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Improving Mathematical Reasoning Skills Through an Open-Ended Approach Assisted by Google Classroom and Google Meet

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Abstrak

Penelitian ini bertujuan untuk meningkatkan kemampuan penalaran matematis siswa melalui pemanfaatan Google Classroom dan Google Meet. Subjek penelitian adalah 21 siswa kelas XI SMK Negeri 2 Kota Sorong. Penelitian ini dilakukan dalam dua siklus, yaitu siklus I dan siklus II, dengan pendekatan penelitian tindakan kelas. Data dikumpulkan melalui penilaian hasil belajar dan observasi kelas, lalu dianalisis secara kuantitatif dan kualitatif. Hasil penelitian menunjukkan adanya peningkatan kemampuan penalaran matematis siswa pada berbagai indikator, yaitu: menyajikan proposisi dan ilustrasi matematika tertulis (47,43%-85,89%), melaporkan dan memanipulasi tuduhan matematika (36,80%-77,77%), menyusun data dan memberikan justifikasi solusi (44,20%-81,40%), serta mencapai kesimpulan (28,12%-47,39%). Rata-rata respons positif siswa terhadap pendekatan open-ended mencapai 9,5%. Berdasarkan temuan ini, pendekatan open-ended yang didukung oleh Google Classroom dan Google Meet terbukti efektif untuk meningkatkan kemampuan penalaran matematis siswa. Implikasi dari penelitian ini adalah bahwa integrasi teknologi dengan pembelajaran berbasis open-ended dapat diterapkan secara lebih luas untuk meningkatkan kualitas pembelajaran matematika di sekolah, terutama dalam situasi pembelajaran jarak jauh.
Kata kunci: Google Classroom; Google Meet; Penalaran Matematis; Open-Ended.

Abstract

This study aims to improve students' mathematical reasoning ability using Google Classroom and Google Meet. The subjects of the study were 21 grade XI students of SMK Negeri 2 Sorong City. This study was conducted in two cycles, namely cycle I and cycle II, with a classroom action research approach. Data was collected through assessment of learning outcomes and classroom observations, then analyzed quantitatively and qualitatively. The results of the study showed an increase in students' mathematical reasoning ability in various indicators, namely: presenting written mathematical propositions and illustrations (47.43%-85.89%), reporting and manipulating mathematical accusations (36.80%-77.77%), compiling data and providing justification for solutions (44.20%-81.40%), and reaching conclusions (28.12%-47.39%). The average positive response of students to the open-ended approach reached 9.5%. Based on these findings, the open-ended approach supported by Google Classroom and Google Meet has proven effective in improving students' mathematical reasoning skills. The implication of this study is that the integration of technology with open-ended learning can be applied more widely to improve the quality of mathematics learning in schools, especially in distance learning situations.
Keywords: Google Classrooms; Google Meet; Mathematical Reasoning; Open-Ended.

I. INTRODUCTION

According to the National Council of Teachers of Mathematics, connections, reasoning, communication, problem-solving, and representations are the five mathematical talents that must be cultivated (Ariawan & Nufus, 2017). One of the mathematical skills that must be developed and strengthened is reasoning (Nasir et al., 2023). Mathematical reasoning is students' ability to draw inferences from mathematical problems (Latifah & Mahmudi, 2018). One of a student's most important hard talents is the ability to reason mathematically, especially when tackling difficulties in daily life (Hidayat et al., 2022a). High-reasoning students can better convey their thoughts clearly, comprehend new material more quickly, and typically solve math problems.

According to the Indonesian Minister of Education's Circular of the Minister of Education and Culture Number 4 of 2020 (Kemendikbud, 2020), the COVID-19 epidemic impacts the country's educational system because learning is done online from home. At the beginning of the implementation of online education, many teachers finally only gave questions to be done independently at home. Some teachers did house-to-house learning (Mulyono et al., 2022). This dramatically impacts study habits and students' understanding of math problems (Alzahrani et al., 2023). In this context, a learning strategy is needed that can support improving students' mathematical reasoning abilities even in distance learning conditions.

