Blended learning in improving students' mathematical critical thinking and mathematical communication abilities

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Abstract

In this digital era, the use of technology in the learning process is a necessity. E-learning is a solution to improve the quality of learning through a blended learning model. This research aims to analyze the application of the blended learning model in improving students' mathematical critical thinking and students' mathematical communication abilities. The research method used is a mixed method with an embedded design. The population of this study was class XI students at a private high school in Cimahi, Indonesia, with a sample of two classes as an experimental group consisting of 28 students and a control group consisting of 28 students. The experimental group received learning using a blended learning model and the control group received a regular learning model. The instruments used in this research were descriptive and multiple choice tests to test students' mathematical crtitical thinking and students' mathematical communication abilities, questionnaires were used to see students' attitudes towards blended learning, and observation guides regarding the implementation of blended learning. Data testing was analyzed using normality, homogeneity and difference of the means of two groups, and N-gain was used to determine the increase in students' critical thinking and students' mathematical communication skills. Based on the research results, it was found that students' mathematical critical thinking and students' mathematical communication abilities who received blended learning were higher than students who received regular learning. Students' attitudes towards implementing the blended learning model in positive mathematics learning. The blended learning implementation used utilizes Google Classroom and combines it with face-to-face learning in class. Online learning settings via Google Classroom provide material in the form of power point, PDF and video files.

Key Words: digital era, e-learning, google classroom, mixed method, students' attitude

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INTRODUCTION

Critical thinking is a reasoning activity that aims to gather information in order to make a decision or take an appropriate action. Students' mathematical crtitical thinking ability means the ability to collect, identify and use information to solve mathematical problems and evaluate the results of problem solving correctly. Apart from that, critical thinking is an effective thinking step that a person has so that he is able to make, assess and implement decisions that are relevant to what he believes and does. Someone who is able to think rationally and logically in receiving information and systematically in solving problems is a characteristic that someone has the ability to think critically (Hidayah et al., 2017). In other words, someone who has critical thinking abilitiy is able to assess the information he receives and is able to evaluate the results of problem solving that he has found. critical thinking as a thoughtful ability to display self-regulation in expressing reasoning considerations on evidence, context, standards, methods, and conceptual structures to make decisions or what should be done.

Students' mathematical crtitical thinking ability can be developed in classroom learning by using student-centered learning, presenting non-routine problems, namely problems that students are not yet familiar with, using mathematical reasoning, and involving communicating a problem solution. Irawan et al. (2017) stated that teachers must be competent in selecting, designing, developing learning and facilitating students to practice mathematical critical thinking. Another opinion, Aghababaeian et al. (2017) stated that by developing a curriculum according to learning in the education system, it could be a way to achieve and develop students' mathematical critical thinking abilities.

Students' mathematical crtitical thinking ability needs to be supported by other abilities, one of which is students' mathematical communication. Baird (Riasari, 2018) states that communication is a process of conveying and receiving the results of individual thoughts through symbols to other people. In line with this, Baird (Riasari, 2018) stated that communication is a process of conveying and receiving the results of individual thoughts through symbols to other people. In line with that, according to Ziebarth (Hulukati, 2005) students' mathematical communication is the ability to explain algorithms and unique ways of solving problems and constructing real world phenomena using graphics, words, equations, tables and other forms of mathematical representation. So, communication skills are the ability to express mathematical ideas and understanding orally and in writing using numbers, symbols, pictures, graphs, diagrams or words. Meanwhile Yaniawati et al. (2019) stated that students' mathematical communication ability is a very important ability for students, because they can influence many things, including in everyday life.

Thus, so that everyone knows the logical reasons, expertise is needed in communicating these ideas to everyone. Likewise, in learning mathematics, apart from students being required to think critically, students need to communicate their ideas or thoughts to other people. Yuliani and Saragih (2015) state that someone who is able to think critically is not someone who is only able to solve a problem, but he must also be able to provide logical reasons for every solution he provides. Apart from that, changing shapes or making mathematical representations is also a students' mathematical communication ability.

In learning mathematics, apart from students being required to be able to communicate their ideas or thoughts to others, students can also change shapes or make mathematical representations. However, in practice, learning aimed at improving students' mathematical communication ability still produces unsatisfactory results. Kasum and Hadi (2015) stated that educational practices that treat students as objects are what have been going on in schools and are apparently very far from the true essence of education, namely education that makes students human beings who have the ability to learn to develop their potential and develop further knowledge for his own benefit. The phenomenon that has occurred so far is that some teachers have not optimized students' high-order mathematical thinking abilities, especially students' mathematical critical thinking and students' mathematical communication abilities. Teachers only emphasize the procedural skills process, this causes students to only understand and remember the formula and then the procedure for solving it routinely. So when students are faced with problems that are non-routine in nature, it causes very few students to be able to solve these problems.

