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LEVERAGING AI TECHNOLOGY FOR MATHEMATICAL PROBLEM-SOLVING: THE ROLE OF DESMOS IN PROBLEM-BASED LEARNING ENVIRONMENT

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Abstract

This study aims to determine students' mathematical problem-solving abilities in linear program materials through problem-based learning (PBL) assisted by a Desmos graphing calculator. This research is qualitative descriptive research. The subject of this study is a class X student of Srijaya Negara High School, Palembang. Data collection uses tests, interviews, and observation methods. The analysis of test data was carried out by describing the subject's ability to solve mathematical problems, the analysis of interview data was carried out by transcribing the interview results into written form, and the analysis of observation data was carried out by making a brief description based on the observation results. The results of the study show that students' problem-solving skills in the medium category can be developed by applying a problem-based learning model assisted by the Desmos graphing calculator. This can be seen in students who can understand the problem presented, create a problem-solving plan in the form of a mathematical model, execute the plan using a Desmos graphing calculator, analyze the results obtained, and re-check the problem-solving process.

Keywords: desmos; graphing calculator; linear program; problem-based learning; problem-solving

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Introduction

Mathematical problem-solving skills are abilities where students try to find solutions to achieve the desired goals, which require knowledge, understanding, ability, and application in daily life (Adlina et al., 2024). Solving mathematical problems is an important ability that must be present in students (Purba & Ramadhani, 2020). The rationale underlying the statement's truth includes: (1) Mathematical problem-solving is an ability listed in the curriculum and mathematics learning objectives (Foster et al., 2021). (2) Mathematical problem-solving includes methods, procedures, and strategies that are the core and main processes in the curriculum (Jamil et al., 2024). (3) Mathematical problem-solving helps to think critically and creatively and develop other mathematical abilities (Khaesarani & Ananda, 2022).

However, problem-solving skills are still in the low category, especially in real linear program materials (Octaria et al., 2023). This can be seen from students' difficulties in understanding linear programming concepts and applications, and there are still many difficulties experienced by students in working on linear program problems. Namely, students do not understand mathematical concepts (Adawiyah et al., 2022; Aleupah et al., 2023), find it challenging to know the purpose of the problem, are not able to convert the problem into the form of a mathematical model, cannot make mathematical sentences, are not thorough in doing calculations and students still have difficulty in identifying the solution area, mistakes in creating charts, difficulties in finding corner points and cut points on the graph (Jaenal et al., 2023).

The cause of low mathematical problem-solving skills is the lack of precision in choosing the suitability of the learning model to be used in conveying learning objectives and materials (Juniar & Meiliasari, 2025; Kurino et al., 2024). In addition, the low comprehension ability of students in determining the set of settlement areas and how to describe the settlement area is due to educators who have not tried to explore the use of other technologies in the learning process (Angriani et al., 2021; Hayati, 2021). So, a learning model and learning media that help the learning process to develop students' mathematical problem-solving skills are needed (Amal et al., 2024).

One of the learning models that helps develop mathematical problem-solving skills is the problem-based learning model. Problem-based learning focusing on real problems can encourage students' problem-solving skills and increase students' understanding through the learning process (Anitha & Kavitha, 2023; Apriatni et al., 2022). Using the problem-based learning model can develop students' mathematical problem-solving skills because students will be able to work together in solving a problem actively, ask questions, and put forward their ideas so that they can improve learning outcomes and mathematical problem-solving skills (Acharya, 2023; Rahman & Abdullah, 2022).

In addition to selecting the learning model, the use of learning media is also important, especially to help students overcome various kinds of difficulties in working on linear program problems, namely the Desmos graphing calculator (Nuri et al., 2023; TLS & Herman, 2020). The Desmos application is considered to be an alternative solution in teaching mathematical materials related to drawings and graphs, and Desmos can help students find the set of solution areas in linear programming materials (Jihan & Hendriana, 2023).

