped classroom framework, learning video; 3) development: the practical framework of flipped classroom validated through focus group discussion (FGD), and 4) implementation: class test; and 5) evaluation: test the effectiveness of flipped classroom implementation.

A preliminary study was conducted at 10 junior high schools in Central Java and Yogyakarta - Indonesia. The survey was conducted from May to July 2020. The mathematical learning video consists of content with solid shapes with a flat side. The effectiveness testing of flipped classroom implementation used an experimental design. The subjects who participated in this research were teachers and all students in 8th grade in a junior high school in Central Java and Yogyakarta-Indonesia. Research data analysis techniques used qualitative and quantitative descriptive analysis.

3 Results and Discussions

Preliminary survey results on mathematics learning practices

Based on the approaches and methods used, the models applied by teachers in learning mathematics vary, starting from lesson study, problem-solving, expository, and think pair share. Teachers in learning have ever used the problem-solving model. In addition, the expository model has also been used by teachers in learning. It shows that junior high school mathematics teachers in Central Java and Yogyakarta have implemented various learning models in mathematics.

The interview has shown that in the teaching approach used, the teachers focus on the students, meaning that the teachers encourage students to learn actively and provide a direct learning experience on how to deal with mathematics exercises. The teachers only provide them with a piece of information to understand the materials to learn. Then, the teachers apply strategies, models, and methods that make the students active during learning.

Students have diverse characteristics, and not all students can ask the teacher if there is a thing that they do not understand. The characteristics of the students vary; some students actively answer the teacher's questions. However, some students are passive, afraid of asking questions, and decide to keep silent so that their understanding is not yet established. Students' activeness in the learning was also triggered by rewards given to those who participate in solving the exercise.

The problems in learning are teacher books and student books considered confusing for teachers and students to use. Then, teachers also have obstacles in time management. There are a lot of materials in mathematics. However, the allocated time is still not sufficient to cover all materials. Sometimes, the teacher only supplies homework to study independently and provides practice questions to increase their experience in solving particular cases. The obstacles are that the teachers are seniors who rarely use learning media such as a projector. The use of media is considered too troublesome and takes a long time, then makes the materials delivered slowly. Other schools also experience problems related to the projector, and for example, the teachers cannot use projector media due to being out of order.

Based on a preliminary survey, it can be concluded that students want varied and fun learning activities, such as using media and learning outside the classroom. The reason is that mathematics contains a formula, and students must understand them to solve any given problem. In addition, the problem often experienced by teachers in learning is time limit, so teachers need to develop effective learning models that can maximize the allocated time. A new learning model that can be developed is a flipped classroom learning model. This flipped classroom learning model leads students to learn new materials by watching learning videos at home, and then in class, the materials are discussed. The steps in developing a flipped classroom-based learning model can be seen in Figure 1.
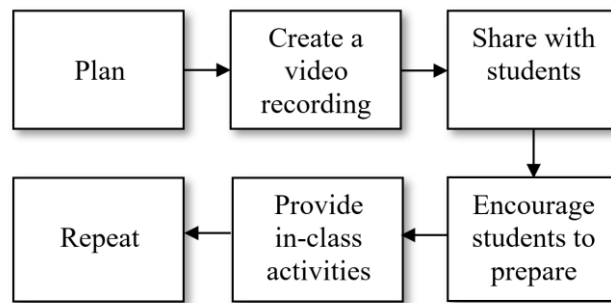
Figure 1. Flipped Classroom-based Mathematics Learning Model

Plan. Determine which lessons, in particular, you want to flip. Once decided, outline the key learning outcomes you want the students to take away when the lesson is complete.
Create a video recording. Turn teach in-class into video learning.
Share with students. Post it online and share it for your students to view outside of class. When they come to class, they should be ready to discuss and collaborate.
Encourage students to prepare. Clearly state the expectations for your students and the goal of studying at home. Give your students a course syllabus and consider handing out a lecture. Encourage students to prepare for class by having frequent pop quizzes or lecture quizzes.
Provide in-class activities. It's essential to use the class time to give your students immediate feedback and answer the lecture questions. Facilitate and encourage class discussions to inspire collaboration and learning.
Repeat. In an entirely flipped classroom, all the teaching is out of class. It means you need to have your lectures prerecorded, uploaded online, and ready to go. Remember to do activities planned, as you would with a lesson plan before.

