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Improving Students' Mathematical Problem Solving Ability in Trigonometry Material Using the Flipped Classroom Model

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Abstract

This research was motivated by the relatively low learning outcomes and problem solving abilities of class IX students. So this research aims to improve learning outcomes and improve students' mathematical problem solving abilities. The objectives were achieved through the classroom action research method by applying the flipped classroom model for 3 cycles in trigonometry learning. This research involved 32 students from SMA N 1 Pedes. Data was collected using test instruments, observation sheets, and interviews. Data were analyzed using the Miles & Hubberman method. The results of the analysis show an increase in learning outcomes and an increase in mathematical problem solving abilities. The increase in learning outcomes is shown by the average value in cycle I of 67.28, cycle II of 72.97, and cycle III of 75.41. The percentage of mathematical problem solving ability from cycle I was 47%, increasing in cycle II to 71.87%; and in cycle III it was 84.37%. Thus, student learning outcomes have reached the specified criteria of 74, and meet the criteria for the percentage of problem solving ability set at 80%. So the application of the flipped classroom model can be recommended for further use in mathematics learning, especially trigonometry.

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INTRODUCTION

Mathematics is taught to students in Indonesia from elementary to secondary level, one of the goals is to equip students with problem solving skills (Kemendiknas, 2010). Through the learning process students will practice solving mathematical problems which will be useful when they are carrying out the process of integrating mathematics into other fields or when implementing it into everyday life problems (English & Sriraman, 2010). This goal is also in line with the mathematics learning outcomes standard from the National Council of Teachers of Mathematics (NCTM) which states that students are able to solve everyday problems with the help of the mathematical concepts and procedures

they have learned (Bossé et al., 2010). It was also stated that strengthening the attitude of perseverance and never giving up for students during the process of solving mathematical problems is part of the cultivation of positive national character that needs to be continuously developed (Almerico, 2014; Freeman-Green et al., 2015; Rokhman et al., 2014). So strengthening problem-solving abilities in students through learning mathematics is very important. Previous experts such as Dewey (1916) and Bruner (1961) have also argued about the importance of an educational process that is oriented towards the formation of problem-solving competencies.

Unfortunately, the ability to solve mathematical problems which is the target of mathematics learning in schools in Indonesia is not yet fully as expected. The results of the analysis of problem solving abilities carried out by previous researchers show that students' mathematical problem solving abilities at several levels of Senior High School are still in the low category (Akbar et al., 2018; Nugraha & Zanthy, 2019; Rachmawati & Adirakasiwi, 2021). Therefore, researchers are challenged to participate in efforts to improve the problem-solving abilities of students in Indonesia, the aim of which is none other than to ensure that the quality of graduates is increasingly high quality. This is one of the reasons why this research needed to be carried out. To find out students' mathematical problem solving abilities in more detail, the researchers made observations at one of the high schools in Karawang, Indonesia. Based on the results of observations at SMA N 1 Pedes, the researchers obtained data on mathematical problem solving abilities that were still relatively low in class IX. This is shown by the results of the Final School Examination where only 20% of students succeeded in achieving the Minimum Completeness Criteria. To confirm the students' mathematical problem solving abilities in this class, the researchers gave pretest questions. The pretest results are presented in Figure 1.

