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PAPER

Distance Learning: GeoGebra-Learning Videos to Improving Mathematical Communication Ability

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ABSTRACT

This study aims to use the GeoGebra application as a learning aid and ascertain the efficacy of learning videos in calculus education. Using a mathematical communication test, the research employs a quantitative approach and a quasi-experimental technique to acquire data. This study's sample is a second-year student enrolled at a Serang-Banten university. The sample is comprised of two divisions. One class is utilized for the control group of 25 pupils and another for the experimental group of 30. In the control group, students were only taught in an online learning environment using the Zoom Meet application without explaining GeoGebra-learning videos. The findings show differences in the increase in mathematical communication skills of students who study online using GeoGe-bra-learning videos (the experimental group) and those who get online learning without using GeoGebra- learning videos (the control group). Thus, GeoGebra-learning videos are a learning support tool that can improve students' mathematical communication skills.

KEYWORDS

distance learning, GeoGebra, learning videos, mathematical communication

1 INTRODUCTION

Communication is an essential component in the process of learning mathematics. The communication process in learning mathematics can build one's understanding through ideas and knowledge that are reflected, discussed, and improved [1]. Unfortunately, several studies have shown that students at various levels of education in Indonesia still have low mathematical communication skills [2–5].

Various studies have made efforts to improve mathematical communication skills by using learning methods such as Quantum Learning [6–9], the Think-Talk-Write method [10–12], problem-based learning [13–16], Reciprocal Teaching [17–19], Think-Pair-Share [20–23], as well as group investigations [22], [24].

The use of technology in the mathematics learning environment is a component that can help mathematical communication because it can be used as a tool for

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students to discuss mathematical ideas [1]. This statement shows that the approach to learning methods and the use of technology can be used to improve mathematical communication skills in learning mathematics. Efforts made include the use of technology with applications [25][26], computer-assisted, and mobile learning [27][28].

One technology that has been used in mathematics learning is GeoGebra software. GeoGebra software can be an alternative program that can make it easier to make math learning videos. GeoGebra is software that has been proven to have essential benefits for learning mathematics [29]. The benefits obtained from using the GeoGebra software include dynamic effects on student achievement in teaching geometry transforms [30], helping students understand the concepts being taught more deeply [31][32], improving students' positive attitudes towards mathematics [33], social cognitive skills [34], and improving learning outcomes [35]. Unfortunately, the benefits of using GeoGebra have not been explicitly applied to learning using learning videos to improve mathematical communication skills.

Students' mathematical communication skills can be developed by fostering an environment where they can interact with their instructors and peers [36][37]. Creating a pleasurable learning environment that encourages student interaction is one of the benefits of using GeoGebra, and numerous studies have demonstrated increased student engagement [38][39]. These facts demonstrate that GeoGebra has the potential to enhance the mathematical communication skills of students.

The learning process using dynamic and effective technology in conveying information is video [40][41]. Video offers many advantages, including self-directed learning, communicative and iterative content, and the ability to present things in detail and in complex ways. Learning videos can be repeated, slowed down, or even expanded, and the ability to compare two or more scenes at the same time can be used in learning. However, learning videos in the mathematics learning process also has several shortcomings, including videos that require the help of other media, such as computers, and the process of making videos takes much time, and costs money; videos cannot stand alone [42]. GeoGebra software can be an alternative program to help visualize images when making online math learning videos during the current pandemic.

GeoGebra is unique in terms of facilitating online learning in mathematics during the current pandemic. However, GeoGebra and its peculiarities have not been widely studied for their benefits in learning mathematics in general and improving mathematical communication skills, particularly in learning videos. In addition to learning software, the effect of continuity of access and use is also interesting to investigate. One way to develop students' ability to communicate mathematical thinking is to get them used to doing it continuously [43], with communication breakthroughs in interactive learning [44]. This continuity can be managed through additional supporting devices provided to students so that it occurs in terms of access and use of learning materials. Thus, the purpose of this study is to investigate the improvement of mathematical communication skills obtained through GeoGebra-learning videos as a supporting device or not.

