ISSN 2614-5103 (Print)
2614-5111 (online)
IndoMath
Indonesia Mathematics Education
https://indomath.org/index.php/indomath
Vol 7, No. 2, August 2024, pp. 196-215

The Impact of Realistic Mathematics Education-based Student Worksheet for Improving Students' Mathematical Problem-Solving Skills

Wana Rukmana Tumangger
Mathematics Education Department, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
2108050023@webmail.uad.ac.id

Ibrahim Alhussain Khalil
Department of Curriculum and Instruction, University of Bisha, Bisha, Saudi Arabia
ikhalil@ub.edu.sa

Rully Charitas Indra Prahmana*
Mathematics Education Department, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
Corresponding Author: rully.indra@mpmat.uad.ac.id

ABSTRACT

Mathematical problem-solving ability is a critical skill required to meet the challenges of the 21st century, making it imperative for Indonesian students to master these skills. However, international assessments have consistently shown that Indonesian students' competencies, particularly in mathematical problem-solving, remain low. Research attributes this deficiency to the lack of connections between mathematical concepts and real-life applications, which are essential for enhancing problem-solving skills. On the other hand, Realistic Mathematics Education (RME) is a learning approach that emphasizes the integration of real-world contexts in learning activities and has been shown to improve these skills. Therefore, this study aims to develop a student worksheet based on the RME approach to enhance students' problem-solving abilities. The development process followed the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation. Various research and development instruments were employed, including validation by material and media experts, student assessments of the electronic worksheets, and pre-test and post-test evaluations. Data collection methods encompassed both non-test and test techniques. The results demonstrate that the developed student worksheets are valid, practical, and effective. The validity was confirmed by high average scores from material and media expert validators, categorizing the worksheets as valid. Practicality was supported by positive student assessments, placing the worksheets in the practical category. These findings indicate that the developed worksheets significantly enhance students' problem-solving abilities. This study provides empirical evidence supporting the effectiveness of the RME approach in improving mathematical problem-solving skills among Indonesian students. It also offers a theoretical and practical framework for advancing mathematics education in Indonesia, advocating for the adoption of learning approaches that better address the demands of the 21st century. Detailed analysis of the product's acceptability and impact will be discussed further in the paper.

Keywords: Mathematical Problem-Solving Ability, Number Pattern, Realistic Mathematics Education, Research and Development, Student Worksheet.

ABSTRAK

Kemampuan pemecahan masalah matematis adalah keterampilan penting yang diperlukan untuk menghadapi tantangan di abad ke-21, sehingga sangat penting bagi siswa Indonesia untuk menguasai keterampilan ini. Namun, penilaian internasional secara konsisten menunjukkan bahwa kompetensi siswa Indonesia, khususnya dalam pemecahan masalah matematika, masih rendah. Penelitian mengaitkan kekurangan ini dengan kurangnya hubungan antara konsep matematika dan aplikasi kehidupan nyata, yang sangat penting untuk meningkatkan kemampuan pemecahan masalah. Di sisi lain, Pendidikan Matematika Realistik (RME) adalah pendekatan pembelajaran yang menekankan pada integrasi konteks dunia nyata dalam kegiatan pembelajaran dan telah terbukti dapat meningkatkan kemampuan tersebut. Oleh karena itu, penelitian ini bertujuan untuk mengembangkan lembar kerja siswa berbasis pendekatan RME untuk meningkatkan kemampuan pemecahan masalah siswa. Proses pengembangan mengikuti model ADDIE, yang meliputi tahap analisis, desain, pengembangan, implementasi, dan evaluasi. Berbagai instrumen penelitian dan pengembangan digunakan, termasuk validasi oleh ahli materi dan media, penilaian siswa terhadap LKS elektronik, dan evaluasi pre-test dan post-test. Metode pengumpulan data meliputi teknik non-tes dan tes. Hasil penelitian menunjukkan bahwa lembar kerja siswa yang dikembangkan valid, praktis, dan efektif. Kevalidan ditegaskan dengan nilai rata-rata yang tinggi dari validator ahli materi dan media yang mengkategorikan LKS yang dikembangkan valid. Kepraktisan didukung oleh penilaian siswa yang positif, menempatkan LKS dalam kategori praktis. Temuan ini menunjukkan bahwa LKS yang dikembangkan secara signifikan meningkatkan kemampuan pemecahan masalah siswa. Penelitian ini memberikan bukti empiris yang mendukung keefektifan pendekatan RME dalam meningkatkan kemampuan pemecahan masalah matematis siswa Indonesia. Penelitian ini juga menawarkan kerangka kerja teoritis dan praktis untuk memajukan pendidikan matematika di Indonesia, mengadvokasi adopsi pendekatan pembelajaran yang lebih baik untuk memenuhi

tuntutan abad ke-21. Analisis yang lebih rinci tentang penerimaan dan dampak produk akan dibahas lebih lanjut dalam makalah ini.

Kata Kunci: Kemampuan Pemecahan Masalah Matematika, Pola Bilangan, Pendidikan Matematika Realistik, Penelitian dan Pengembangan, Lembar Kerja Siswa.