Based on previous studies, both Desmos and Problem-Based Learning (PBL) have demonstrated significant potential in enhancing students' understanding of mathematical concepts and increasing their engagement. Desmos offers an interactive visual tool to enrich students' learning experiences (Chechan et al., 2023), while PBL effectively encourages critical thinking and contextual problem-solving (Yanto et al., 2021). Research findings also indicate that using Desmos in the context of mathematical instruction can improve students' understanding and learning outcomes (Supiter & Rabut, 2025). However, these studies have mostly been limited to applications involving functions and graph transformations (Peni & Dewi, 2023).

Another issue that arises is the limited use of Desmos in teaching more complex mathematical content, such as feasible regions or the optimization process in linear programming (TLS & Herman, 2020). This is a critical gap, as the integration of Desmos with PBL approaches remains relatively basic and has not been deeply explored to enhance students' meaningful mathematical understanding. Previous research has also shown that PBL is not always implemented effectively, particularly in educational contexts where access to technological infrastructure is limited or inconsistent (Alsaif et al., 2023; Hendarwati et al., 2021). These limitations suggest further investigation into how Desmos and PBL can be synergistically applied to support students' mathematical reasoning and problem-solving, especially in linear programming topics within Indonesian classrooms (G. Zhou et al., 2025). Based on this explanation, the researcher is interested in conducting a study to describe students' mathematical problem-solving skills in linear program materials through PBL assisted by a Desmos graphing calculator.

Methods

This research is descriptive research with qualitative and quantitative approaches (Santos et al., 2020) that aims to describe students' mathematical problem-solving abilities in linear program materials through problem-based learning (PBL) assisted by a Desmos graphing calculator. The research subjects comprised 36 students with various abilities: high, medium, and low. This group selected one student from each ability category as the subject for in-depth qualitative analysis (Shorey & Ng, 2022). The rationale for selecting only one student per category is to gain rich, detailed insights into the problem-solving processes representative of each ability level. This purposive sampling strategy allows for an in-depth exploration of individual thinking patterns and learning experiences, which is appropriate for qualitative descriptive research (Çetin et al., 2024). While this limits the generalizability of the findings, the depth of analysis offers a valuable understanding of how students with different ability levels engage with PBL and technology in solving linear programming problems. The quantitative data from the group of 36 students complements this by providing broader patterns and trends.

The data collection techniques used in this study were observation, written tests, and interviews. Observations were conducted using an observation sheet as a rubric that focused on students' engagement, participation, and use of strategies during the problem-based learning process. This rubric was adapted from previous studies on mathematical problem-solving and revised to suit the context of linear programming and the use of the Desmos graphing calculator. The written test was administered after completing the learning process over two meetings. It consisted of two open-ended questions designed to assess students' mathematical problem-solving abilities based on established indicators. Two experts in mathematics education reviewed the interview guidelines, written test items, and observation rubric to ensure content validity (Lewis & Sireci, 2022; Macedo et al., 2020).

Additionally, a pilot test was conducted with students outside the study sample to evaluate the clarity, appropriateness, and difficulty level of the test items and interview questions. Revisions were made accordingly. To ensure the credibility of qualitative data analysis, inter-rater reliability was checked by having two researchers independently coded the interview transcripts and observation notes (Abbott et al., 2025; Shah et al., 2023). Any discrepancies were discussed until a consensus was reached. This triangulation of instruments and validation procedures enhanced the trustworthiness of the data collected. The following are the test questions used in the research, namely:

1. Fikri merupakan seorang pengrajin sendal. Setiap hari ia memproduksi dua jenis sendal. Modal untuk sendal A adalah *Rp*30.000,00 dengan keuntungan 55%. Sedangkan modal untuk sendal B 40% lebih besar dari modal sendal A dengan keuntungan 3 kali lebih besar dari keuntungan sendal A. Jika modal setiap harinya adalah *Rp*1.200.000,00 dan dapat memproduksi paling banyak 48 sendal. Gambarkanlah grafik daerah penyelesaian sistem pertidaksamaan linearnya!
2. Wisata Paralayang kota Malang memiliki parkiran dengan luas 1.760 m^2 . Perbandingan luas area sepeda motor 1 : 5 dari luas area mobil. Luas area sepeda motor dan mobil 24 m^2. Daya tampung tempat parkir kedua kendaraan tersebut tidak dapat menampung lebih dari 200 kendaraan. Wisata tersebut akan menentukan harga parkir setiap jam nya sebesar *Rp*2.000,00/jam untuk sepeda motor dan *Rp*3.000,00/jam untuk mobil. Jika dalam satu jam tempat parkir tersebut penuh dan tidak ada kendaraan yang keluar masuk. Tentukanlah penghasilan maksimum yang diperoleh tempat parkir wisata tersebut?

