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DEVELOPMENT OF PROBLEM-BASED LEARNING MATERIALS ON LINEAR PROGRAMMING TO FACILITATE STUDENTS' MATHEMATICAL PROBLEM-SOLVING SKILLS

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ABSTRACT This study aims to develop Problem-Based Learning (PBL) instructional tools, including a syllabus, lesson plans, and student activity sheets, to enhance students' mathematical problem-solving skills. The development process follows the 4-D model, consisting of four stages: Define, Design, Develop, and Disseminate. Data were collected through interviews, observations, and questionnaires, using validation sheets and student response surveys as instruments. The validity of the instructional tools was assessed by experts, with results indicating high validity, with average scores of 3.82 for the syllabus, 3.93 for the lesson plans, and 3.79 for the student activity sheets. Additionally, the practicality of the LAS was tested in both small and large groups, showing high practicality with average scores of 3.52 and 3.64, respectively. These findings indicate that the developed instructional tools meet the required standards of validity and practicality, making them suitable for classroom use. This study successfully created PBL-based instructional tools that effectively support the development of students' mathematical problem-solving skills and are expected to positively impact mathematics learning.

Keywords: problem-based learning (PBL), mathematical problem-solving skills, instructional tools development

ABSTRAK Penelitian ini bertujuan untuk mengembangkan perangkat pembelajaran berbasis Problem-Based Learning (PBL), yang mencakup silabus, rencana pelaksanaan pembelajaran (RPP), dan lembar aktivitas siswa (LAS), untuk meningkatkan kemampuan pemecahan masalah matematis siswa. Proses pengembangan mengikuti model 4-D, yang terdiri dari empat tahap: Pendefinisian (Define), Perancangan (Design), Pengembangan (Develop), dan Penyebaran (Disseminate). Data dikumpulkan melalui wawancara, observasi, dan angket, dengan menggunakan lembar validasi dan survei respons siswa sebagai instrumen. Validitas perangkat pembelajaran dinilai oleh para ahli, dengan hasil yang menunjukkan validitas tinggi, dengan skor rata-rata 3,82 untuk silabus, 3,93 untuk RPP, dan 3,79 untuk LAS. Selain itu, kepraktisan LAS diuji dalam kelompok kecil dan besar, menunjukkan kepraktisan tinggi dengan skor rata-rata masing-masing 3,52 dan 3,64.

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Temuan ini menunjukkan bahwa perangkat pembelajaran yang dikembangkan memenuhi standar validitas dan kepraktisan yang diperlukan, sehingga cocok untuk digunakan di kelas. Penelitian ini berhasil menciptakan perangkat pembelajaran berbasis PBL yang secara efektif mendukung pengembangan kemampuan pemecahan masalah matematis siswa dan diharapkan dapat berdampak positif terhadap pembelajaran matematika.

Keywords: problem-based learning (PBL), kemampuan pemecahan masalah matematis, pengembangan media pembelajaran

INTRODUCTION

Mathematical problem-solving skills are essential life skills that every individual must possess in order to independently solve various problems (Hayati et al., 2022). According to Sumartini (2016), problem-solving is a process undertaken to overcome difficulties faced in order to achieve desired goals. Zakiyah et al. (2019) emphasize that proficiency in mathematical problem-solving is crucial for students, as it is one of the determining factors for their success in learning mathematics.

However, the importance of mathematical problem-solving skills has not been reflected in actual results in the field. Research conducted by Adhyan & Sutirna (2022) shows that as many as 60% of students have relatively low mathematical problem-solving skills, where they struggle to find solutions to non-routine problems because they are not accustomed to problem-based learning. This is supported by Junitasari et al. (2021), who found that out of 49 students, 43 had low levels of mathematical problem-solving skills. Another study by Tampubolon et al. (2021) revealed that from the results of a diagnostic test in the form of word problems given to 36 students at SMAN 17 Medan, only 33.33% of students passed, indicating that mathematical problem-solving skills have not been a focus in teaching activities. Furthermore, Tampubolon et al. (2021) found that at the school, teachers had not yet designed learning materials focused on developing students' mathematical problem-solving skills.