As a preliminary study, researchers conducted observations by giving students critical thinking and communication skills questions. From the analysis of the students' work results, it can be seen that the critical thinking and students' mathematical communication abilities of students in secondary schools are still low. This is supported by the research results of Wijayanto et al. (2018) reported that students' low critical thinking and communication skills were because teachers still used the lecture method so that

students received less attention from the teacher, so that students did not express their opinions correctly and clearly, either in writing or orally. students find it difficult to write/recognize what is being asked and what they are looking for, students don't understand how to transfer everyday commands into mathematical language and they don't understand the concepts being applied so that students have difficulty determining the necessary strategies.

METHOD

This research approach is a mixed method with an embedded design and uses a quasi-experimental method. The embedded design chosen is quantitative which is dominant and embeds qualitative as a reinforcement of data obtained quantitatively (Indrawan & Yaniawati, 2017). A quantitative approach is used to analyze differences in students' critical thinking and students' mathematical communication abilities, in sequence and series material. Meanwhile, a qualitative approach is used to obtain an overview of the results of critical thinking work and students' mathematical communication, as well as students' attitudes towards learning mathematics using the blended learning model.

The population of this study was class XI students at a private high school in Cimahi, Indonesia, with a sample of two classes as an experimental group consisting of 28 students and a control group consisting of 28 students. The experimental group received learning using a blended learning model and the control group received a regular learning model. The instruments used in this research were a description test and multiple choice with 15 questions to test critical thinking and students' mathematical communication abilities, a questionnaire was used to see students' attitudes towards the blended learning model, and an observation guide regarding the implementation of blended learning. The test instrument was tested first on class XI students, because they had received similar material in class VIII. This instrument is valid and reliable with a reliability value of 0.730 indicating that the questions have high (good) reliability.

This research uses quasi-experimental design with True Experimental Design with its form, namely the Pretest-Posttest Control Group Design. In this form of design, there are two randomly selected groups which are essentially called control classes and experimental classes, then these two groups are given a test to find out the initial capabilities of each of these groups. The expected result of this test is that there is no significant difference between the control class and the experimental class. Pretest-posttest control group design form can be described in Table 1. as follows.

Tabel 1. Quasi experimental design

Kelompok	Prior Test	Threat	Final Test
Experiment	Y_1	X	Y_2
Control	Y_1	-	Y_2

Indrawan & Yaniawati (2017)

Y1 = Pre-Test
Y2 = Post-Test
X = treatment

RESULTS AND DISCUSSION

1. Pretest And Pos Test Data Analysis Of Students' Mathmematical Critical Thinking

The t-test results can be seen in Table 2.

Table 2. t-test of Critical Thinking PreTest & Pos Test

Independent Samples 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
Critical Thinking Pretest	Equal variances assumed	0.163	0.688	1.342	54	0.185	0.786	0.585	-.388	1.959
	Equal variances not assumed			1.342	53.583	0.185	0.786	0.585	-.388	1.960
Critical Thinking Postest	Equal variances assumed	2.869	0.096	5.650	54	0.000	4.607	0.815	2.972	6.242
	Equal variances not assumed			5.650	50.775	0.000	4.607	0.815	2.970	6.244

Table 2 shows that there is no significant difference between the prior students' mathematical crtitical thinking ability in the experimental class and those in the control class. Thus, the prior students' mathematical crtitical thinking ability in both sample groups are relatively the same. Furthermore, a t-test was carried out to see the difference between the two average results of the critical thinking ability posttest in the experimental class and the control class.

By drawing conclusions according to Didi (2020), if the value of Sig. (2-tailed) < 0.05, then there is an influence on a treatment. So based on table 3 above, namely the Posttest of the Experimental Class and the Control Class, the value of Sig. (2 Tailed) of 0.000 0.05 can be concluded that the research hypothesis is acceptable that the mathematical ≤critical thinking ability of students who get the blended learning model is better than that of students who get the conventional learning model. which means that the use of the Google Classroom-assisted blended learning model in the experimental class has an influence on the students' critical thinking ability.

2. Data Analysis Improvement Of Mathematical Critical Thinking Ability

To see the quality of improving critical thinking skills, the researcher used normalized gain data analysis.