Translation:

1. Fikri is a sandal craftsman. Each day, he produces two types of sandals. The cost to produce one pair of Sandal A is Rp30,000.00 with a profit of 55%. Meanwhile, the cost to produce Sandal B is 40% higher than the cost of Sandal A, and the profit is 3 times greater than the profit from Sandal A. If his daily capital is Rp1,200,000.00 and he can produce a maximum of 48 sandals per day, draw the graph representing the solution area of the linear inequality system!

2. The Paralayang tourist site in Malang has a parking area measuring 1,760 m². The area occupied by a motorcycle is in a 1:5 ratio to that of a car. Each motorcycle occupies 24 m². The parking area cannot accommodate more than 200 vehicles. The tourist site management plans to set a parking fee of Rp2,000.00/hour for motorcycles and Rp3,000.00/hour for cars. Assume the parking lot is always full and no vehicles are entering or exiting during that time. Determine the maximum revenue that the parking area can generate!

Figure 1. Test Questions

This study's data analysis process involved quantitative and qualitative methods aligned with the mixed-methods approach (Zhou, 2023). The written test results were analyzed quantitatively by scoring students' answers based on a rubric developed from problem-solving indicators, which included understanding the problem, devising a plan, carrying out the plan, and evaluating the solution (Difinubun et al., 2024). Each response was given a score according to these indicators, and descriptive statistics (such as mean and distribution across ability levels) were used to identify general patterns in students' problem-solving abilities (Salsabila et al., 2024). The following are the categories of mathematical problem-solving skills.

Table 1. Categories of Mathematical Problem-Solving Ability

Student Grades	Category
$80 - 100$	Tall
$50 - 79$	Keep
$0 - 49$	Low

For the qualitative analysis, observation data were analyzed using the rubric-based observation sheet. Each student's behavior during the learning process was categorized and rated according to the rubric dimensions, such as participation, use of strategies, and collaboration. These data helped support the interpretation of students' engagement and learning processes. Interview data were analyzed thematically using a qualitative coding process. Transcripts were read multiple times to identify patterns, key statements, and themes related to students' problem-solving approaches, difficulties, and use of the Desmos graphing calculator. Two researchers did coding independently to ensure inter-rater reliability, and differences in interpretation were discussed until agreement was reached. Finally, the results from the test, observation, and interviews were triangulated to provide a comprehensive understanding of students' mathematical problem-solving abilities (Muqarrabin et al., 2024). This triangulation allowed for cross-validation of findings and enriched the interpretation by combining quantitative trends with qualitative insights.

Results

Learning Process with Desmos

This research was conducted during three meetings, consisting of two meetings for problem-based learning with the help of a Desmos graphing calculator, and one meeting for the implementation of written tests. The learning stage consists of five stages of problem-based learning, namely student orientation to problems, organizing students to learn, guiding individual and group experiences, developing and presenting works, and analyzing and evaluating the problem-solving process. The stages of problem-based learning are as follows:

1. **Student orientation to problems**

   The stages of student orientation to the problem are carried out with the aim that students can identify contextual problems in the form of writing down things that become known and asked, making tables to summarize information, making examples, making mathematical models, and determining objective functions and constraint functions, describing the graph of the solution area of each inequality, determining the area of the solution set from the combination of graphs, determining the cut-off point of The first and second inequalities present the conclusion of the question, as well as re-checking the answers obtained.