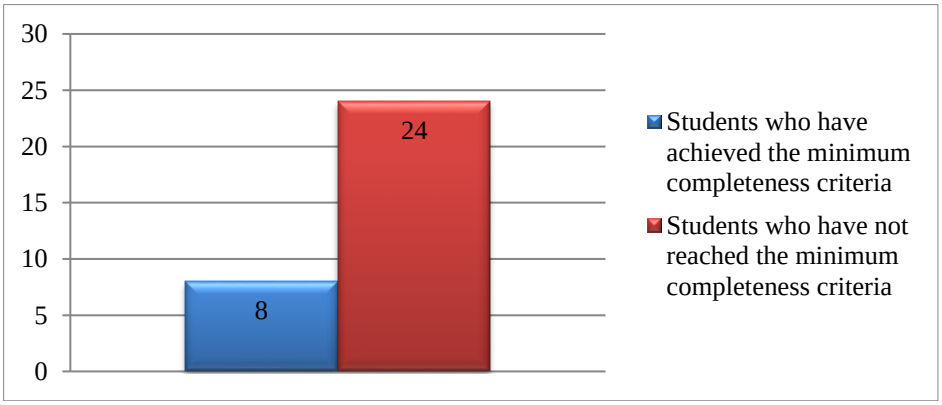

Figure 1. Pretest results of mathematical problem solving ability

Through the pretest results shown in Figure 1, it can be seen that only 8 students or around 25% of the 32 students succeeded in reaching the Minimum Completeness Criteria. So, through the results of this pre-test, it can be said that the students' mathematical problem solving abilities in this class are really low.

The researcher then carried out further observations to find out the factors causing the low mathematical problem solving abilities in this class. Based on observations, it is known that the learning usually carried out by teachers has not

integrated certain learning models with an orientation towards increasing mathematical problem solving abilities. Another finding is that students are not yet motivated to be actively involved in problem solving from the contextual questions presented. Based on the mathematics learning problems found, researchers were encouraged to get involved in looking for alternative solutions. If it is based on the causal factors found, a learning process is needed that can encourage students to be actively involved in the process of solving mathematical problems. Nurafifah, Nurlaelah, and Usdiyana (2016), argue that if teachers are willing to utilize certain appropriate learning models it will have a positive influence on students' mastery of mathematical problem solving. A similar opinion also states that the use of models that are appropriate to the learning objectives to be achieved will have a positive impact on student learning outcomes (Alifah, 2019; Fahrurrozi, Mohzana, & Murcahyanto, 2021; Khoerunnisa & Aqwal, 2020; Warsita, 2018).

As an alternative solution, it is necessary to improve learning methods from the methods previously used by teachers. Before determining the learning method to be used, it is necessary to remember that the current implementation of the Independent Curriculum requires the integration of technology in the learning process (Cholilah et al., 2023; Nuridayanti et al., 2023; Widiyono & Millati, 2021). Thus, the learning method that is intended to be used as an alternative solution needs to consider the objective aspect, namely increasing student activity in solving mathematical problems, and the aspect of using technology to accommodate the demands of implementing The Independent Curriculum.

Based on the literature, one learning model that can increase student activity and at the same time involve the use of technology is the flipped classroom model. The flipped classroom is a learning model that uses multimedia devices and technology to help exchange time for delivering learning material (Hwang & Lai, 2017), so that students receive the most support when they are working on assignments that require a lot of additional theory while in class (Lai & Hwang, 2016). Apart from that, the flipped classroom model is the right strategy and is in accordance with the development of 21st century learning technology (Widyasari, Masykur, & Sugiharta, 2021). The flipped classroom model is recommended for use in this research based on several opinions which state that there are benefits in line with the objectives of this research. This benefit is that it can maximize student activity through the process of interaction between students and teachers, and between students and each other, which can encourage an increase in students' mathematical problem solving abilities (Rohmatulloh & Nindiasari, 2021; Threlkeld, 2017; Widyasari et al., 2021; Zainuddin & Attaran, 2016). The steps for the flipped classroom learning model that will be used are adapted from Pardimin et al. (2020) which consists of learning outside the classroom and inside the classroom. Sequence of learning steps outside the classroom consists of: (1) the teacher shares learning videos via WhatsApp group; (2) students study the material by listening to the video; (3) students record the problems they find. As for the class, it consists of: (1) the teacher asks about the material that has been studied through video; (2) the teacher asks if there is any material that the students have not understood; (3) the teacher explains the material that the students have not understood; (4) the teacher gives practice questions to the students; (5) the teacher gives instructions for students to solve the questions, and; (6) the teacher

monitors the student discussion process. Next, the learning steps will be applied to learning trigonometry material. Trigonometry material was chosen because it corresponds to the target material that must be taught in the curriculum, and is based on analysis results which show that high school students still experience errors when solving trigonometry problems (Setiana, Fitriani, & Amelia, 2021; Tunnajach & Gunawan, 2021).