2 METHODS

2.1 Participants

This research was conducted at a private university in Serang-Banten. The fact that the research at the university cannot be randomly selected purely for the control and experimental groups, the right choice is to use quasi-experimental research. Quasi-experimental research is research conducted to see the effect of a particular variable on other variables under certain conditions that has a control class but cannot function fully as a control because the sample is not randomly selected and considers certain factors that can cause the experiment to fail [45].

The research procedure does not involve the creation of new classes. The existing class categories are then chosen to determine the experimental and control classes, which share nearly identical characteristics. The sample comprises of two classes. The calculus course in the study lasted three weeks, with each class meeting once a week for 150 minutes. One class was used for the control group, comprising of 25 students and the other for the experimental group, comprising of 30 students.

2.2 Research design

A quasi-experimental study was designed to compare mathematical communication using GeoGebra-learning videos with those that did not receive such assistance. The control group participated in an online learning environment through the Zoom Meet application without an explanation GeoGebra-learning videos. In contrast, the experimental group is accompanied by an explanation GeoGebra-learning videos. Both groups started the study in a face-to-face setting for three weeks, during which no treatment was applied to them. Subsequently, for three weeks, students in the experimental group were provided with material in GeoGebra-learning videos. These videos were given one day before the lesson begins and were sent via Google Classroom. When the learning session commenced, students engaged in a discussion room through the Zoom Meet application do discuss the video content that had been provided. Meanwhile, students in the control group continued with their online learning environment through the Zoom Meet application, but they did not receive an explanation GeoGebra-learning videos.

2.3 Instrument

The instruments used in the study were five questions on the mathematical communication ability test. The mathematical communication ability instrument is a test used to assess students' mathematical communication skills in experimental and control classes. In this research, the experimental group received learning by using GeoGebra-learning videos, while the control group received learning without GeoGebra-learning videos. The control group and the experimental group were given a pre-test before learning and a post-test after learning was completed. The pre-test is given to see the students' initial mathematical communication ability, and the post-test shows the students' mathematical communication ability after learning. The normalized gain is used to see the increase in students' mathematical communication skills (N-Gain). The hypotheses tested in the study are:

- H0: There is no difference between students who study online using GeoGebra-learning videos and those who study online without using GeoGebra-learning videos regarding their mathematical communication abilities.
- H1: There is a difference between students who study online using GeoGebra-learning videos and those who study online without using GeoGebra-learning videos regarding their mathematical communication abilities.

2.4 Data collection technique

Data in the form of students' mathematical communication skills were obtained through test techniques. Research data collection uses a test that aims to measure a person's abilities [32]. Before being used, the test questions given had their content validated by expert validators and were declared valid for use. Mathematical communication test instrument through content validity using the Index of Item Objective Congruence (IOC) with five experts consisting of four mathematics education lecturers and a mathematics teacher. The validity test results indicate that all items can be used because their indices fall between (0.66 and 1.00). To ascertain the reliability of internal consistency, a test was administered to 30 students in other classes using Cronbach's Alpha coefficient with an average value of. The reliability results indicate that the Cronbach's Alpha value is 0.78 (classified as highly reliable).

Mathematical communication test questions are presented in the form of pre-test and post-test versions of the same questions. The pre-test questions are given before the learning is done, while the post-test is given after the learning is finished. The test is structured based on indicators of mathematical communication skills. Mathematical communication indicators include: interpreting, exemplifying, summarizing, inferring, comparing, and explaining [46].

2.5 Data analysis

The data was collected using an evaluation of mathematical communication in the context of learning mathematics with GeoGebra-learning videos. Before being administered for pre-test and post-test, mathematical communication test questions are evaluated for validity, reliability, difficulty index, and discriminating power. Next, a pre-test was administered, and the normality test, homogeneity test, and similarity test of the two averages were calculated to determine whether there was a significant difference in initial mathematical ability between experimental class a and control class b.