To address this issue, teachers must prepare thoroughly, one of which involves creating effective learning materials. Junitasari et al. (2021) state that good planning in learning materials serves as a benchmark for the success of the teaching process and the achievement of learning objectives. Daryanto & Dwicahyono (2014) also support the importance of designing learning materials, which they view as a teacher's effort in preparing for instruction before it is carried out and as a standard for the success of teaching activities. Ibrahim (in Hamdayama, 2016) mentions that learning materials are a set of plans designed as a guide for classroom learning activities, encompassing the formulation of objectives, delivery methods, and the necessary media or tools.

At SMA Negeri 1 Tambusai Utara, interviews with mathematics teachers revealed that the learning materials currently used were only aimed at fulfilling school administrative requirements and had not been aligned with the demands of the

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2013 curriculum. The learning resources used by teachers were only printed books from publishers, and in assigning tasks, they did not use Student Activity Sheets (LAS) but instead relied on problem sets from textbooks. Therefore, there is a need to develop learning materials that can improve students' mathematical problem-solving skills.

These learning materials should be integrated with an appropriate instructional model, one of which is Problem-Based Learning (PBL). Sumartini (2016) found that the mathematical problem-solving abilities of students who received instruction through the PBL model were better than those who received conventional teaching. Several previous studies, such as those by Yustianingsih et al. (2017), Karima et al. (2020), and Tampubolon et al. (2021), have developed PBL-based learning materials, but none have focused on the development of materials for the Linear Programming content.

Linear programming is one of the mathematics topics closely related to contextual problems in students' daily lives. According to Nurjanah et al. (2018), students often struggle to formulate mathematical models, determine solutions to systems of linear inequalities, create graphs of linear functions, and use corner points. This is also supported by Nurohmah & Setianingsih (2014), who stated that the obstacles students face when learning linear programming include (1) transforming mathematical problems into mathematical models, (2) calculating the optimum value, (3) determining the coordinates of corner points, (4) creating graphs of the solution region, and (5) drawing final conclusions.

Based on the problems and solutions outlined, this study aims to develop PBL-based learning materials on the topic of linear programming that can enhance students' mathematical problem-solving skills and meet the requirements of validity and practicality for learning materials

METHODS

This study utilized a developmental research approach following the steps outlined in the 4-D model, as described by Al-Tabany (2017). The 4-D model consists of four main stages: Define, Design, Develop, and Disseminate. In the Define stage, a series of analyses were conducted to identify the root causes of the problem related to the low level of students' mathematical problem-solving skills and to determine the necessity of developing a solution through problem-based learning materials. The activities in the Design stage included selecting the format and media, as well as designing the initial product of the learning materials, specifically focusing on the topic of linear programming.

The Develop stage involved the creation and development of the learning materials, which were then validated by experts to ensure their validity. Subsequently, the materials were tested by students to evaluate their practicality. In the Disseminate

stage, the final product of the learning materials was documented and disseminated through various channels, including the publication of relevant scientific articles.

Data were collected through observation, interviews, and questionnaires. The questionnaires included validation sheets for the syllabus, lesson plans, and student activity sheets, as well as student response questionnaires related to the use of the student activity sheets in mathematics for the topic of linear programming in grade XI of senior high schools. The collected data were then analyzed using two main techniques: validity analysis and practicality analysis. The learning materials were considered valid and practical if the scores obtained were above 2.50

FINDING AND DISCUSSION

This study developed educational materials that include a syllabus, lesson plans, and student activity sheets based on the Problem-Based Learning (PBL) model on the topic of Linear Programming to facilitate the mathematical problem-solving abilities of eleventh-grade students in senior high school. The study followed the stages of the 4-D development model, which consists of four phases: define, design, develop, and disseminate.

In the define phase, the root of the problem was identified, requiring a solution through interviews with teachers and a review of existing educational materials developed by the mathematics teachers at SMAN 1 Tambusai Utara. It was found that the available materials, such as the syllabus and lesson plans, were created mainly to meet school administrative requirements and were not fully aligned with the 2013 curriculum as regulated by the Ministry of Education and Culture Regulation No. 22 of 2016. Additionally, the teachers had not developed student activity sheets and were instead using practice problems from textbooks, specifically the revised 2017 edition of the mathematics textbooks. A needs analysis revealed that students were struggling to understand linear programming problems, particularly in identifying what is given and what is asked, as well as in translating problems into mathematical models due to a lack of guidance from the teacher.