In accordance with the background of the problem that has been explained, after being given treatment in learning trigonometry using the steps of the flipped classroom learning model, it is hoped that students' learning outcomes and mathematical problem solving abilities will increase. Learning outcomes are said to improve if there is an improvement in the average value obtained after being given treatment. Students' mathematical problem solving abilities are said to increase if they fulfill the indicators from Polya (1985): (1) understanding the problem; (2) planning the solution; (3) resolve problems according to plan, and; (4) recheck the results obtained.

RESEARCH METHODS

This research is in the form of Classroom Action Research, namely research conducted on learning activities which are deliberately raised and actions carried out together in a class (Arikunto, 2021). The purpose of doing class action in this study was to improve the learning process with the ultimate goal of improving the mathematical problem solving abilities of class XI students. The class action carried out was in the form of applying the flipped classroom learning model to trigonometry material which consisted of three cycles. Each class action cycle is carried out following the procedure developed by (Arikunto, 2021) as shown in Figure 2.

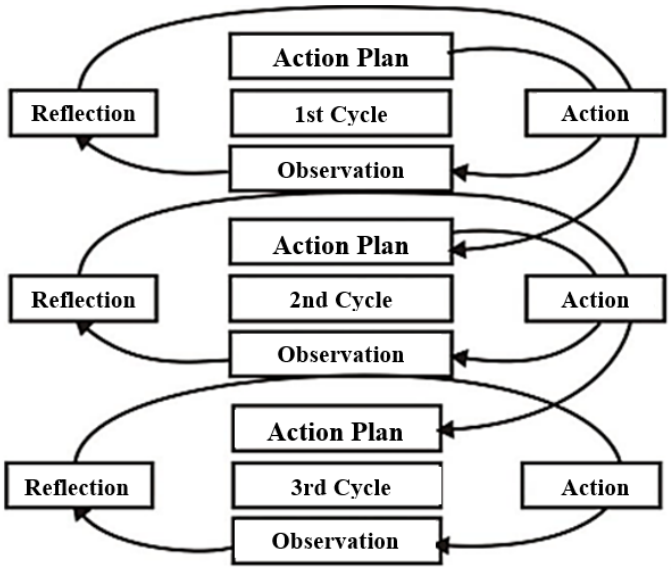

Figure 2. Classroom research model by Arikunto (2021)

It can be seen from Figure 2 that the classroom action research procedure carried out consists of the following stages: (1) planning; (2) action; (3) observation, and; (4) reflection. Before the class action was carried out, the

researcher first carried out the pre-action stage which aimed to divide the learning material into the three planned cycles, as well as establish the initial conditions as the basis for measuring an increase in mathematical problem-solving abilities.

This classroom action research involved 32 students who were in one class and the researcher himself acted as a teacher. The other party involved is the senior mathematics teacher at the school who acts as an observer. Research data were collected using written test instruments, observation, interviews, and documentation. The developed written test instrument contains indicators of problem-solving abilities from Polya (1985), which consist of: (1) understanding the problem; (2) determine a strategic plan for problem solving; (3) complete the strategic plan, and; (4) recheck answers. Observations were made using an observation sheet which contained indicators: (1) students focused on problems; (2) students are able to describe the sketch of the problem; (3) students carry out planning for completion; (4) students carry out plans, and; (5) evaluation of results. The interviews were conducted using the indicators contained in the interview guidelines. The data obtained was then processed using the method by Miles and Hubberman (1984) until a conclusion was drawn. The criteria for the success of the learning process determined in this research are if 80% of students have achieved the Minimum Completeness Criteria and the percentage of students' mathematical problem solving ability achievement is 75%.