Table 3. T-Test of Gain Group Statistics

Group Statistics

	Class	N	Mean	Std. Deviation	Std. Error Mean
Gain of Students' Critical Thinking Ability	Experimental Class	28	0.5547	0.24321	0.04596
	Control Class	28	0.2333	0.17283	0.03266

Based on Table 3, the average gain for the experimental class is better than that of the control class, it can be said that the improvement of students' mathematical crtitical thinking ability who obtain the blended learning model is better than that of students who obtain the conventional learning model. The improvement of students' mathematical critical thinking skills in the experimental class with a mean value of 0.55 is classified as medium category and the control class with a mean of 0.23 is classified as low category (Hake, 1999).

From these results, it is known that the average score of the experimental class is higher when compared to the control class, which means that the class that received the treatment was given the blended learning model better than the class that was not treated. The results of the study prove that with the application of the blended learning model, students' critical thinking skills increase. Based on the average results of the posttest of critical thinking skills in grade XI IPA-5 students in the row and series material, the results can be seen to be different. This proves that the blended learning method is effective in stimulating students to improve their critical thinking skills. In the observation results, there is a clear difference between the experimental and control classes. The results of this study are in line with research (Hasanah & Malik, 2020) that (1) The application of the blended learning model is effective in improving critical thinking skills. (2) The use of blended learning model is effective in improving students' communication skills and (3) Based on the independent sample test, the critical thinking skills of the experimental class have significant differences with the control class. This is also in line with research (Prafitasari et al., 2021) which proves that the blended learning model can effectively improve students' critical thinking skills. Research conducted by (Lumbatoruan E. P & P Hidayat, 2019), (Suryani et al., 2021), (Kenney & Newcombe, 2011) and (Marito & Riani, 2022) also stated that the blended learning model is effective in improving students' critical thinking skills as evidenced by the results of higher experimental classes with control classes based on quantitative research. This significant difference is based on using a variety of models, so that children are not easily bored in learning.

3. Pretest And Postest Data Analysis Of Students' Mathematical Communication Abilities

Based on the analysis of the normality test through Saphiro Wilk with the significance value for the experimental class is 0.012 and the control class is 0.000, this means that the significance value of the two classes is less than 0.05, it can be said that the control class and the experimental class are not normally distributed. Because the data from the two classes were not normally distributed, the mean difference test with the Mann-Whitney U non-parametric statistical test was used.

Table. 4 Results of the Difference Test Average Score (Pretest & Postest) Students' mathematical communication Ability

Test Statistics[a]		
	Pretest Value	**Postets Value**
Mann-Whitney U	276.000	280.500
Wilcoxon W	682.000	686.500
Z	-1.922	-1.848
Asymp. Sig. (2-tailed)	.055	0.065
a. Grouping Variable: Class		

Based on table 4 of pretest, Asymp.sig (2-tailed) was obtained which is 0.05, which means that there is no significant difference in the average pretest score of students' mathematical communication ability in the experimental class and the control class. Therefore, the average students' mathematical communication ability ≥ in the experimental class and the control class did not have a significant difference.

Based on the results of the calculation through Shapiro-Wilk The significance of the posttest ability test data for the experimental class was 0.000 and for the control class was 0.005. Because the significance value of the two classes is 0.05, it shows that the experimental class and the control class are not normally distributed. Since the data from the two classes were not normally distributed, it was decided to conduct an average difference test with a non-parametric test.

Based on table 4 of postest, Asymp.sig (2-tailed) was obtained which is 0.05, this means that the average postest score of students' mathematical communication ability in the experimental class is not higher than that of the control class. Although in descriptive statistics it shows that the average score and score ranking of the students' mathematical communication ability of the experimental class are higher, but there is no significant difference. So it can be concluded that the average posttest score rating of students' mathematical communication ability who obtain ≥ Blended Learning is not higher than conventional learning.

4. Data Analysis To Improve Students' Mathematical Communication Ability

Table 5. Descriptive Statistics of Communication Ability Gain Index Data

Class	N	Mean Score	Category
Experiment	28	0.77	High
Control	28	0.60	Medium

From Table 5., the results of descriptive statistics show that there is a difference in the average score of N-gain critical thinking ability of the experimental class and the control class. So to find out whether the difference in the increase is significant or not, a test of the difference in the average N-gain score is carried out. Previously, the distribution was tested first and based on the results of the calculation using the Shapiro-Wilk test, because the N-gain is not normally distributed, it was decided to conduct a non-parametric test, To test the average difference, the test technique used was the Mnn-Whitney U test.

Table 6. Results of the Difference Test Average Score (Postest) Students' mathematical communication Ability

Test Statistics[a]	
	Result
Mann-Whitney U	390.000
Wilcoxon W	1986.000
Z	-6.880
Asymp. Sig. (2-tailed)	.000
a. Grouping Variable: kelas	

Based on Table 6., it can be concluded that the improvement of students' mathematical communication ability who obtain blended learning is significantly higher than that of students who obtain regular learning.