The topic of linear programming developed in this study is studied by eleventh-grade students aged 16-17 years, who, according to Piaget (as cited in Zulkarnain & Heleni, 2014), have the capacity for logical reasoning and drawing conclusions. Therefore, a learning model that encourages students to be active and independent in the learning process, yet still under the teacher's guidance, is needed. Subsequently, the researcher conducted a concept analysis, task analysis, and formulated learning objectives to design the learning activities, teaching methods, detailed topics, competencies, and goals to be achieved in accordance with curriculum requirements and student needs.

In the design phase, prototypes of the syllabus, lesson plans, and student activity sheets were created through three main activities: selecting the media, choosing the format, and drafting the initial design. The selected media were printed materials,

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including the syllabus, lesson plans, and student activity sheets. The components in the syllabus and lesson plan formats were based on the Ministry of Education and Culture Regulation No. 22 of 2016 concerning process standards. The format of the student activity sheets was aligned with the stages of Problem-Based Learning, the scientific approach, and included steps for mathematical problem-solving, while also meeting technical, construction, and didactic requirements. The Basic Competencies were designed based on the Ministry of Education and Culture Regulation No. 37 of 2018, corresponding to the topic of linear programming. The content of the educational materials was integrated with the phases of the Problem-Based Learning model and the scientific approach, and incorporated mathematical problem-solving skills to address linear programming problems. Additionally, validation sheets for the syllabus, lesson plans, and student activity sheets, as well as student response questionnaires, were developed.

In the develop phase, the educational materials that had been developed, namely the syllabus, lesson plans, and student activity sheets, were then evaluated by two university lecturers and a senior high school teacher with a master's qualification to assess the validity of these materials before further analysis. The results of the syllabus validation are presented in Table 1.

Table 1. Summary of Syllabus Validation Data

Assessed Aspect	Average Rating by Validator			Average	Criteria
	I	II	III		
Learning Topics	4,00	4,00	4,00	4,00	Very Valid
GPA	3,33	4,00	4,00	3.78	Very Valid
Learning Activities	3,33	4,00	4,00	3,78	Very Valid
Learning Outcomes Assessment	3,5	4,00	4,00	3,83	Very Valid
Time Allocation	3,00	4,00	4,00	3,67	Very Valid
Learning Resources	3,5	4,00	4,00	3,83	Very Valid
Total Average Validity				3,81	Very Valid

Based on Table 1, the average score for each aspect evaluated in the syllabus falls under the 'Very Valid' criterion. The overall average validity score of the syllabus is 3.81, which means it is categorized as 'Very Valid.' This interpretation aligns with Sugiyono (2016), which states that a product can be considered 'Very Valid' if it has an average score above 3.25. No part of the syllabus needs improvement as there were no criticisms from the validators, indicating that the syllabus is ready for implementation.

Table 2. Recap of Lesson Plan Validity Data

Assessed Aspect	Average Rating by Validator				Average	Criteria
	I	II	III	IV		
Identity and Components of RPP	Yes	Yes	Yes	Yes	-	-
KI and KD	Yes	Yes	Yes	Yes	-	-
GPA (IPK)	3,67	3,78	3,67	3,67	3,70	Very Valid
Learning Objectives	3,83	3,83	3,58	3,75	3,75	Very Valid
Learning Topics	4	4	4	4	4	Very Valid
Selection of Approach, Model, and Learning Methods	Yes	Yes	Yes	Yes	-	-
Media, Tools, and Learning Resources	4	3,50	3,83	3,67	3,75	Very Valid
Learning Activities	3,81	3.94	3,78	3,77	3,82	Very Valid
Learning Outcome Assessment	3,88	3,60	3,86	3,73	3,77	Very Valid
Total Average Validity	3,86	3,84	3,80	3,79	3,82	Very Valid

From Table 2, it is known that the average validation score for Lesson Plan I is 3.86, Lesson Plan II is 3.84, Lesson Plan III is 3.80, and Lesson Plan IV is 3.79, with all four lesson plans falling into the "very valid" category. The overall average validity score for all lesson plans is 3.82. According to Sugiyono (2016), this score indicates that the product is considered very valid. In the aspect of "Media, Tools, and Learning Resources," the average score obtained is 3.75, which means that this aspect is already appropriate for the learning topic and supports the achievement of learning objectives, and it is rated as very valid. However, the validator suggested that the learning resources should be made more varied. The results of the validity assessment for LAS are as follows.