Selecting a teaching strategy that assists students in solving the provided problem is one technique to help students become more proficient in mathematical reasoning (Raharjo et al., 2020; Sariningsih & Herdiman, 2017). To accomplish learning objectives, the choice of learning medium, learning strategies, or suitable learning models has an ideal carrying capacity (Mutiarawati et al., 2022; Pakirnathan et al., 2023; Trisnawati & Sundari, 2021). The educational strategy aims to give students the ability to generate and assess arguments using mathematical reasoning (Herdiman, 2017; Palinussa et al., 2021; Santos et al., 2024; Sukirwan et al., 2018). One of the learning techniques that can be applied to online learning to improve mathematical reasoning abilities is the open-ended method (Kholil, 2020).

An open-ended method makes use of open-ended questions, or questions that have multiple possible answers (Grace et al., 2022; Johar et al., 2023). Open-ended questions can encourage creativity, originality, and invention in mathematics (Wirawan & Wibisono, 2018; Freiman, 2018; Nurfadillah & Afriansyah, 2022). According to research by Lesmana (2018), SMP Negeri 3 Angkola Selatan successfully uses an open-ended strategy to teach algebraic operations in class VIII, which can improve students' mathematical reasoning skills. These results support the class action study by Fatimah (2019), which discovered that open-ended questions can improve students' ability to reason mathematically. This is demonstrated by the average test score percentage increasing from 66.6% in cycle I to 83.3% in cycle II, as well as the high category.

Teachers use several online learning applications: Google Classroom and Google

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Meet (Yulianto, Yulianto, & Hidayanto, 2022; Jasildo et al., 2023; Mahdiyah et al., 2023; Dewi & Afriansyah, 2022; Enriquez, 2014). Google Classroom and Google Meet are learning applications that are relatively easy to use and mastered by students and teachers (Crawford, 2021; Mulyatiningsih et al., 2023; Trisnawati et al., 2022). This is based on the analysis done by Solahudin (2022), who found that providing open problems is adequate in online learning. Students are required to think about solving problems with various solutions (Jamil, Sa'dijah, & Susanto, 2022; Demir et al., 2023).

The importance of this research is to answer the need for effective learning methods in improving students' mathematical reasoning skills in the era of online learning. The novelty aspect of this research lies in the integration of an open-ended approach with the use of Google Classroom and Google Meet to improve the mathematical reasoning skills of vocational high school students in a distance learning environment. This approach has not been widely explored, especially in the context of mathematics learning during the pandemic.

II. METHOD

This study was conducted in a classroom setting (CAR). Using the Open-Ended learning approach, this CAR was put into place at SMK Negeri 2 in Sorong City in November 2020 to enhance the mathematical reasoning skills of eleventh graders. The subjects of this study were 24 students in the eleventh grade at SMK Negeri 2 Sorong City. The study design references the Kemmis and McTaggart model, which is cyclical in nature. Two cycles make up this class action research strategy. Each cycle is carried out according to the intended modifications, such as those in the factors under investigation. Figure 1 below shows the design that was used.

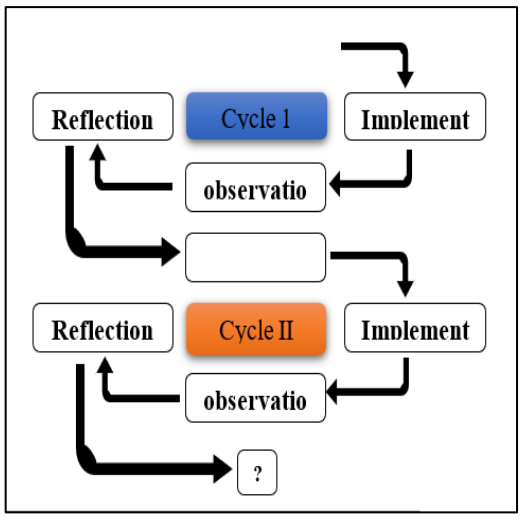

Figure 1. The Classroom Action Research (CAR) Design

Prior to usage in this investigation, every gadget underwent a validation test. This study was carried out in multiple cycles (cycles 1, II, and so forth) to observe how the Open-Ended approach improved students' mathematical reasoning skills. If the cycle of learning mathematics with the Open-Ended technique reaches the success markers, then the cycle will end.