The affectivity of flipped classrooms on learning mathematics

The experimental approach determines the effectiveness of flipped classrooms in learning mathematics. The subjects who participated in this research were 300 students in 8th grade from 10 junior high schools in Central Java and Yogyakarta-Indonesia. The participants were divided into two groups randomly. The experimental group was taught using Flipped Classroom model, and the control group was taught using the Direct Learning model (DL).
    Both groups were given the same mathematical learning topics. However, the experimental group was taught using learning videos and ppt slides uploaded online. The in-class learning activities focused on peer discussion of doing practice and problem-solving. The teacher provided the students in the control group with in-class activities.

Figure 2. Sample learning video uploaded on youtube channel

Before experimenting, the initial abilities of the two groups were first measured. After being given treatment to the two groups, the amount of increase in each group was then measured. The results of achievement testing of the Flipped Classroom and Direct Learning model group are shown in Table 1.

Table 1
Achievement Test Scores Between Group

Group	Pre-test	Post-test
Experimental (Flipped Classroom)	64.88 ± 3.26	79.40 ±10.48
Control (Direct Learning)	65.07 ± 3.11	67.31 ±10.92
t statistic	-0.508	9.782
p-value	0.612	<0.05

A geometry test measured the students' academic achievements before and after the treatment—the range of geometry test scores was between 0 and 100. The data of students' achievements (geometry test results) were analyzed using an independent sample t-test by SPSS to identify statistical differences between experimental and control groups.

The results of the pre-test geometry showed no significant difference between the experimental and control groups. The mean pretest score for the experimental group is 64.88, and for the control group is 65.07. After being treated, the test results showed a significant difference (p-value <0.05) in the geometry test scores between the experimental and control groups. The post-test score for the geometry of the flipped classroom group (79.40) was higher than the direct learning group (67.31).

The impact of the flipped classroom learning model is also seen through student responses, not only by measurable academic achievements. A questionnaire was provided to investigate the student's responses who are learning using the flipped classroom model. The results of student responses to flipped classrooms were presented in Table 2.

Table 2
The student responses on the flipped classroom

No.	Indicators	Mean	SD
1.	Encourage student participation in discussion effectively	4.08	0.80
2.	Discussions assisted students in understanding the topics	4.06	0.86
3.	Encourage students to search for topics on the internet to improve learning participation	3.94	0.83
4.	Provided a positive learning experience	3.99	0.79
5.	Be able to learn from the topics well	4.00	0.84
6.	Stimulate students to complete additional assignments	4.01	0.80
7.	The learning activities and assignments are often found in everyday life	3.96	0.83
8.	The flipped classroom can achieve student learning expectations	4.09	0.78
9.	The flipped classroom can improve students learning outcomes	3.96	0.84
10.	There is an intention to take other flipped classroom courses in the future	3.98	0.80

The results of the questionnaire showed a good response in learning using flipped classrooms. It is proven with an average Likert score > 3.00. Discussions in flipped classrooms assisted students in understanding the topics (M=4.06 ± 0.86). The flipped classroom encourages student participation in discussion effectively (M=4.08 ± 0.80). The flipped classroom can achieve student learning expectations (M=4.09 ± 0.78). An analysis of student responses based on the questionnaire results stated that the flipped classroom learning model provided a positive learning experience. They commented that the flipped classroom model allowed them to ask questions in the forum both of peers and educators, challenged their understanding, and encouraged them to apply what they had learned.

Discussion

The study develops of flipped classroom-based mathematics learning model. There are six stages in the development of flipped classrooms, 1) Plan, 2) Create a video recording, 3) Share with students, 4) Encourage students to prepare, 5) Provide in-class activities, and 6) Repeat. Flipped classroom-based learning is suitable for mathematics learning processes that involve teaching materials at the junior high school level of remembering and understanding the material that can be studied independently, and activity-based education to apply theory in the classroom (Lai & Hwang, 2016).

Classroom activities such as explaining the material, giving assignments, exercises, and assignments are transformed into flipped online-based learning (Herreid & Schiller, 2013). Learning in the classroom with an inverted class model will lead to more student-centered learning. Student activities in the classroom will turn into completing case studies, carrying out problem-based learning, practicing and collaborating between students and students, and completing the material studied at home (Cheng, Ritzhaupt, & Antonenko, 2019). Reverse learning involves transferring student-teacher interactions within the classroom to create more time for active learning (Stratton, Chitiyo, & Mathende, 2020).