Table 3. Recap of Student Activity Sheets Validity Data

Aspect	Average Evaluation of Student Activity Sheets				Average	Criteria
	I	II	III	IV		
Learning Topics	3,73	3,80	3,80	3,67	3,75	Very Valid
Learning Activities	3,58	3,66	3,67	3,75	3,66	Very Valid
Suitability of Mathematical Problem Solving Skills Process with Problem Based Learning Model	3,53	3,73	3,53	3,60	3,60	Very Valid

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Aspect	Average Evaluation of Student Activity Sheets				Average	Criteria
	I	II	III	IV		
Suitability of Student Activity Sheets with Didactic Requirements	3,66	3,83	3,66	3,66	3,70	Very Valid
Suitability of Student Activity Sheets with Construction Requirements	3,57	3,57	3,67	3,89	3,67	Very Valid
Suitability of Student Activity Sheets with Technical Requirements	3,77	3,57	3,61	3,77	3,68	Very Valid
Overall Average Validity	3,67	3,64	3,65	3,71	3,68	Very Valid

Based on Table 3, the average validity scores for Student Activity Sheets I, II, III, and IV are 3.67, 3.64, 3.65, and 3.71, respectively. The overall average validity score for the student activity sheets is 3.68, indicating that the developed sheets fall under the "very valid" criteria. The validator suggested adding student identities to the student activity sheets, particularly in the section for group member names. Since the sheets are distributed per group, it would be better to directly list all the names of the group members.

From the presentation of the learning device validity results, it can be concluded that the product is highly valid. The average validity scores for the syllabus, lesson plan, and student activity sheets are 3.81, 3.82, and 3.68, respectively, all of which are classified as "very valid." This indicates that the syllabus and lesson plan are aligned with the established components, and the student activity sheets have met all assessment criteria. The validators concluded that the product is ready for implementation, provided that revisions are made according to the critiques and comments.

On Wednesday, March 1, 2023, information was provided regarding the learning activities conducted before completing the exercises contained within the student activity sheets. Students were directed to sit in their previously assigned groups, and the learning objectives were communicated. Students were instructed to read the instructions for completing the student activity sheets. The researcher acted as a facilitator for students working on the sheets and provided guidance if difficulties arose. After the students completed the exercises in Student Activity Sheet I, the researcher conducted a poll on the students' reactions to the findings completed using the first sheet. The students then proceeded to work on Student Activity Sheet II, following the same activities as in the first sheet. After completing the second sheet, the researcher conducted a poll on the students' reactions to the findings using it.

On Monday, March 6, 2023, students worked on Student Activity Sheets III and IV. The researcher re-explained the activities in the sheets and communicated the learning objectives. The students then worked on the third sheet according to the instructions, and the analyst provided guidance if students encountered problems. The researcher asked the students to fill out a questionnaire on the learning they had obtained from the third sheet after completing the activities. The students then proceeded to work on the fourth sheet, following the same activities as in the third sheet. After completing the fourth sheet, the researcher conducted a survey of the students' responses regarding the learning conducted using the fourth sheet. Table 4 displays the students' responses to the student activity sheets response questionnaire.

Table 4 Recap of Small Group Practicality Analysis Data

Aspect	Average Evaluation of Student Activity Sheets				Average	Criteria
	I	II	III	IV		
Appearance	3.60	3.43	3.50	3.40	3.48	Very Practical
Content/ Material	3.52	3.53	3.64	3.47	3.54	Very Practical
Ease of Use	3.55	3.72	3.66	3.66	3.64	Very Practical
Total Average	3.56	3.47	3.53	3.48	3.51	Very Practical

Table 4 illustrates that in the small-scale testing, the average scores for Student Activity Sheet I was 3.56, Student Activity Sheet II was 3.47, Student Activity Sheet III was 3.53, and Student Activity Sheet IV was 3.48. The overall average student response score was 3.51, indicating that the student activity sheets for all four sessions met the "very practical" criteria. This result aligns with Suharsimi Arikunto (as cited in Pratiwy et al., 2019), which states that a product is considered very practical when the practicality score exceeds 3.25.