The improvement of students' mathematical communication ability can be measured by comparing the pretest and postest scores with their ideal scores. It was obtained that the average score of the normalized gain score for the experimental class was 0.77 obtaining the high category, while the N-gain score for the Control class was 0.60 obtaining the medium category. Meanwhile, based on the results of the calculation using the Shapiro-Wilk test, the significance of the normalized gain score data on the students' mathematical communication ability for the experimental class was 0.001 and the significance of the normalized gain score data for the control class was 0.051. Because the significance value of the experimental class is less than 0.05 and based on the decision-making criteria, it can be concluded that the N-gain data is not normally distributed. So it was decided to conduct a non-parametric test, To test the mean difference, the test technique used was the Mnn-Whitney U test. From Table 8, Asymp.sig (2-tailed) is obtained which is smaller than 0.05. This means that the average increase in the students' mathematical communication ability rating of students in the experimental class is higher than that of the control class. Although in descriptive statistics it shows that the average score and score ranking of the students' mathematical communication ability of the experimental class are higher, but there is no significant difference. So it can be concluded that the improvement of students' mathematical communication ability who obtain Blended Learning is significantly higher than that of students who obtain regular learning.

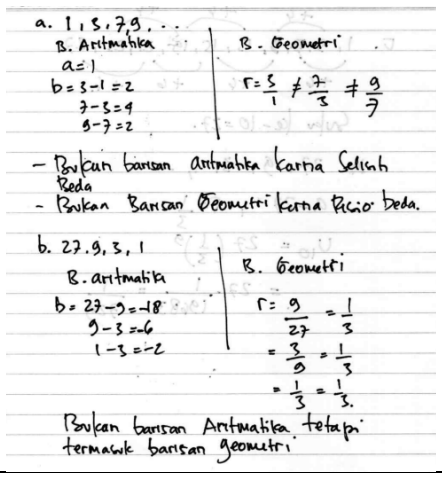
Various activities in the blended learning model familiarize experimental class students with scientific thinking, namely analytical, critical, and rational thinking, which is of course indispensable in the process of practicing students' mathematical communication ability. Students are used to explaining ideas, situations, and mathematical relationships orally or in writing to communicate solutions to problems, Through the learning process in grade XI IPA-5 students as this experimental class, students are also trained to explain the answers to the HOTS questions given by the teacher, so that the solution of problems obtained through the scientific process with indicators that support the research objectives. The existence of face-to-face learning in blended learning certainly also strengthens students' mathematical communication ability. With this, it can be said that the application of the blended learning learning model trains the mental training of experimental class students to dare to express opinions and train and develop students' thinking through the learning communication process, both online and face-to-face which is carried out in this model.

Learning that is carried out consecutively between online learning and offline learning makes blended learning can improve students' mathematical communication ability. The average N-Gain test score showed that the improvement of students' mathematical communication ability before and after blended learning was relatively high with a score of 0.77. This is because blended learning is a conducive environment in communicating students' mathematical ideas. An adequate environment is an environment that makes students more comfortable in expressing their ideas freely (Clark and Jennifer, 2005). Blended learning conditions that make students more active so that students can express their opinions boldly (Marlina, ddk., 2014). Teachers must be aware of the communication characteristics of their students to create a communicative classroom (Herheim, 2015). During online learning, students communicate their mathematical ideas to explore their knowledge in order to find concepts through online modules given on google classroom. So that during offline learning, it is hoped that students already have mathematical concepts that are ready to be applied in completing offline modules. If during online learning students experience obstacles, then it is in offline learning that students can overcome these obstacles. Likewise, if students experience obstacles during offline learning, students can pour it into online learning.

The following are some of the students' answers after learning with blended slopening can be seen in Figure. 1 and Figure. 2.

Question 1. Pay attention to the following row pattern!

a. 1, 3, 7, 9, …
b. 27, 9, 3, 1, ….
c. Does the line include an arithmetic line or a geometric line? Determine the 10th quarter of the lineup?