In addition, treatment was administered to the experimental group, which consisted of students who used GeoGebra-learning videos for online study. In contrast, the experimental group differs from the control group, which consists of students who study online without using GeoGebra-learning videos. This research is based on the theory of social media platforms that enable educators and students to share ideas, files, activity schedules, and assignments [47]. Next, a post-test was conducted. If the obtained data exhibit a normal and homogeneous distribution, the next step is to evaluate the average difference using the independent samples test. (Uji-t). Alternatively, the non-parametric U Mann-Whitney test is performed if the data are not normally distributed.

The research analysis techniques are: first, descriptive data analysis was carried out to provide an overview of students' mathematical communication skills before and after learning; second, Inferential analysis was carried out to conclude that using GeoGebra-learning videos to improve students' mathematical communication skills. Increasing students' understanding of mathematical concepts before and after learning with GeoGebra-learning videos is calculated using the normalized gain formula (N-Gain) with Equation Formula 1.

$$\frac{\text{skor posttest} - \text{skor pretest}}{\text{skor ideal} - \text{skor pretest}} \quad (1)$$

The normalized gain values are classified into three groups. High N-Gain group for N-Gain values more than 0.7. Medium N-Gain group for N-Gain values between 0.3 and 0.7. Low gain group for N-Gain value less than 0.3 [48–50].

In conclusion, online mathematics learning activities using GeoGebra-learning videos are as follows:

1. Before engaging in online learning activities utilizing the Zoom Meet application and Google Classroom, the instructor provides a guide on using Zoom Meet and Google Classroom. Students then register themselves based on the examples and steps outlined in the guide. Once they comprehend the use, they can operate the device. Students can utilise the Zoom Meet application and Google Classroom as soon as they interact with their professors and peers.
2. The lecturer then instructs students on how to use learning videos and the GeoGebra application. Then, students practice based on the examples and steps outlined in the guide. Ultimately, once they comprehend its operation, they can use it.
3. The lecturer explains the material and examples of questions in outline in the form of a learning video-assisted by the GeoGebra application to students one day before learning begins through Google Classroom and is equipped with material (PDF, Word, and discussion column) asynchronously (Figure 1).