2. Organizing students to learn

After providing examples of contemporary problems, the researcher allowed students to ask questions related to things that were not understood. Then, the researcher asked students to form groups according to the division that had been determined. Furthermore, the researcher distributed the LKPD Meeting 1 to each group to be worked on and discussed together with their group mates. In working on the problems in LKPD 1, students discuss with their group friends. Students also use the Desmos graphing calculator in working on LKPD 1, especially when drawing a graph of the completion area. During the work, the researcher directs and guides students if there are students who do not understand the purpose of the problem.

3. Mentoring Individual and Group Experiences

At this stage, the researcher gives time to students to complete LKPD 1. Furthermore, the researcher guides students in identifying problems. In the first step, the researcher guides students to understand the problems that exist in the questions and discusses how to identify these problems. At this stage, students must write down what is known and what is asked in the question. This stage is in line with the indicator of mathematical problem-solving, namely understanding the problem, where students understand the meaning of the question by collecting information about the problem by writing down what is known from the problem. Students write down what is known by making the length of each fabric, the materials needed to make each type of party dress, and the price of each type of dress. Next, students write down what they are asking. It can be seen from the results of the students' answers that the entire group has been able to identify problem 1.

In the next step, students are directed to make tables to summarize known information, make analogies, and make mathematical models of problems. At this stage, it is in line with the indicators of making a problem-solving plan. At this stage, students are led to discuss with their groups in making mathematical models, so that mathematical models are formed, including both constraint functions and objective functions. The following are the students' answers.

Figure 1. Answer to Question 1 on the Indicator of Creating a Problem-Solving Plan

Judging from Figure 1, students made a table with an arrangement of 3 columns and 4 rows. The first row is filled with fabric classifications, namely Satin and Prada fabric. The second row was filled with party clothes including 2 m of satin fabric and 1 m of Prada fabric. The third row is filled with party clothes II, including 1 m of satin fabric, and 2 m of Prada fabric. The last row is filled with a total of 4 m of satin cloth and 5 m of Prada cloth. After making the table, students make an analogy from the question by assuming x is a party dress I and a party dress II. Then, students make a mathematical model and determine the function of the constraint and the objective function of the mathematical model. It can be seen from the results of the answers that students can make mathematical models correctly so that students have met the indicators of making a problem-solving plan.

Next, the researcher directed students to open the Desmos graphing calculator website. The use of Desmos is necessary in helping students describe the graph of the solution set area. At this stage, students are led to come up with problem-solving indicators, namely implementing a problem-solving plan, where students will draw graphs using the help of a Desmos graphing calculator. The following is a graph that students can describe.

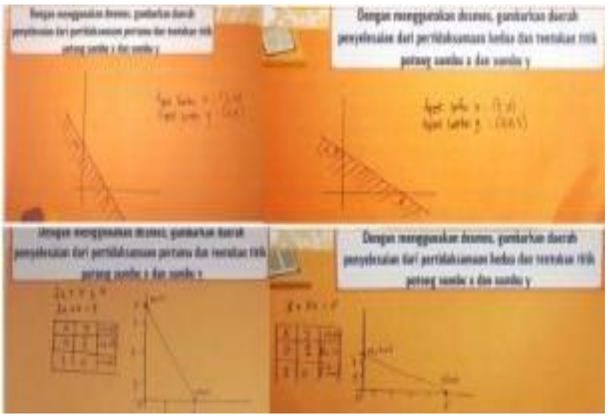

Figure 2. Answer to Question 1 on the Use of Desmos in the Indicator of Implementing a Problem-solving Plan

In Figure 2, the students have appropriately depicted the graph of the solution area of the first and second inequalities. It can be seen that students can determine the cut-off point, namely at the first inequality and the second inequality. However, in Figure 2 there are still students who have not shaded the completion area. It can be seen that student (b) tried to find the cut-off point, but made a mistake in doing the calculation, so the cut-off point obtained was not correct. But when using the help of Desmos, student (b) becomes aware of the correct cut-off point, so when describing the graph, the student uses the correct cut-off point (2,0) (0,4) (5,0) (0,2.5). Furthermore, the researcher directed students to describe the third and fourth inequality graphs, as well as combine the graphs of the four inequalities. The following are the students' answers.