According to the Regulation of the Director General of Education at the Ministry of National Education Number 506/C/Kep/PP/2004 (Gustiadi et al., 2021), the indicators of mathematical reasoning measured in this study include: (1) Presenting mathematical statements in writing and pictorial form; (2) Submitting an allegation; (3) Performing Mathematical

Manipulation; (4) Gathering Evidence, Offering Reasons or Evidence for the Correctness of the Solution; and (5) draw conclusions.

Indicators of success in this study are determined as follows:

1. The Open-Ended learning strategy is being used, and it falls into the excellent category.
2. Based on the results of observations of student activities, the activity of students participating in learning using the Google Meet application and Google Classroom increased from the first cycle to the next cycle to reach the effective category.
3. By comparing the test results from cycle 1 and cycle II with a minimum criterion of 60% of the number of students experiencing an increase above the KKM in the total score indicators of mathematical reasoning ability, it can be determined that there is an increase in students' mathematical reasoning abilities following the application of the Open-Ended approach from cycle 1 to cycle II.

III. RESULT AND DISCUSSION

A. Result

For SMK Negeri 2 Sorong's class XI, learning is accomplished through assigning tasks that involve using Google Meet and Google Classroom in an open-ended manner. The pupils' capacities for mathematical reasoning were observed throughout the course of two learning cycles. Students are also watched to see what they are doing as the action is being carried out. Table 1 below shows the outcomes of the implementation of learning and student activities over two cycles.

Table 1.
Data on the implementation of student learning and activities

Action	1	II	Average	Category
Implementation	90 %	93,75 %	91,875 %	Very good
Student Activities	62,5 %	91,25 %	76,875 %	Effective

According to Table 1, the average usage of Google Meet and Google Classroom to support an open-ended approach to syntax learning falls into the excellent group. Students have no difficulty following learning with these applications and methods because students are already getting used to several online learning applications during the COVID-19 pandemic. Meanwhile, the students' activities that were observed during the two cycles were on the effective average. This is to research conducted by Herdiman (2017) that with an open-ended approach, students become more active and enthusiastic in solving the problems given, and an open-ended approach also makes students more active from day to day.

The percentage of learners who comprehend the standards for indicators of their ability to reason mathematically increases directly to the rise in student achievement from cycle 1 to cycle II. The following are descriptive statistical results from students' Cycle 1 and Cycle II mathematical reasoning ability tests.

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Table 2.
Descriptive Statistics of Students' Mathematical Reasoning Results

Cycle	Total	Range	Minimum	Maximum	Mean	Std. Deviation
I	21	60	25	85	46,43	18,72
II	21	35	60	95	76,67	9,03

From Table 2, it can be seen explicitly that there is a significant difference in the average of the results of mathematical reasoning in cycles I and II. According to (Hidayat et al. 2022; Kinnebrew et al., 2014; Solahudin, 2022), learning with an open-ended approach helps students become accustomed to solving problems and developing their answers. This is in line with the idea that open-ended learning can stimulate creativity and students' reasoning power so that they do not just answer without a thought process. This is also evident from Table 3's presentation of the classical learning mastery, which rose from Cycle I to Cycle II.

Table 3.
The Percentage of Student Completeness Cycle 1 and Cycle II

Category	Minimum Completion Criteria	Total Students		Percentage	
		Cycle I	Cycle II	Cycle I	Cycle II
Finished	70	3	17	14,29%	80,95%
Not Finished	70	18	4	85,71%	19,05%

The number of students who completed the first cycle after the action with an open-ended approach assisted by Google Meet and Google Classroom did not reach 60% of the total students. Thus, the research continued to cycle II. Several corrective actions were implemented in the second cycle using an open-ended approach with the help of Google Meet and Google Classroom. These actions included giving students more time to solve problems, giving them extra motivation at the start and end of their learning, and rewarding students who finished their assignments. On time. Improvements in learning carried out in cycle 2 have a better impact. The classical mastery of mathematical reasoning abilities in cycle II reaches 80.95%, which means the action has been successful and stops in cycle II. Fatimah (2019) achieved classical completeness above 75% and made significant improvements in cycle II's implementation of the open-ended approach in her classroom action research. The mathematical reasoning ability of the students as determined by the five indicators employed in this study is displayed in the accompanying chart, along with the percentage of students' mathematical reasoning ability for each question.