RESULTS AND DISCUSSION

Before implementing the class action stage, a pre-action stage is first carried out which consists of determining the initial conditions and distributing the material to be taught in each cycle. Initial conditions were determined by providing pretest questions, the results of which are presented in Figure 1. Thus, the initial conditions before action was taken showed that only 8 students (25%) passed the Minimum Completeness Criteria. After going through 3 cycles of classroom action, it is assumed that students who successfully achieve the KKM will improve, followed by an increase in students' mathematical problem solving abilities, especially in trigonometry material. The trigonometry material is divided into 3 cycles, namely cycle 1 and cycle 2 with the subject of trigonometric equations, and cycle 3 with the subject of trigonometric equations involving the sum and difference of angles. Next, class action was carried out, the results of which were as explained below.

Class Action Results in Cycle 1

Cycle 1 was held in 3 meetings, each meeting was held in 2 class hours. The first meeting on May 4 2023 held a discussion regarding the learning process plan, and the material on trigonometric equations was explained. The second meeting was held on May 5 2023 and carried out further discussions regarding trigonometric equations. The 3rd meeting on May 11 2023 carried out a posttest. The results of class actions from each stage in cycle 1 are explained as follows.

Results of the Planning Stage

The results of the planning stages are: (1) lesson plan with limited materials on trigonometric equations; (2) develop a cycle 1 posttest instrument consisting of 5

questions; (3) compiling observation sheets; (4) compiling an interview sheet; (5) dividing student groups according to the needs of implementing the flipped classroom model, and; (6) prepare a learning video on the subject of basic trigonometry equations in the video link: https://www.youtube.com/watch?v=l5ec3hUNWSQ.

Results of Implementation Phase

At the first meeting the researcher started the learning activity by informing the results of the division of the study group which was divided into 6 groups consisting of 5 to 6 students. Next, the researcher provided a link to the learning video to be studied at home and used as material for group discussion at the next meeting. At the second meeting, a group discussion was held regarding the concepts of sine, cosine and tan equations, as contained in the video. In general, the learning process at the first and second meetings ran smoothly, and was attended by observers who were tasked with observing teacher and student activities during the lesson. At the third meeting, a posttest was carried out which was attended by 32 people, the results of which can be seen in Table 1.

Table 1. Cycle 1 posttest results

Achievement	The number of students	%	Average
Pass Criteria	15	47%	67,25
Did’n Pass Criteria	17	53%	

Table 1 shows that 47% of students achieved the Minimum Completeness Criteria score and 53% of students did not complete it. Because the success criteria set is that 80% of students must complete the Minimum Completeness Criteria, it can be said that students’ learning outcomes in cycle 1 are still low and improvements need to be made in the next action process.

Observation Phase Results

Based on the observation sheet, it can be shown that the percentage of students' mathematical problem solving abilities in cycle 1 was 61.17%. Because the success criteria are set at 75%, it can be said that the achievement of students' mathematical solving abilities at this stage is still low. Based on the results of the observations, it was found that students lacked focus, which was indicated by behavior that disturbed other students, and it was also found that students felt anxious when they did not understand the problem-solving steps that should be taken. Based on the results of the observer's observations, it was found that teacher activities were not optimal, so it was recommended that their activities be increased.

Results of the Reflection Stage

Based on the observation results, it was found how many things needed to be improved in cycle 2, including teachers needing to increase activities aimed at making students focus more on the learning process. Apart from that, teachers need to take a personal approach to students who are seen as experiencing mathematical anxiety.

Class Action Results in Cycle 2

Cycle 2 was held in 3 meetings, where each meeting was held in 2 class hours. The first meeting on May 12 2023 was held to discuss the learning process that would be carried out and discussed the material on trigonometric equations. The second meeting on May 17 2023 held a further discussion regarding trigonometric equations. The third meeting will be held on May 19 2023, where the posttest will be held. The results of each stage of class action carried out in cycle 2 are explained as follows.