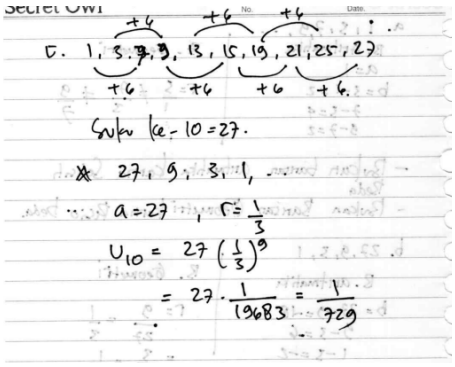


Figure 1a. Critical thinking questions and answers with the application of blended learning for Superior Students

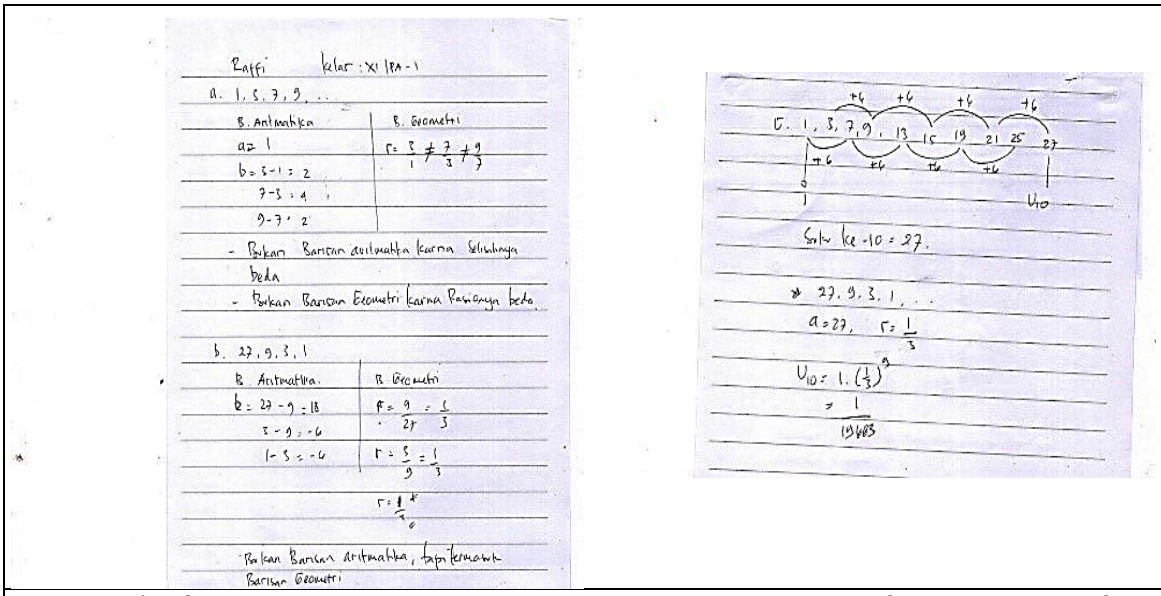


Figure 1b. Critical thinking questions and answers with the application of blended learning for Medium Students

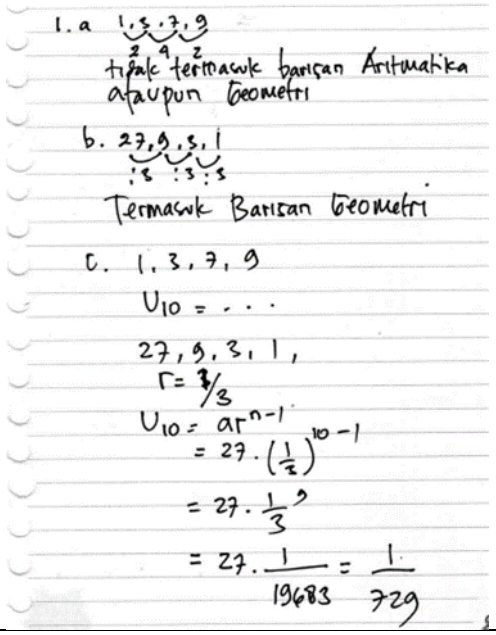


Figure 1c. Critical thinking questions and answers with the application of blended learning for Asor students

Students' critical thinking ability in solving problems are analyzed based on indicators of critical thinking ability, namely analyzing, solving problems, summarizing, and evaluating. Figure 1a shows the results of the students' work with very good criteria, the ability of students to understand the purpose and problems in the questions and be able to analyze information by writing down what is known. On the analysis indicator, students can write whether the problem is an arithmetic sequence or not, can determine the 10th term based on the number pattern correctly. Meanwhile, in the evaluation indicator, students still mistakenly judge their own reasoning by giving inappropriate arguments to questions that ask the subject to check the truth of a claim or opinion listed in the question and write proof with correct calculations. Then on the inference indicator, students can write conclusions according to the problem in the question. So, based on this explanation, students are able to analyze the information contained in the