Table 4.
Average Scores Per Indicator of Mathematical Reasoning Ability

No.	Reasoning Indicator	Cycle 1	Cycle II	Average

1	Presenting mathematical information in an illustrated and written way	47,43%	85,89%	66,66%
2	Giving conjecture	36,80%	65,90%	51,35%
3	Perform Mathematical Manipulation	36,80%	77,77%	57,29%
4	stringing evidence, presenting reasons or evidence for the solution given	44,20%	81,40%	62,80%
5	Draw a conclusion	28,12%	47,39%	37,76%

Table 4 indicates that students in cycles I and II are mostly proficient in delivering written and visual mathematical propositions as markers of mathematical thinking. The lowest indicator, controlled by students, is the conclusion. The process of giving mathematical statements in writing is the first step in the formation of a mathematical reasoning process. From this indicator, students will continue to improve their abilities so that they can master the last indicator, which is concluding.

B. Discussion

Based on table 1, it is known that Google Meet and Google Classroom have proven effective in supporting an open syntactic learning approach, where students can participate in learning more interactively and flexibly (Mulyatiningsih et al., 2023). This approach allows students to participate actively in the teaching and learning process, improves critical thinking skills, and promotes independent learning (Alotumi, 2022). This effectiveness can be attributed to the ease of access and use of both platforms, which allows for smooth interaction between teachers and students even in an online setting (Shak et al., 2022; Tarusu et al., 2024). Students did not experience significant difficulties in adapting this learning method, which can be attributed to their experiences during the COVID-19 pandemic (Al-Maroof et al., 2020). The pandemic period has forced the education system to switch to online learning methods, so that students have acquired skills and adaptation to various online learning applications (Cusi et al., 2023). This reflects the importance of digital readiness for both students and educators in the education 4.0 era.

In two observation cycles, student activities were declared effective. This shows that not only do students feel comfortable with the platforms and methods used, but they also actively participate in the learning process. Effective student engagement is a key indicator in the success of the learning process, especially in the context of distance learning which requires higher motivation and discipline from students (Farida & Thomasson, 2022; Nuryatin et al., 2023; Poçan et al., 2023).

Overall, the use of Google Meet and Google Classroom in supporting the open-ended syntax learning approach is considered very good. However, to continuously improve the quality of learning, educational institutions and educators need to continue to evaluate and adapt their teaching methods according to technological developments and student learning needs. In addition, it is also important to provide adequate technical support and learning resources to ensure that all students can access and

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participate in learning effectively (Videla et al., 2022).

Based on Table 2, there was a significant increase in average from 46.43 in Cycle I to 76.67 in Cycle II. This shows that in general, students' mathematical reasoning abilities increased significantly after the open-ended approach was applied from Cycle I to Cycle II. The lower standard deviation in Cycle II (9.03) compared to Cycle I (18.72) indicates that students' scores in Cycle II were more consistent compared to Cycle I. This could mean that the intervention carried out did not only increase the average score but also makes student achievement more uniform (Ibrahim & Widodo, 2020). The smaller range of scores in Cycle II (35) compared to Cycle I (60) also shows increased uniformity in student abilities. This is reinforced by the increase in the minimum score from 25 to 60, showing that even students with the lowest scores show significant improvement.

Based on table 2, it can be concluded that the results show that what was done between Cycles I and II was very effective in improving students' mathematical reasoning abilities. This is due to the use of better teaching strategies, a greater focus on reasoning skills, or the use of more challenging and interesting material.

Based on table 3, it can be seen that in cycle I, the open-ended approach assisted by Google Meet and Google Classroom was not effective in improving students' mathematical reasoning abilities, where only less than 60% of students successfully completed the cycle. This is due to several factors, namely the lack of effective direct interaction between teachers and students because students are not yet accustomed to hybrid learning, students' limitations in using technology, and the open-ended approach method has not been fully understood or applied by students well in online learning.