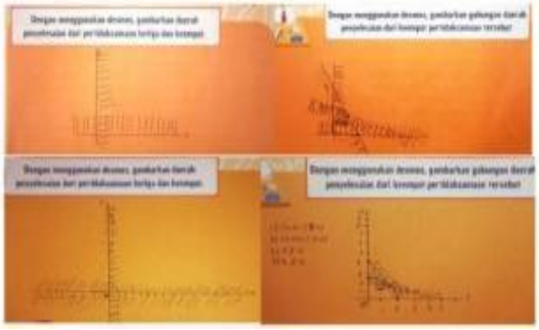

Figure 3. Answer to Question 1 on the Indicator of Implementing a Problem-solving Plan

In Figure 3, the students have been able to describe the combined settlement area correctly and precisely. However, the students are still wrong in combining the solution areas of the four inequalities. The cause of the mistakes made by students is a lack of understanding of how to shade the settlement area. This is also supported by the observation that students (b) do not listen too much to the researcher's explanation and do not dare to ask questions related to things that are not understood. Furthermore, with the help of a Desmos graphing calculator, students are directed to determine the cut-off point of the first and second inequalities. Students determine the cut-off point of the first and second inequalities, i.e. This proves that all groups can determine the cut-off point. Furthermore, students are directed to make conclusions about the problem. At this stage, it is in line with the indicator of rechecking the results of problem-solving.

The second problem was addressed similarly to the first. The researcher guided the entire group through the problem, which involved a contextual situation with incomplete information requiring calculations. Students successfully identified the problem and were directed to construct tables to develop mathematical models using examples. While students were able to model the problem, they made an error in formulating the objective function due to a misinterpretation of the price comparison between items. Next, with the help of the Desmos graphing calculator, the group graphed the solution areas of each inequality step-by-step as they had done in problem 1. Although they correctly graphed individual inequalities, an error occurred when combining them, particularly in redrawing the first inequality. Despite this, they managed to identify the solution area and determine the cut-off points with reasonable accuracy. Finally, students were asked to conclude. In line with the indicator of reviewing problem-solving results, most groups concluded that the solution set area was the region shaded by the four inequalities, though a few groups omitted the conclusion.

4. Developing and presenting works

At this stage of problem development and presentation, the researcher facilitated group discussions to allow students to collaboratively find solutions to the given problems. Afterward, all groups were directed to recheck their answers to ensure accuracy. As shown in Figure 14, students re-evaluated their solutions by selecting a point within the feasible region (DHP) and substituting it into the four inequalities to verify if all conditions were satisfied. This process helped confirm the correctness of the identified solution set. However, some students either performed the rechecking incorrectly or skipped the step altogether. The main goal of this stage was to train students to critically observe and verify their solutions, minimizing calculation errors and improving the accuracy of their problem-solving process.

5. Analyze and evaluate the problem-solving process.

In the stage of analyzing and evaluating the problem-solving process, one group was assigned to present their solutions to each problem orally in front of the class, while the other groups listened and responded with questions or comments. This interactive session encouraged critical thinking, as some groups identified differing answers and discussed more accurate alternatives. After the discussion, the researcher clarified key concepts, especially regarding objective functions and constraints in linear programming. During the closing activity, students were given time to ask questions, summarize their understanding, and were assigned homework along with a preview of the next session's material. In the second meeting, the same problem-based approach using the Desmos graphing calculator was applied, but with a focus on finding the optimum value of a linear program. Students identified corner points of the feasible region, calculated the objective function values, and determined the maximum or minimum profit, aligning with the learning objective of determining optimal solutions.

Result of Mathematical Problem-Solving Skills

At the third meeting, a written test was carried out. The questions given were in the form of 2 linear program material description questions. The questions are compiled based on indicators of problem-solving ability and have been validated. From the test results, the average score of students' mathematical problem-solving skills was categorized as medium, 51,69, which that obtained as follows.