Results of the Planning Stage

The results of the planning stages are: (1) lesson plan with limited material on trigonometric equations; (2) develop a cycle 1 posttest instrument consisting of 5 questions; (3) compiling observation sheets; (4) compiling an interview sheet; (5) dividing student groups according to the needs of implementing the flipped classroom model, and; (6) prepare a learning video on the topic of trigonometric equations involving trigonometric comparisons with the video link: https://www.youtube.com/watch?v=Yk4SmyMqobE.

The teacher's improvement plan to direct students to be more focused is to prepare several rhymes related to trigonometry material. One of the verses of the prepared rhyme reads: *"Pergi ke pasar untuk beli ikan teri, pulangnya ketemu bekantan. Ayo belajar trigonometri, karna sudah ditunggu sin, cos, dan tan."* Next, the teacher plans to take a personal approach to students who experience mathematics anxiety, namely by providing motivation and suggesting more discussions with their colleagues.

Results of Implementation Phase

At the first meeting, the researcher started the learning activities by informing the results of the posttest from cycle 1. Next, the teacher provided a link to the learning video to be studied at home and used as material for group discussion at the next meeting. At the second meeting, the second meeting carried out learning activities using group discussions. At the second meeting A group discussion was held regarding trigonometric comparisons. The learning process generally went smoothly and was attended again by observers. At the third meeting, a posttest was carried out which was attended by 32 students, with the results which can be seen in Table 2.

Table 2. Cycle 2 posttest results

Achievement	The number of students	%	Average
Pass Criteria	23	71,87%	72,97
Did'n Pass Criteria	9	28,13%	

Table 2 shows that 71.87% of students achieved the Minimum Completeness Criteria score, while 28.13% of students did not complete it. Thus, student learning outcomes in cycle 2 cannot be said to be successful because they have not been able to reach the success criteria, namely 80% of students must complete the Minimum Completeness Criteria.

Results of the Observation Phase

Based on the observation sheet, it can be shown that the percentage of students' mathematical problem solving ability increased to 74.17%, thus the action process in cycle 2 cannot be said to have succeeded in reaching the set criteria for the percentage of problem solving ability, namely 75%. Based on the results of observations, it is known that some students' weaknesses in the process of solving mathematical problems are that they still experience difficulties in physically describing problems and planning solutions. Based on the observer's observations, it can be shown that teacher activities have been optimally improved, but teachers still need to provide intensive assistance to several students who experience difficulties when writing forms of mathematical problem solving plans.

Results of the Reflection Stage

Based on the observation results, several things were found that needed to be improved when implementing actions in cycle 3, including researchers needing to provide intensive assistance to several students who were still experiencing difficulties in formulating problem-solving steps.

Class Action Results in Cycle 3

Cycle 3 was held in 3 meetings, each meeting being held in 2 class hours. The first meeting on May 25 2023 held a discussion on trigonometric sum and difference equations. The second meeting on May 26 2023 held a further discussion regarding trigonometric sum and difference equations. The third meeting on May 31 2023 held a posttest. The results of the actions from each stage in cycle 3 are explained as follows.

Results of the Planning Stage

The results of the planning stages are: (1) lesson plan with limited material on trigonometric sum and difference equations; (2) develop a cycle 1 posttest instrument consisting of 5 questions; (3) compiling observation sheets; (4) compiling interview sheets, (5) dividing student groups according to the needs of implementing the flipped classroom model, and; (6) prepare a learning video on the subject of trigonometric equations of quantities and angle differences with the video link: https://www.youtube.com/watch?v=AEnPOa4hubw.

The teacher's plan for students who still have difficulty making problem solving plans is to remind them of the problem solving stages from Polya (1985). Next, the teacher will provide special assistance to students who are still experiencing the same difficulties.

Results of Implementation Phase

At the first meeting, the researcher started the learning activity by informing the results of the posttest from stage 2. Next, they provided a learning video link with material on trigonometric sum and difference equations to be studied at home and used as material for group discussion. At the second meeting, group discussion activities were carried out discussing trigonometric sum and difference equations. Next, at the third meeting, a posttest was carried out followed by 32 students, the results of which are presented in Table 3.