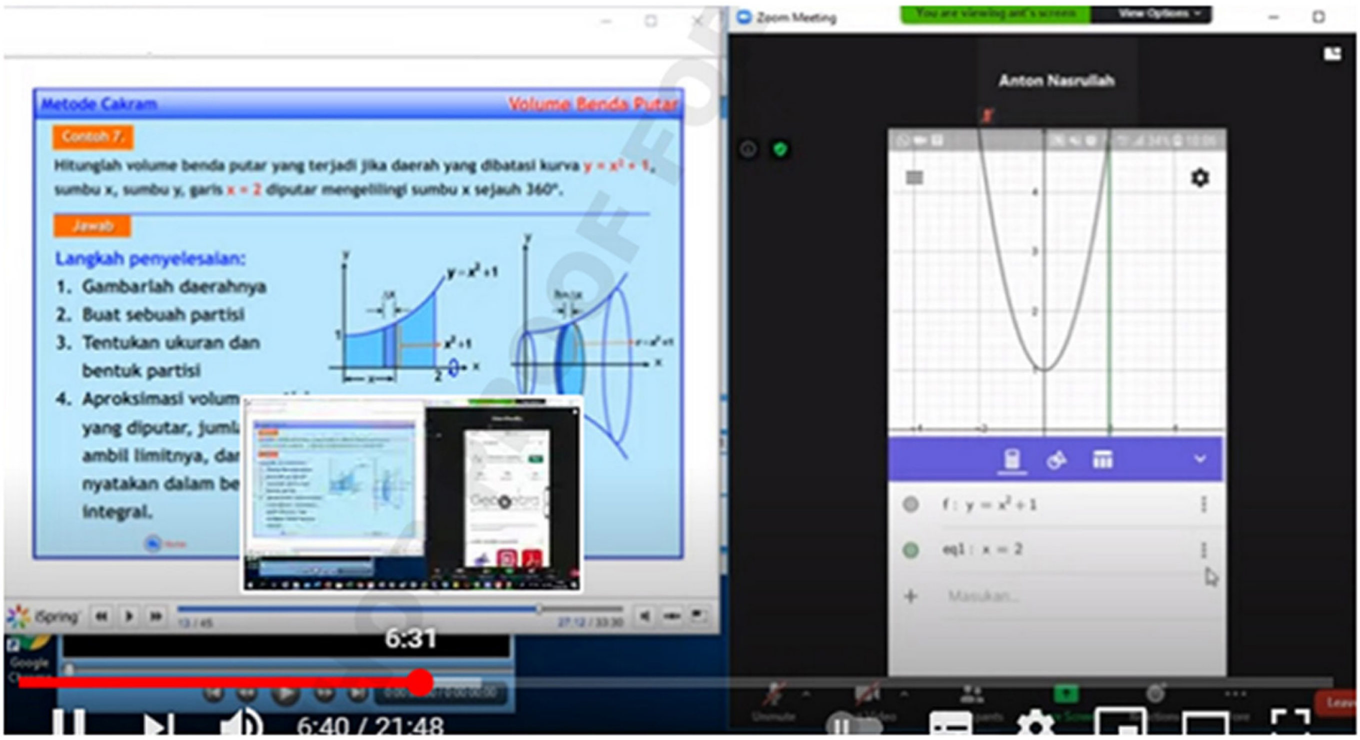

Fig. 1. GeoGebra-learning video explanation via google classroom

4. Lecturers start learning and discuss videos that have been given through the Zoom Meet application synchronously (Figure 2).