Based on this, improvements were made to the shortcomings of cycle I which focused on (1) Increasing student interaction and motivation: Providing more time to solve problems allows students to reflect and understand concepts better; (2) Extra motivation at the beginning and end of learning can increase students' desire to participate actively and complete their assignments; (3) Rewarding students who complete assignments on time is an effective positive reinforcer to encourage student participation and engagement. These improvements indicate a deep understanding of student needs and the dynamics of online learning, as well as adapting learning methodologies to address these challenges.

After the improvements were made, significant improvements were seen in classical mastery of mathematical reasoning abilities which reached 80.95% in cycle II. This shows that with appropriate corrective action, distance learning using technology can be very effective in improving students' mathematical reasoning abilities (Herdiman, 2017; Rohaeti et al., 2019).

the results in Table 4, which include students' mathematical reasoning abilities based on five indicators, offer important insights into mathematics education and the development of students' abilities. From the data presented in Table 4, it can

be seen that there was a significant increase from Cycle I to Cycle II in each indicator, which shows that the intervention or teaching method used between the two cycles was effective in improving students' mathematical reasoning abilities.

The first indicator, presenting mathematical information in an illustrated and written way, results show that students are most proficient in presenting mathematical information in written and visual ways, with an average increase of 66.66%. This emphasizes the importance of visualization in mathematics learning. Visualization not only helps students understand abstract concepts but also strengthens their understanding through concrete representations (Haerudin, 2013).

The second indicator Giving conjecture, providing a conjecture or hypothesis, also shows a significant increase. This shows students are starting to be able to think critically and apply their mathematical knowledge to make predictions or conjectures. This ability is very important because it trains students to think scientifically and analytically, which is a key component in the mathematical reasoning process (Bernard, 2015).

The third indicator, Perform Mathematical Manipulation and the fourth indicator, stringing evidence, presenting reasons or evidence for the solution given, The ability to carry out mathematical manipulation and string together evidence is the basis of solving mathematical problems. An increase in this indicator shows that students are becoming more adept at applying algorithms and theories to solve problems and presenting reasons or evidence for the solutions they find. Strengthening these abilities is very important in mathematics education because it helps students not only understand concepts but also apply them in real or complex situations.

Finally, the fifth indicator, Draw a conclusion, the ability to conclude shows the smallest increase and is the indicator with the lowest average score. This shows that even though students can understand and manipulate mathematical information, they still find it difficult to draw conclusions from the data or information they process. This emphasizes the need for teaching strategies that are more focused on developing students' inferential abilities, helping them to be more effective in inferring and applying their mathematical knowledge in various contexts.

This is also written in a research article by (Bunlang et al., 2023; Lestari et al., 2016), which uses six indicators of mathematical reasoning with an open-ended approach and is proven to affect increasing students' mathematical reasoning. If students have been able to master these abilities, it can be said that students have achieved mathematical reasoning abilities.

to develop students' mathematical reasoning abilities comprehensively, teaching approaches must be diverse and focus on all aspects of mathematical reasoning, from understanding and application to inference. Improvements in each indicator show progress, but special emphasis on areas that are still weak, such as conclusions, will further strengthen students' overall mathematical reasoning abilities.

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IV. CONCLUSION

Based on the results of the study, it can be concluded that the implementation of learning with an open-ended approach to class XI students of SMK Negeri 2 Sorong City went well. Observations of student activities showed an increase in student activity in participating in learning using the Google Meet and Google Classroom applications from cycle I to cycle II, reaching the practical category. In addition, students' mathematical reasoning abilities increased after using the open-ended approach from cycle I to cycle II. This can be seen from the comparison of test results in the two cycles, where at least 60% of students experienced an increase above the Minimum Completion Criteria (KKM) in the mathematical reasoning ability indicator, with achievements of up to 80.95% of students in cycle II.

This study shows that the open-ended approach supported by Google Meet and Google Classroom is effective in improving students' mathematical thinking skills. As a suggestion, this study can be further developed by exploring other learning models that can improve students' mathematical reasoning abilities, especially in the context of classroom learning. The contribution of this study is to provide guidance in using a technology-based open-ended approach in online learning, especially during the pandemic, so that it can be a reference for teachers to improve students' mathematical reasoning skills.

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