Table 3. Cycle 3 posttest results

Achievement	The number of students	%	Average
Pass Criteria	27	84,37%	75,41
Did'n Pass Criteria	5	15,63%	

Table 3 shows that 84.37% of students have reached the Minimum Completeness Criteria, while 15.63% of other students have not yet completed it. If it refers to the set criteria, the learning process in cycle 3 can be said to have succeeded in achieving the set criteria.

Observation Phase Results

Based on the observation sheet, it can be shown that the percentage of students' problem solving abilities has increased to 81.83%. Thus, it can be said that the increase in students' mathematical problem solving abilities has reached the expected criteria.

Results of the Reflection Stage

Based on the achievement of learning outcomes and the increase in the percentage of students' mathematical problem solving abilities in cycle 3, it was decided that this classroom action research did not need to be continued in the cycle, and this research was considered successful.

Classroom action research which was planned to be carried out in 3 cycles has been completed according to established procedures. In general, the class action process in the form of implementing the flipped classroom model in class XI in learning trigonometry has been carried out without problems. Based on the results of the posttest in cycle 1, it is known that only 47% of students whose learning outcomes reached the Minimum Completeness Criteria, and the percentage of problem solving ability achieved was 61.17%. Next, the action process in cycle 2 is carried out based on suggestions for improvement provided by the observer. Based on the results of the posttest in cycle 2, it can be shown that 71.87% of students achieved the Minimum Completeness Criteria with a percentage of problem solving ability achievement of 74.17%. Learning in cycle 3 was carried out again by following suggestions from the observer. Based on the results of the posttest in cycle 3, it can be shown that student learning results have achieved the Minimum Completeness Criteria of 84.37% with a problem solving ability percentage of 81.83%. In general, the increase in student learning outcomes is presented in Figure 3.

Based on Figure 3, researchers have been able to show that there is an increase in learning outcomes in each cycle, namely from the pre-cycle stage to cycle 1 it increased by 22%, then from cycle 1 to cycle 2 it increased by 24.80%, and from cycle 2 to cycle 3 increased again by 12.57%. Based on Figure 3, it can also be shown that the student learning outcomes in cycle 3 have reached the specified criteria, namely that there are 27 students or around 84.37% who have reached the Minimum Completeness Criteria. This concludes that the action process taken has had a positive impact on efforts to improve learning which is the aim of this research.

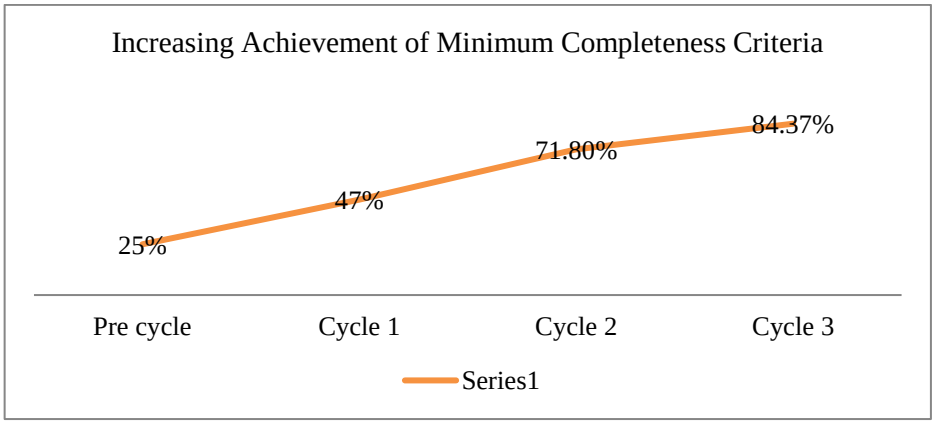

Figure 3. Improved learning outcomes in each cycle

Furthermore, based on the results of the analysis of the observation sheet, it can be shown that there is an increase in the percentage of students' achievement of mathematical problem solving abilities. The increase in the percentage achievement of students' mathematical problem solving abilities from each cycle is presented in Figure 4.