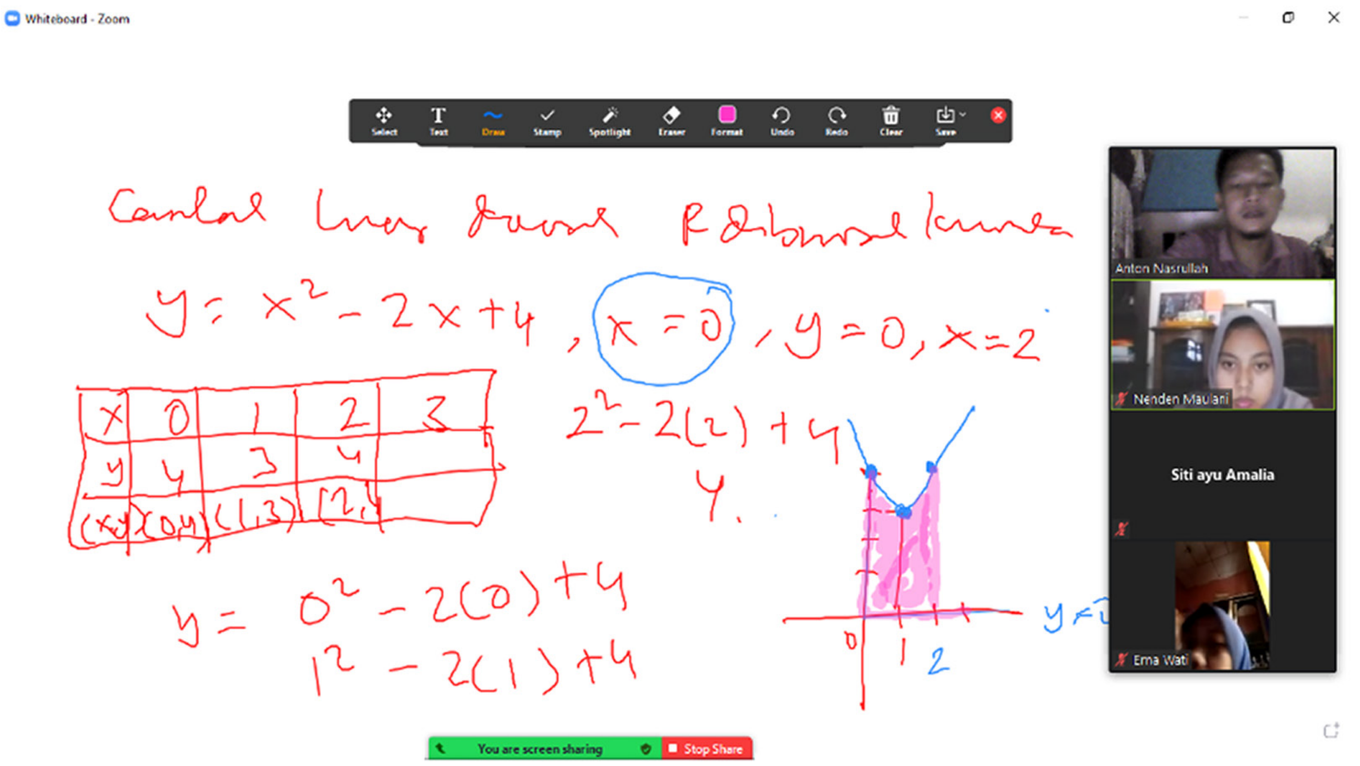

Fig. 2. Learning activities through zoom meet

5. Next, the lecturer gives assignments to students, where students individually make video explanations and solutions for the exercise (Figure 3). Then students receive feedback from the lecturer based on the assessment rubric. This is done to train students' mathematical communication skills both orally and in writing.

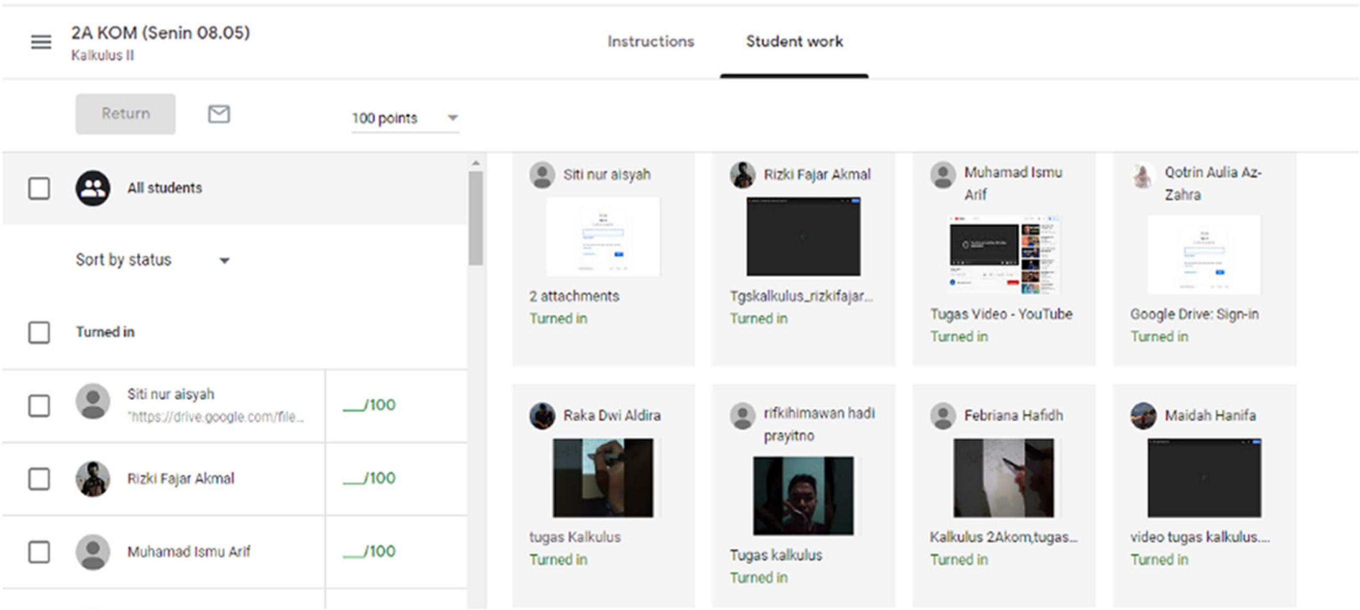

Fig. 3. Screenshot of video work by students in google classroom

The experimental class received online mathematics learning using GeoGebra-learning videos (Figure 4).