questions, collect data, sequence steps to solve problems and conclude the results of the solutions that have been written. Figure 1b shows the results of student work with moderate criteria, students' ability to understand the purpose and problems in the problem and be able to analyze information by writing down what is known. On the analysis indicator, students can write whether the problem is an arithmetic sequence or not, can determine the 10th term based on the number pattern correctly. Meanwhile, in the evaluation indicator, the student is able to assess the reasoning he makes himself but does not give the right argument for the problem, which should be the first term value of 27, the student wrote, so the student writes proof with inaccurate calculations. While Figure 1c shows the results of student work with the Asor criteria, the ability of students to understand the purpose and problems in the problem and be able to analyze information by writing down what is known. On the analysis indicator, students can write whether the problem is an arithmetic sequence or not, but they have not been able to determine the 10th term based on the number pattern correctly. Meanwhile, in the evaluation indicator, students are able to assess their own reasoning by giving the right argument to the problem, so that the student writes proof with the right calculation.

Question 2. The middle quarter of an arithmetic sequence is equal to 20, its last quarter is equal to 47 and its third term is equal to -1. Calculate:

a. The first quarter and the difference between the arithmetic sequence
b. There are many terms in the arithmetic line.

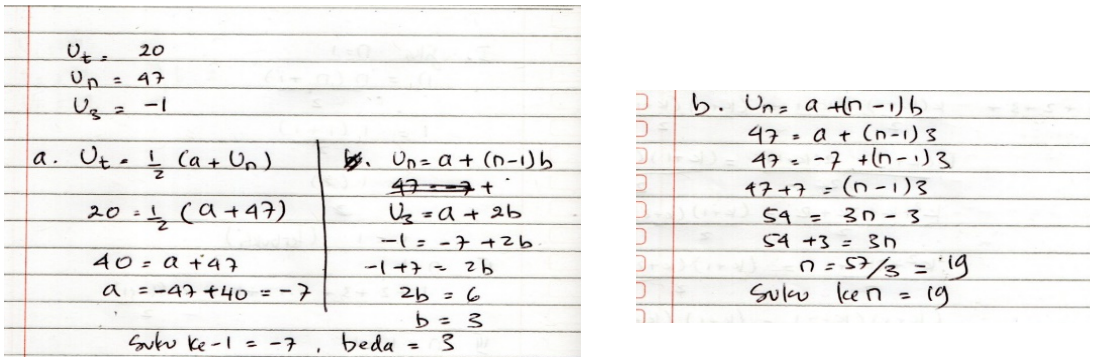


Figure 2a. Mathematical Communication Answers with the Application of Blended Learning for Superior Students

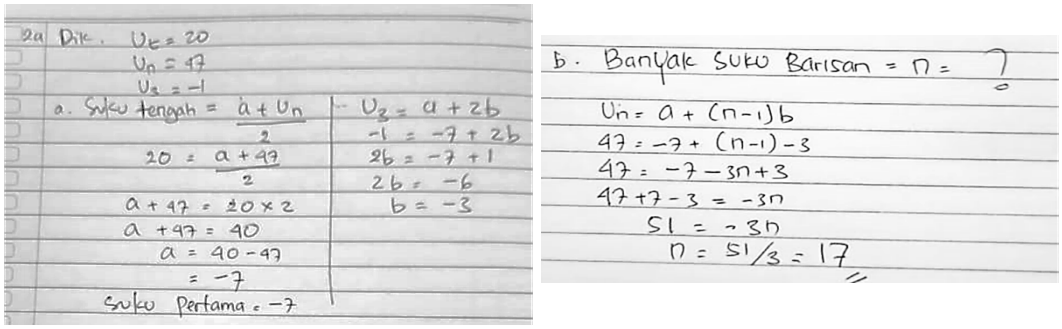


Figure 2b. Mathematical Communication Answers with the Application of Blended Learning for Medium Students