Table 2. Average Score of Mathematical Problem-Solving Ability

Interval	Frequency	Percentage	Category
$80 - 100$	4	11,11%	Tall
$50 - 79$	19	52,78%	Keep
$0 - 49$	13	36,11%	Low
Sum	36		
Average	51,69		
Category	Keep		

The MCR subject demonstrates high cognitive ability in mathematical problem-solving. Figure 3 shows the written response from the MCR subject. In the problem-understanding stage, the MCR subject fulfilled the indicator and received a score of 3. This is evident from their ability to identify the known information, such as the capital for Sandal A (Rp30,000.00), the profit of Sandal A, the capital for Sandal B being greater than that of Sandal A, the profit of Sandal B being three times that of Sandal A, the daily capital limitation, and the maximum production of 48 sandals. Additionally, the MCR subject clearly stated the problem to be solved, which was identifying the graph of the solution area of the system of linear inequalities. In the planning stage, the MCR subject again scored 3 for successfully developing an appropriate mathematical model, including both the constraint functions and the objective function. This achievement is also supported by interview results, which confirm the subject's understanding of the problem-solving plan. The MCR subject also met the indicator for implementing the problem-solving plan, as shown by correctly solving the mathematical model, earning another score of 3. However, in the final stage, which involved evaluating or rechecking the results, the MCR subject did not meet the indicator, as they did not verify the solution and only wrote a conclusion stating that the maximum profit obtained was Rp460,000.00. As a result, the MCR subject received a score of 2 in this stage. Overall, the MCR subject successfully met three out of the four problem-solving indicators.

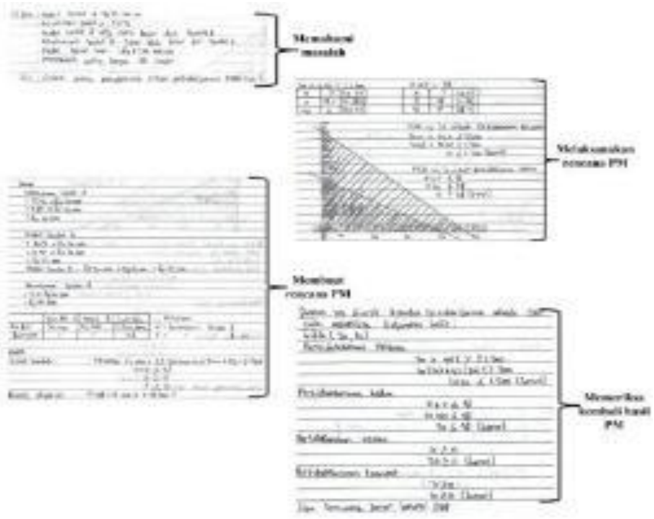

Figure 3. MCR Subject Answers

Figure 3 below is CN Answers. The CN subject demonstrates a moderate level of cognitive ability in problem-solving. CN successfully met the indicators for understanding the problem, planning the solution, implementing the plan, and partially rechecking the results. In the problem-understanding stage, CN earned a score of 3 by clearly identifying both the known information and what was being asked. CN also fulfilled the indicator for planning a solution, similar to the ZA subject. Notably, CN simplified the first inequality to $15x + 21y \leq 600$, which made the calculations easier and more efficient, contributing to a score of 3 for this stage. In the implementation stage, CN again achieved a score of 3 by accurately graphing the solution area, starting with identifying the intercepts, performing a point test using (0,0), and correctly determining the feasible region (DHP). However, CN did not fully meet the indicator for rechecking the results. This is evident from the lack of a written conclusion and the limited verification effort, which only involved checking a single point (11,10). As a result, CN received a score of 2 for this final stage. The following is an excerpt from the interview with CN regarding this indicator.