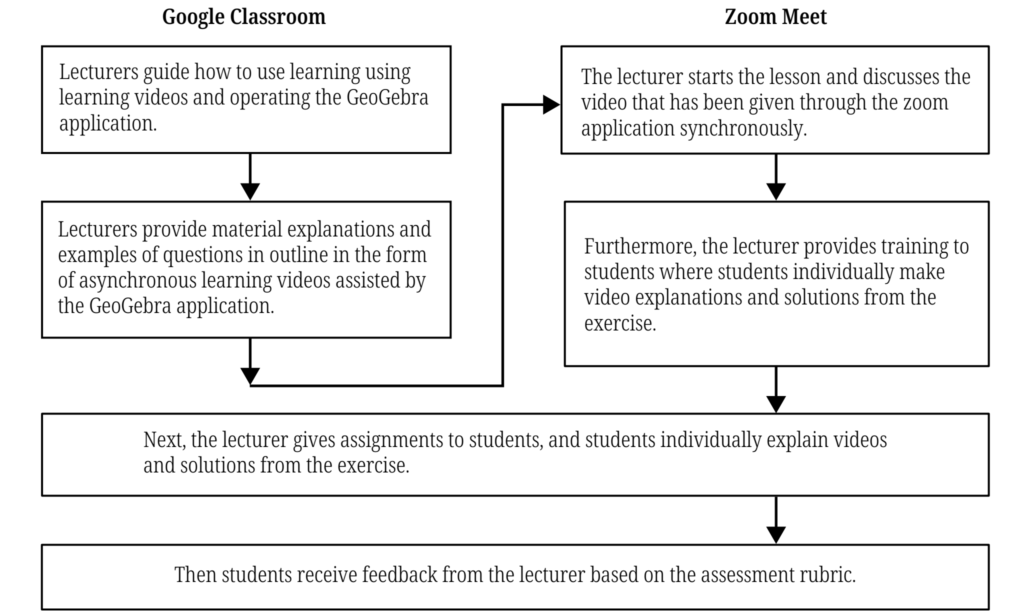

Fig. 4. Learning mathematics online using modified GeoGebra- learning videos [51]

3 FINDINGS

The results of the pre-test are very helpful to see the development of mathematical communication before being given the treatment of experimental and control classes. Based on Table 1, it shows $t = -1.57$ and $Sig = 0.145$ (> 0.05), indicating that the two groups did not have a significant difference in the pre-test of the two groups.

Table 1. Skor pre-test experiment and control

Parameter	Experiment	Control
N	25	30
$\bar{x}$	13.10	11.39
s	12.37	12.40
t	–1.57	
Sig	0.145	
Ideal Score	100	

The results of the pre-test of mathematical communication skills showed that the initial abilities of the control class and experimental class students were the same (Table 1). The next step is to do a post-test. The results of the post-test are very helpful to see the development of mathematical communication after being given the treatment of experimental and control classes. Based on Table 2: $t = 3.43$ $Sig = 0.017$ (<0.05) indicates that there is a significant difference between the two groups.

Table 2. Skor post-test experiment and control

Parameter	Experiment	Control
N	25	30
$\overline{X}$	78.10	70.86
s	8.57	10.40
t	3.43	
Sig	0.017	
Ideal Score	100	

The results of the post-test of mathematical communication skills showed that there was a significant difference in the final abilities of the control class and experimental class students (Table 2). Next, is to do the N-Gain. The N-Gain results are very helpful to see the increase in the development of mathematical communication after being given the treatment of experimental and control classes. Based on Table 3, it shows that the experimental class has increased in the medium category (0.45) and the control class is in the low category (0.29).