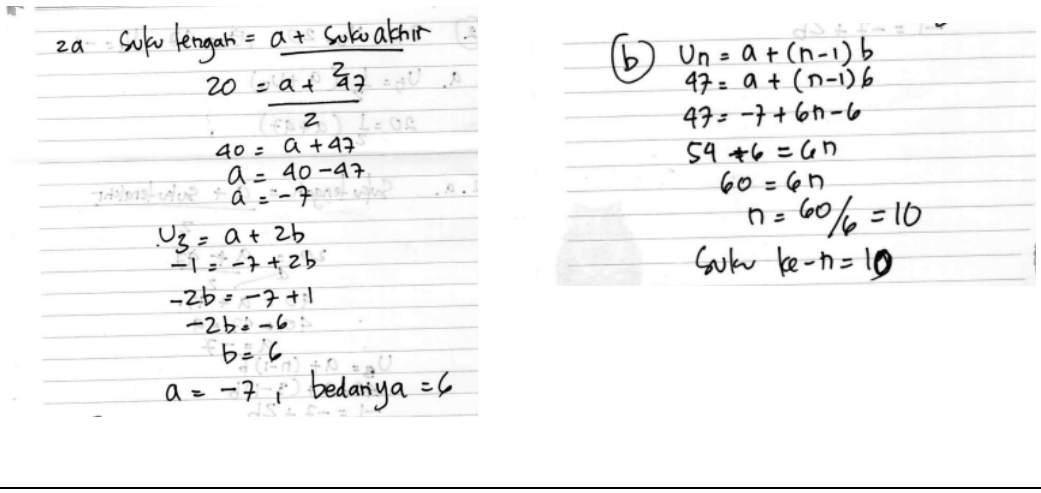


Figure 2c. Mathematical Communication Answer with the Application of Blended Learning for Asor Students

From Figure 2a, it can be seen that the results of the completion of one of the students who has high communication ability, students can provide solutions according to the indicators of students' mathematical communication ability, namely students can write mathematical ideas so that mathematical forms and provide information on mathematical patterns. The student was able to present the completion of the answer in sequence and correctly and also write calculations mathematically according to the formula of rows and rows. In addition, students have used mathematical symbols in the process of solving and deducing the answers from the calculation process with their own communication language and can be understood well at the end of the work. Figure 2b can be seen as a result of the completion of one of the students who has moderate communication ability, students can provide solutions according to the indicators of students' mathematical communication ability, namely students can write mathematical ideas so that mathematical forms and provide information on mathematical patterns. The student has been able to present the completion of the answer in sequence and correctly and also write the calculation mathematically according to the formula of rows and rows, although in the calculation process there is a mistake in placing the negative sign (-) so that in the final result of the calculation which should be 3 to -3, but the student has been able to use mathematical symbols in the process of completion. And at the end of the work, the student does not conclude the answer from the calculation process with his own communication language. While in Figure 2c you can see the results of the completion of one of the students who has ASOR communication ability, students can provide solutions according to the indicators of students' mathematical communication ability, namely students can write mathematical ideas so that mathematical forms and provide information on mathematical patterns. The student has been able to present the completion of the answer in sequence and also write down the calculation mathematically according to the formula of rows and rows, but there is a mistake when looking for a difference value that should be -6 : -2 = 3, the student writes 6. In addition, students have used mathematical symbols in the process of solving and deducing the answer from the calculation process with their own communication language and can be understood well at the end of the work, even though the answer is wrong because it has been started with the wrong calculation of division at the beginning.

This shows that the blended learning model can improve students' mathematical communication ability. And after learning using the blended learning model for the experimental class and ordinary learning in the control class, a score with an n-gain result value was obtained which showed that there

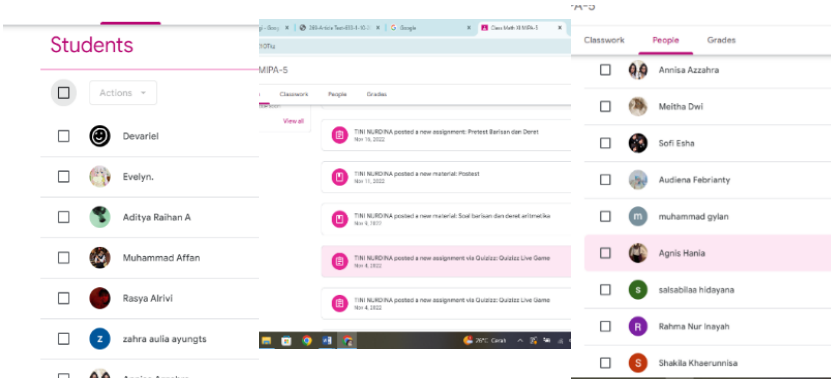
was an improvement in the direction of better students' mathematical communication ability. One of the factors that causes significant differences is because of the use of the blended learning model, the concepts studied require students to be active in groups and individually and be responsible in learning the material so that students' knowledge and insight develop and convey information to other groups in pairs, thus increasing students' cohesiveness and confidence. In this activity, it can further improve the students' mathematical communication ability possessed by students. Thus, based on the results of the pretest and posttest carried out, the row and series material contains three indicators of students' mathematical communication ability, namely writing down daily life problems in the form of mathematical models, performing mathematical calculations and connecting tables and graphs into mathematical ideas. Therefore, blended learning is considered very appropriate to solve the learning problems that have been described. Students are active when using the blended learning model relevant to the research of Astuti (2019) with the title "Blended Learning Towards Students' mathematical communication Ability". The results of this study are obtained that with mathematical communication ability, students can share ideas to deepen their understanding and also to solve mathematical problems, so as to increase students' success in learning mathematics. This blended learning can make the learning process more fun and provide opportunities for students to associate mathematics with other sciences so as to motivate students to learn.