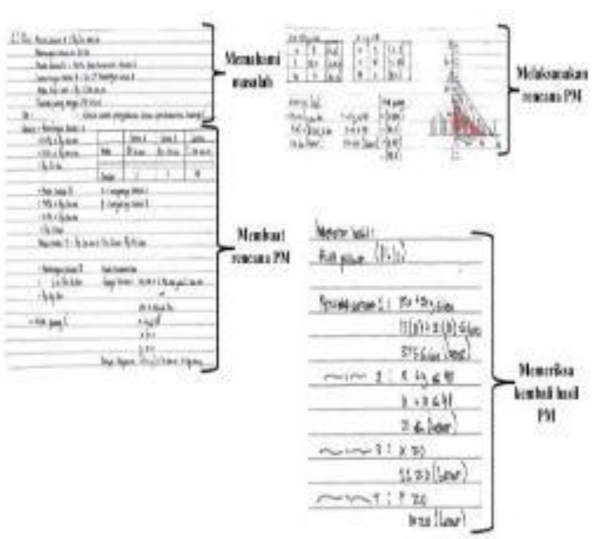

Figure 3. CN Subject Answers

The MYK subject demonstrates a low level of cognitive ability in solving problems. MYK was able to meet the indicators for understanding the problem, planning a solution, and rechecking the results, but showed difficulties in implementing the solution plan. As seen in Figure 4, MYK was able to identify what was known and what was being asked in the problem, thus earning a score of 2 for problem understanding. However, the information recorded was not entirely accurate—specifically, the profit of Sandal B was omitted, and the number of sandals produced was mistakenly written as 58 pairs. Despite this, MYK successfully met the indicator for planning a solution and scored 3 by constructing a mathematical model.

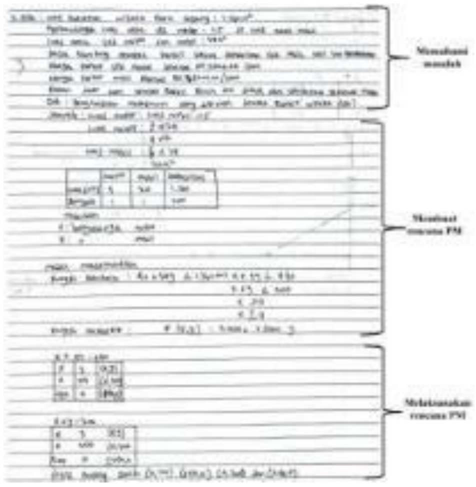

Figure 4. MYK Subject Answers

In contrast, MYK did not meet the indicator for implementing the problem-solving plan. Although MYK could identify the cut-off point, convert it into Cartesian coordinates, and conduct a point test using (0,0), they failed to complete the graph of the solution area, did not apply shading correctly, and did not determine the feasible region (DHP). This was confirmed through an interview, where MYK admitted forgetting to complete the graph and not fully understanding how to draw it. As a result, MYK received a score of 2 for this stage.

Interestingly, MYK was able to meet the indicator for rechecking the results of problem-solving in question 1 and earned a score of 3 by writing a conclusion and verifying the solution using the point (11,12). However, in question 2, while MYK was again able to construct a mathematical model, there was a mistake in simplifying the first inequality (incorrectly simplified $4x + 20y \leq 1760$ to $x + 4y \leq 440$ instead of the correct $x + 5y \leq 440$. This mistake led to an incorrect cut-off point. Through interviews, the researcher found that MYK made several conceptual and calculation errors, including a misinterpretation during simplification and running out of time before completing the graph or finding the objective function value. Therefore, in question 2, MYK failed to meet the indicators for both implementing the problem-solving plan and rechecking the results.

Discussion

Based on the study's results, it could be concluded that students' ability to solve mathematical problems in linear programming materials through problem-based learning (PBL) assisted by the Desmos graphing calculator was in the moderate category. The moderate level of problem-solving skills was influenced by several factors, including difficulties in understanding problem statements, errors in mathematical modeling, computational mistakes that affected final answers, and students' lack of experience with non-routine word problems (Adlina et al., 2024; Khaesarani & Ananda, 2022).

The analysis of students' written test results showed that some students were able to solve problems by understanding the problem, creating correct mathematical models through systematic approaches such as organizing data in tables and working with specific examples, using the Desmos calculator to visualize and interpret graphs, drawing conclusions, and checking their answers (Kurino et al., 2024). These students demonstrated higher engagement in the learning process and effectively used Desmos as a visual and interactive support tool (Chechan et al., 2023). However, other students still struggled with interpreting problem statements, made computational errors, or forgot to verify their answers.