Table 3. Improved mathematical communication ability

Parameter	Class	
	Experiment	Control
N-Gain	0.45 (Medium)	0.29 (Low)

There is a significant difference in improving mathematical communication skills between pupils who learn using GeoGebra-based videos and those who receive traditional instruction. Consequently, this GeoGebra-based learning video effectively enhances students' mathematical communication skills (Table 3).

4 DISCUSSION

There was an increase in post-test scores in both the experimental group and the control group (Table 3). Based on post-test scores, shows that online learning using Zoom Meet (with or without using GeoGebra-based videos) can also improve student learning outcomes, as is the case with studies showing that online learning using Zoom Meet can improve student math learning outcomes [52–54]. However, the improvement in the control and experimental classes was different. The findings of the study showed an increase in mathematical communication skills in both the control class (without GeoGebra-based video) and the experimental class (accompanied by GeoGebra-based video), although the level was different (low in the control class and medium in the experimental class). The experimental group has higher communication skills because, when explaining the lecture material about the volume of rotating objects, it is very suitable to be studied using GeoGebra-learning videos. The use of GeoGebra-learning videos has many advantages, namely that it can improve student geometry learning outcomes [55], and increase motivation [56] and students have a positive perception of GeoGebra [57].

The improvement of students' mathematical communication skills in the experimental class is treated; namely, the lecturer explains the material and examples of questions in outline in the form of learning GeoGebra-learning videos to students one day before learning begins through Google Classroom and is equipped with material (PDF, Word, and discussion column) asynchronously. GeoGebra-learning videos gives students plenty of time to learn the subject matter that will be taught, and videos offer many advantages, including self-study, communicative and repetitive content, and the ability to present things in detail and complexity. In addition, the use of GeoGebra software in the production of mathematics learning videos saves time for drawing on the whiteboard and doing calculations, so more time can be used to learn and explore the material [32].

Although it has many advantages in its use, video cannot be used as a learning medium for every meeting or face-to-face. The ideal video duration is around 5 to 20 minutes. The use of multimedia learning, such as video, will have a better effect if the narration and animation are presented in short and alternating segments [32].

Students can play back and slow down the video when they do not understand the GeoGebra-based video given by the lecturer. When giving videos, the lecturer also provides a discussion column in the comments section of the Google Classroom application for discussion between teachers and students and between students in their class. In addition, students can screen shot which parts are not understood and for how many minutes so that lecturers can find out and provide comments on them.

In the implementation of mathematics learning during this pandemic, lecturers used the Zoom Meet application, and previously students had received, watched, and discussed it through Google Classroom. Lecturers provide explanations for parts that are not understood and discuss them together through the Zoom Meet application. To prevent boredom, the lecturer re-shows the GeoGebra-based video for how many minutes you can't understand; the lecturer acts as a facilitator; the lecturer can stop the video and challenge students to predict and solve problems together and communicate it mathematically.

After the learning was completed, a post-test was given, and the results of the study showed that there was a difference in the increase in mathematical communication skills of students learning online using GeoGebra-learning videos compared with those without using GeoGebra-learning videos. Thus, GeoGebra-based learning videos can be an alternative medium for learning mathematics that is effective, efficient, and proven to improve students' mathematical communication skills. This is reinforced by the results of research, which states that learning using video in learning activities can be effective in encouraging argumentation in mathematics [58][59].

5 CONCLUSION

GeoGebra learning with or without GeoGebra-learning videos can improve students' mathematical communication skills, at different levels. Improved mathematical communication was found in the experimental class students because the presence of GeoGebra-learning videos could maximize the increase in students' mathematical communication skills, which then manifested into improving students' mathematical communication skills.

The improvement of mathematical communication skills through Zoom Meet and Google Classroom with the addition of GeoGebra-learning videos in this study is still at a moderate level and is at the level of students' mathematical communication skills.

Future research is suggested to further explore aspects of learning media that can support and help accelerate conceptual understanding, problem-solving, and mathematical communication in mathematics learning.

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