THE IMPLEMENTATION OF BLENDED LEARNING

The implementation in this study is carried out in blended learning activities through google classroom. The implementation of blended learning used utilizes Google Classroom and combines it with face-to-face learning in the classroom. The online learning setting through google classroom is given material in the form of power point files, pdfs and videos. Students can download the material and study it before the offline learning setting in the classroom is carried out. Face-to-face learning is as a reinforcement of material through the class discussion process. The teacher as a facilitator provides explanations related to the material that needs to be straightened out and explained in more depth. Learning planning is carried out so that learning becomes more directed and effective in achieving learning goals (Suryadi & Mushlih, 2019). The independent learning results carried out by students are then developed and deepened with teachers in the classroom. Students have the responsibility to be creative and innovative in exploring knowledge through various sources independently (Rahmad et al., 2019). In addition, students are also trained to be more critical in finding solutions to problems related to classroom discussion activities and assignments outside of face-to-face. Thus, blended learning through Google Classroom has online and offline learning activities that can provide a meaningful learning experience through the learning activities carried out. The following is presented in Figure 3 regarding the process of using the blended learning model.

Offline Learning Activities (face-to-face)

Online learning activities (Blended learning) with google classroom media



Learning with Google Classroom

Figure 3. *Teaching and Learning Activity Process in class XI IPA-5*

Students' Attitudes Towards The Implementation Of Blended Learning

Based on the analisis, it is reported that 92.9% of students are positive that learning using the Blended Learning model is fun, 82.2% of students are positive that blended learning can foster independent learning attitudes, 100% of students have a positive attitude can foster motivation and creativity in the learning process, 75% of students have a positive attitude blended learning can foster an active attitude, and 22% show a negative attitude, 92.9% of students have a positive attitude as well It is strongly agreed that learning using information technology needs to be applied. This shows that students are satisfied with the Blended Learning learning design that combines face-to-face meetings and the use of Google classroom. indeed the design dimension is the factor that most affects student satisfaction with the e-learning component in Blended Learning. Learning with the Blended Learning model provides the opportunity to learn mathematics anywhere and anytime without being limited by time. This is in line with the opinion of Keogh et al. (2017) and Haka et al. (2020) who explained that one of the advantages of Blended Learning is the opportunity to be able to continue to access material even though it is not present in ordinary (conventional) learning and can adjust the learning process to the characteristics and learning styles of students themselves. This ease of learning will certainly help students understand the learning material well. This result is in line with Bibi's (2015) research which shows that Blended Learning can improve students' understanding compared to ordinary learning.

CONCLUSION

The improvement of critical thinking and mathematical communication ability of students who obtained blended learning was higher than that of students who obtained conventional learning. The critical thinking ability of superior students are able to assess the reasoning they make on their own by providing the right argument to the question that asks the subject to check the truth of a claim or opinion stated in the question and write proof with correct calculations. Then on the inference indicator, students can write conclusions according to the problem in the question. Asor students, at the stage of identifying, are not able to identify the concepts used from the problems provided, the stage of generalizing and performing calculation operations students are not able to generalize what is known in the problem and are not precise in the calculation process, at the stage of formulating problems to mathematical models students are not able to formulate a description or symbol in the model or mathematical formula.

Meanwhile, in mathematical communication ability, students excel at being able to write mathematical ideas so that mathematical forms and provide information on mathematical patterns, students can already present the completion of answers in sequence and correctly and write calculations mathematically according to the formula of rows and rows, and students have used mathematical symbols in the process of solving and concluding answers from the calculation process in their own communication language and can be understood well at the end of the job. The students' answers are not yet able to solve the problem according to the correct answer, but the students are able to make conclusions at the end of the work.

There are limitations in the blended learning process, when using google classroom media, there are still students who do not have laptops and gadgets that do not support it. In addition, accessing online media is still constrained by poor signals. Recommendations for further research include expanding the scope of the research and being able to add to the variables studied. Schools need to facilitate facilities and infrastructure for teaching and learning activities with an adequate internet network so that the blended learning learning model can be carried out optimally.

The implication of this study is that blended learning provides an opportunity to improve and develop an education system that is more inclusive, adaptive, and relevant to student needs and technological developments. With the implementation of blended learning, teachers have the opportunity to collaborate with fellow teachers and engage in online professional development.

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