During the COVID-19 pandemic, flipped classroom models can be combined with online learning. Efforts to improve the quality of online learning are by packaging learning methods to be more flexible; one of the appropriate learning models to be applied in current conditions is the flipped classroom model. The development of online education is synchronous online teaching with simultaneous interaction between teachers and students during teaching and learning. Online live education as a new form of education has grown rapidly and is widely used nationwide, especially during the COVID-19 pandemic.

In an experimental group, the flipped classroom was implemented. The experimental group watched the videos that were made. Students should watch the video of the next class's topic at home, take notes, summarize, or resolve the exercises offered in the film. Students discussed the videos in class and completed supplemental exercises. Students used the remaining time in class to put what they had learned into practice. Compare and contrast the experimental and control groups. A knowledge-based exam assessed the students' performance in both groups. The test ranged from 0 to 100, with the experimental group scoring higher than the control group.

In online classes, teachers and students do not do enough with static learning methods such as online tests and watching videos. They try new forms of learning that are more intuitive, interactive, and direct. Teachers implement online teaching through online platforms, such as Zoom and Google meet. Synchronous online teaching realizes simultaneous interaction between teachers and students. During online teaching, the teacher can adopt a flipped classroom or give lectures and interact directly with teachers and classmates. In this way, the teacher can simultaneously supervise the student's learning process and test the learning effects. However, the most obvious drawback of online teaching is network congestion, which directly impacts the smooth running of online teaching.

There is a consideration related to the material needs to promote learner autonomy and the digital technology used in delivering material (Chaeruman, Wibawa, & Syahrial, 2020). The material's order is from the most general to the most specific according to complexity. In online learning, the teacher also facilitates discussion forums using the WhatsApp group. The flipped classroom has potential for student performance and happiness as long as curricular activities of a flipped course are created and sequenced via some processes based on the ideals and nature of the flipped classroom and instructional design models' concepts (Arslan, 2020).

The findings of this study indicate the flipped classroom learning model provided a positive learning experience. Based on research conducted in America and several schools in Indonesia that have practiced flipped classrooms, the results are very encouraging, and the quality is better (Komalasari & Apriani, 2021). Students who practice this method have very high learning motivation, increased creativity, increased responsibility, and more active in-class learning, and their academic scores are better when compared to traditional learning methods. Likewise, the teachers also feel they have more time to discuss with students.

Effective online learning designs enable independent learning as a form of learning freedom. The teacher who implemented flipped classrooms made students the opportunity to control their learning (Ng, 2015) freely. Accordingly, learning is not just about uploading materials via the Internet, but about making students learn by taking advantage of the convenience of technology.

Learning resources in online learning, including flipped classrooms, are learning resources to provide independent learning opportunities while material is easily accessible (Suparman, 2014). The teacher also gradually provided feedback to encourage students to reflect and continue learning by correcting what is less than perfect. With an open communication process, the implementation of student-centered learning will be more optimal. The flipped classroom also indicated an increase in the involvement of learners (Khan & Watson, 2018).

The study of Febrianto et al. (2020), found that not all students prefer online learning, including expressing their disagreement that online learning is effective. Rural communities in Indonesia are not ready to use the latest learning methods, and they are still comfortable using conventional methods. The availability of supporting facilities and infrastructure and facilitated internet connection in rural communities and financial help and public awareness of the relevance of online learning are all required. Video is an alternative that is often used as input for independent study because it is accessible and allows students to stop and watch content as needed. Students who are given video materials do better in mastery than students who are not provided video materials (Bishop & Verleger, 2013). Student accomplishment improves when the video is used in an active learning environment assisted by teachers (Gustilo et al., 2015)

4 Conclusion

There are six stages in the development of flipped classroom-based mathematics learning model, 1) plan, 2) create a video recording, 3) share with students, 4) encourage students to prepare, 5) provide in-class activities, and 6) repeat. Students who are taught using flipped classrooms have higher math performance than students taught traditionally. The application of video-assisted flipped classroom learning models in mathematics learning is practical in terms of learning outcomes, student actions during learning, and student responses after learning. Learning during the COVID-19 epidemic necessitates productive technological and mathematical abilities. It is now vital to investigate the significance of practical and ongoing aid to students in establishing flipped classrooms.

Furthermore, educational institutions must improve the effectiveness and efficiency of their online learning technologies. This research yielded policy recommendations for online learning. Indonesia's Ministry of Education must pay close attention to issues of access to education in rural and remote locations. The federal and regional governments should offer adequate infrastructure and education access, particularly in rural areas.

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