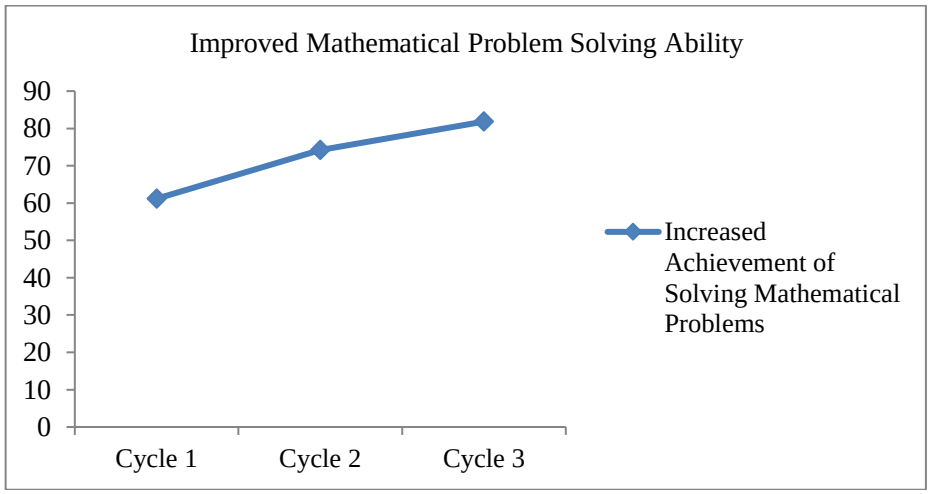

Figure 4. Percentage increase in students' mathematical problem solving ability

Based on Figure 4, it can be shown that there is an increase in the percentage of mathematical problem solving abilities from cycles 1 to 3. Based on Figure 4, it is known that the percentage increase in students' mathematical problem solving abilities has reached 81.83% in cycle 3, so that it has met the success criteria to be achieved in this research. namely 75%. If detailed further, the percentage increase from cycle 1 to cycle 2 increased by 13%, and from cycle 2 to cycle 3 it increased again by 7.66%.

Based on the description above, researchers have been able to show that providing classroom actions through the application of the flipped classroom model in trigonometry material has succeeded in improving learning outcomes and also improving students' mathematical problem solving abilities. The results of this research are in line with the results of previous research, including research conducted by Widyasari et al. (2021) which stated that there was an increase in

critical mathematical thinking skills and learning motivation among Madrasah Tsanawiyah students in learning using the flipped classroom. Meanwhile, Saputra and Mujib (2018) research stated that students' understanding of mathematical concepts using the flipped classroom learning model was better than their ability to understand concepts using the lecture learning method.

CONCLUSION

Based on the results of data analysis researchers have been able to show an increase in student learning outcomes and an increase in problem solving abilities. The increase in learning outcomes is shown by the results of the posttest, namely: (1) the average value of learning outcomes in cycle I is 67.28; (2) in cycle II it was obtained at 72.97, and; (3) in the third cycle of 75.41. While the increase in problem solving ability is shown through the observation results sheet, namely: (1) problem solving ability in the first cycle of 47%; (2) in cycle II increased by 71.87%, and; (3) in cycle III it increased again by 84.37%. These results indicate that student learning outcomes have met the specified criteria, specifically achieving a score of 74 and meeting the criteria for problem-solving ability at 80%. Therefore, it can be concluded that the classroom action, in the form of applying the flipped classroom model, improves learning outcomes and enhances students' mathematical problem-solving abilities, particularly in trigonometry. The conducted research has successfully achieved its stated objectives, suggesting that the application of the flipped classroom model is recommended for subsequent years in trigonometry education.

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