The large group trial was conducted at SMAN 1 Tambusai Utara in Class XI IPA 3, consisting of 30 students with varying academic abilities. The class was chosen based on recommendations from the school's arithmetic educator. This preliminary study aimed to assess the practicality of the student activity sheets on a larger scale.

On Tuesday, March 7, 2023, trials for Student Activity Sheets I and II were conducted, followed by trials for Student Activity Sheets III and IV on Thursday, March 9, 2023. Each trial lasted 25 minutes due to the limited face-to-face learning time provided by the school. The learning activities were carried out through group discussions, with students divided into 6 groups of 5 members each. Below is a summary of the practicality analysis results for the student activity sheets on a larger scale.

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Table 5 Recap of Large Group Practicality Analysis Data

Aspect	Average Evaluation of Student Activity Sheets				Average	Criteria
	I	II	III	IV		
Appearance of Student Activity Sheets	3.58	3.56	3.58	3.64	3.59	Very Practical
Content/Topics in Student Activity Sheets	3.62	3.58	3.63	3.66	3.62	Very Practical
Ease of Use of Student Activity Sheets	3.67	3.71	3.68	3.80	3.71	Very Practical
Overall Average	3.62	3.62	3.63	3.70	3.64	Very Practical

Table 5 reveals that the large-scale trial of the student activity sheets yielded an average score of 3.64 across the three evaluated aspects, positioning the sheets firmly within the "very practical" category. This outcome aligns with the criteria established by Arikunto (as cited in Pratiwy et al., 2019), which stipulates that a product is deemed very practical when it achieves a practicality score exceeding 3.25. The results from both the validity and practicality assessments demonstrate that the student activity sheets have successfully met the necessary standards for educational effectiveness. This indicates that the materials are not only theoretically sound but also highly functional in practical application. As the research progresses into the dissemination phase, the learning device will be compiled and refined into a formal book format. Additionally, the findings and methodologies will be disseminated to the academic community through publication in a peer-reviewed scientific journal, ensuring that the research contributes to the broader field of educational development.

CONCLUSIONS AND RECOMMENDATIONS

The final product of this research is a comprehensive set of educational tools that include a syllabus, lesson plans, and student activity sheets, all of which are designed using the Problem-Based Learning (PBL) approach, specifically tailored for the topic of linear programming. These learning materials have been meticulously developed to effectively support and enhance the mathematical problem-solving skills of eleventh-grade students in high schools and madrasah (SMA/MA). Through rigorous evaluation, these tools have been validated and have proven to meet the high standards of both validity and practicality, ensuring that they are both effective and user-friendly in a real classroom setting.

The significance of these materials lies not only in their immediate application to the topic of linear programming but also in their potential to serve as a model for other educational contexts. The structured integration of PBL within these learning

devices encourages active student engagement, critical thinking, and the practical application of mathematical concepts, which are essential skills in today's educational landscape.

For future research, it is strongly recommended that similar PBL-based learning devices be developed for other mathematical topics and even across different subjects. Expanding this approach to various educational domains will not only contribute to a deeper understanding of PBL's effectiveness but will also provide students with diverse opportunities to develop their problem-solving skills in a wide range of contexts. By continuously refining and adapting these educational tools, educators and researchers can work together to create a more dynamic and interactive learning environment that better prepares students for the complex challenges of the future.

REFERENCES

Adhyan, A. R., & Sutirna. (2022). Kemampuan pemecahan masalah matematis siswa mts pada materi himpunan. *JPMI*, 5(2), 451-462. https://doi.org/10.22460/jpmi.v5i2.10289

Al-Tabany, T. I. B. (2017). *Mendesain Model Pembelajaran Inovatif, Progresif, dan Kontekstual*. Kencana.