Learning through the PBL model enhanced students' problem-solving abilities more effectively than traditional lecture methods (Hendarwati et al., 2021; Yanto et al., 2021). The PBL approach encouraged students to actively engage in group discussions using worksheets (LKPD), enabling them to explore and discover solutions collaboratively (Anitha & Kavitha, 2023; Rahman & Abdullah, 2022). This active engagement fostered deeper understanding and improved academic performance (Aleupah et al., 2023). PBL required students to understand the problems thoroughly, design appropriate solutions, execute their plans, and evaluate the outcomes (Alsaif et al., 2023), which aligned well with the goals of developing mathematical problem-solving skills.

During the implementation, students showed high enthusiasm when using the Desmos graphing calculator. The interactive interface of Desmos helped increase student engagement and conceptual understanding (Chechan et al., 2023) and raised their interest in learning mathematics (Jihan & Hendriana, 2023; Nuri et al., 2023). Specifically, Desmos assisted students in visualizing linear constraints and identifying feasible regions more efficiently (Supiter & Rabut, 2025; TLS & Herman, 2020). This visual support was especially beneficial for students with stronger spatial reasoning skills or prior exposure to technology-based tools. These students could translate algebraic models into graphical representations more easily, recognize intersections, and interpret solution sets accurately.

On the other hand, students with limited spatial reasoning or minimal prior experience with technology encountered challenges despite using Desmos. Some became overly dependent on the tool, struggling with basic calculations such as identifying intersection points or determining solution regions without direct guidance. Sometimes, these students misinterpreted visual data or failed to integrate graph-based information with algebraic reasoning. Moreover, students with lower problem-solving performance often face difficulties in reading comprehension (Adawiyah et al., 2022). They were unfamiliar with non-routine story problems, leading to errors in identifying key information and translating it into mathematical models (Jaenal et al., 2023). Long and complex problem statements also contributed to student fatigue and lack of focus, prompting rushed responses that resulted in miscalculations and incorrect solutions.

This study had several limitations. First, the qualitative analysis focused only on one student from each ability category (high, medium, and low), which limited the generalizability of the in-depth findings. Although this approach provided rich insights into students' thinking processes, it may not capture the full range of strategies and difficulties experienced by the broader student population. Second, the study was conducted in a single school with a specific context and technology access, which may limit the applicability of the results to other settings with different levels of digital readiness or curriculum implementation. Third, while Desmos was integrated effectively, the study did not compare its impact with other graphing technologies or traditional tools, which could have offered a more comprehensive evaluation of its relative effectiveness.

The implications of these findings are twofold. Pedagogically, educators should consider the varying levels of students' spatial reasoning and technological familiarity when integrating digital tools like Desmos (Foster et al., 2021). Scaffolded guidance and differentiated support may help ensure that all students benefit from such tools. Training in interpreting complex problem statements and strengthening modeling skills should also be emphasized, especially for students with lower reading comprehension (Jamil et al., 2024). From a research perspective, future studies should consider involving a larger number of participants in the qualitative phase or conducting longitudinal studies to examine how students' skills develop over time with continuous exposure to PBL and technology-enhanced learning environments (Octaria et al., 2023; G. Zhou et al., 2025).

Conclusion

Based on the results of the study, it can be concluded that the application of the problem-based learning model to linear program materials assisted by the Desmos graphing calculator can develop problem-solving skills. This can be seen from students who can understand the problem of the problem, make a problem-solving plan in the form of making a mathematical model, carry out the problem-solving plan using a Desmos graphing calculator, conclude the results of the answers that have been obtained, and re-check the results of the problem-solving. The use of the Desmos graphing calculator as a problem-based mathematics learning medium has a positive effect on mathematical problem-solving skills. The PBL learning model, whose context of the problem is related to the real world, while Desmos is a tool that helps students draw and explore graphs, find cut-off points, and determine the solution area. Thus, learning that combines PBL with the Desmos Graphing Calculator as a medium can develop mathematical problem-solving skills.

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Conflicts of Interest
The authors declare no conflict of interest regarding the publication of this manuscript. In addition, the authors have addressed ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies.

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