Daryanto, & Dwicahyono, A. (2014). *Pengembangan perangkat pembelajaran (Silabus, RPP, PHB, Bahan Ajar)*. Gava Media.

Hamdayama, J. (2016). *Metodologi pengajaran*. Bumi Aksara.

Hayati, R., Fachrurazi, F., Karim, A., & Marzuki, M. (2022). Peningkatan kemampuan pemecahan masalah menggunakan model problem based learning berbantuan video pembelajaran di sekolah dasar. *Jurnal Absis: Jurnal Pendidikan Matematika Dan Matematika*, 5(1), 621–629. https://doi.org/10.30606/absis.v5i1.1558

Junitasari, J., Roza, Y., & Yuanita, P. (2021). Pengembangan perangkat pembelajaran matematika berbasis model core untuk memfasilitasi kemampuan pemecahan masalah matematis peserta didik SMP. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, 5(1), 744-758. https://doi.org/10.31004/cendekia.v5i1.415

Karima, Q., Murni, A., & Siregar, S. N. (2020). Pengembangan perangkat pembelajaran dengan penerapan model problem based learning untuk memfasilitasi kemampuan pemecahan masalah matematis peserta didik kelas VIII SMP/MTs pada materi statistika. (*Undergraduate thesis, Universitas Riau*). Universitas Riau.

Nurjanah, S., Istiqomah, & Sujadi, A. A. (2018). Analisis kesulitan siswa dalam menyelesaikan soal-soal program linear pada siswa kelas X TKJ SMK Piri 2 Yogyakarta. *Prosiding Seminar Nasional Etnomatnesia*, 821–827.

Nurohmah, S. D., & Setianingsih, R. (2014). Implementasi scaffolding untuk

https://doi.org/10.30606/absis.v7i1.2339

mengatasi kesulitan siswa kelas X SMK kartika 1 surabaya dalam menyelesaikan soal cerita pada materi program linear. *Mathedunesa: Jurnal Ilmiah Pendidikan Matematika*, 3(3), 221-229. https://ejournal.unesa.ac.id/index.php/mathedunesa/article/view/12948

Pratiwy, S. E., Anggraini, R. D., & Yuanita, P. (2019). Pengembangan perangkat pembelajaran matematika dengan model discovery learning pada materi bangun ruang sisi datar kelas VIII SMP/MTs. Jurnal Online Mahasiswa (JOM) Fakultas Keguruan dan Ilmu Pendidikan Universitas Riau, 6(2). https://jom.unri.ac.id/index.php/JOMFKIP/article/view/25443

Sugiyono. (2016). *Metode penelitian kuantitatif, kualitatif dan R&D*. Alfabeta.

Sumartini, T. S. (2016). Peningkatan kemampuan pemecahan masalah matematis siswa melalui pembelajaran berbasis masalah. *Mosharafa: Jurnal Pendidikan Matematika*, 5(2), 148–158. https://doi.org/10.31980/mosharafa.v5i2.391

Tampubolon, R., Sinaga, B., & Mulyono. (2021). Pengembangan perangkat pembelajaran berbasis masalah untuk meningkatkan kemampuan pemecahan masalah siswa SMA Negeri 17 Medan. *Paradikma Jurnal Pendidikan Matematika*, 14(1), 16-28. https://doi.org/10.24114/paradikma.v14i1.24890

Yustianingsih, R., Syarifuddin, H., & Yerizon. (2017). Pengembangan perangkat pembelajaran matematika berbasis problem based learning (PBL) untuk meningkatkan kemampuan pemecahan masalah peserta didik kelas VIII. *JNPM (Jurnal Nasional Pendidikan Matematika)*, 1(2), 258-274. https://jurnal.ugj.ac.id/index.php/jnpm/article/view/563

Zakiyah, S., Hidayat, W., & Setiawan, W. (2019). Analisis kemampuan pemecahan masalah dan respon peralihan matematik dari SMP ke SMA pada materi SPLTV. *Mosharafa: Jurnal Pendidikan Matematika*, 8(2), 227–238. https://doi.org/10.31980/mosharafa.v8i2.555

Zulkarnain, & Heleni, S. (2014). *Strategi Pembelajaran Matematika*. Cendikia Insani.