INTRODUCTION

Mathematical problem-solving ability is a critical skill necessary for individuals to navigate the complex challenges of the 21st century (Radmehr & Vos, 2020). However, the proficiency in mathematical problem-solving among Indonesian students remains notably low (Nurqamar & Nur, 2022; Hadi et al., 2023). Additionally, Indonesian students' problem-solving capabilities fall short of international benchmarks, hindered by challenges in curriculum implementation, teacher competency, and resource availability (Paidi et al., 2020). Despite ongoing educational reforms and initiatives, substantial improvements are still required to elevate these skills across the educational system (Yurkofsky et al., 2020). According to an analysis conducted by the OECD, the majority of Indonesian students struggle to achieve proficiency levels 5 and 6 in the PISA assessment, which includes tasks that evaluate problem-solving abilities (OECD, 2023). This deficiency in problem-solving skills can be attributed to multiple factors, including the absence of an effective learning approach that connects mathematical concepts to real-world problems, which is essential for enhancing students' mathematical problem-solving skills (Franestian & Wiyono, 2020). Therefore, there is an urgent need for the development of innovative educational approaches to improve students' problem-solving abilities.

Problem-solving skills can be cultivated through educational approaches and activities that are closely aligned with students' everyday experiences (Szabo et al., 2020; Malasari & Awofala, 2022). A prominent approach in this regard is Realistic Mathematics Education (RME), originally developed by Freudenthal at Utrecht University, Netherlands (Zulkardi et al., 2020). RME emphasizes not only the integration of learning activities with real-life contexts but also the enhancement of students' mathematical thinking strategies and cognitive development (Van den Heuvel-Panhuizen & Drijvers, 2020). Numerous studies have demonstrated that the features and principles of RME are instrumental in improving students' problem-solving abilities (Anggraini & Fauzan, 2020; Ndiung et al., 2021; Negara et al., 2021). Furthermore, Ukobizaba et al. (2021) suggest that mathematical problem-solving skills can be significantly improved through innovative pedagogical approaches that incorporate real-world problems. Furthermore, Montague et al. (2019) argue that to enhance mathematical problem-solving abilities, educators must engage students in mathematical thinking strategies tailored to their cognitive levels, thereby enabling them to solve problems more effectively. Consequently, Realistic Mathematics Education (RME), with its focus on connecting learning activities to students' everyday lives and fostering their mathematical thinking strategies, emerges as an effective approach for developing problem-solving skills.

In mathematics education, the Realistic Mathematics Education (RME) approach can be implemented not only in instructional activities but also in the design of teaching materials (Purwitaningrum & Prahmana, 2021). To effectively enhance students' problem-solving skills, it is crucial that teaching materials incorporate a variety of mathematical problems for students to solve

(Asnawi et al., 2022; Luzano, 2023). A key strategy of the RME approach is integrating mathematical problems that are relevant to students' daily lives into these materials (Hafid et al., 2022). For instance, incorporating traditional practices like Rangku Alu into mathematics education promotes inclusivity and enhances mathematical understanding in multicultural environments (Pangestuti et al., 2024). Furthermore, students' conceptual understanding and mathematics performance can be improved by integrating Ethno-RME with digital technology (Nurnaningsih et al., 2024). Additionally, the exploration of modulo arithmetic within a cultural context presents a compelling avenue for enriching mathematical pedagogy, particularly in the area of modulo operations (Khasanah et al., 2023). These strategies aim to foster a deeper understanding of mathematical concepts and enhance students' independent problem-solving abilities (Szabo et al., 2020). Therefore, the RME approach in mathematics education effectively enhances students' problem-solving skills by embedding real-life, relevant problems into teaching materials, which in turn fosters a deeper understanding of mathematical concepts and promotes independent problem-solving.

Students are motivated to actively engage in mathematics learning and cultivate a strong interest in problem-solving by incorporating contexts familiar to them through the Realistic Mathematics Education (RME) approach (Inci et al., 2023). This approach includes utilizing situations from their environment or daily activities and employing well-designed instructional materials (Hafid et al., 2022). The RME emphasis on real-world problem-solving effectively bridges the gap between the mathematical theories taught in school and their practical applications (Dinglasan et al., 2023; Van den Heuvel-Panhuizen & Drijvers, 2020). Consequently, students not only grasp mathematical concepts abstractly but also recognize their immediate relevance and applicability. Additionally, this approach supports the development of critical and creative thinking skills, which are crucial for addressing concrete problems in everyday life (Ismunandar et al., 2020).

Therefore, this study aims to develop student worksheets, referred to in Indonesia as “Lembar Kerja Peserta Didik” (LKPD), utilizing the Realistic Mathematics Education (RME) approach to enhance students' problem-solving abilities. The research is expected to provide empirical evidence regarding the effectiveness of the RME approach in improving mathematical problem-solving skills among Indonesian students. Additionally, it seeks to offer both theoretical and practical foundations for mathematics education in Indonesia, advocating for the adoption of learning approaches that are more aligned with students' needs and better suited to addressing the challenges of the 21st century.

METHOD

This study employs a research and development approach using the ADDIE model to create student worksheets that are valid, practical, and effective in enhancing problem-solving skills. The ADDIE model consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009). For the pilot test, the subjects comprised 20 eighth-grade students from a junior high school in the Aceh Singkil area. These students were purposively selected based on recommendations and input from the class teachers, considering the heterogeneity of students' abilities.

During the analysis stage, researchers conducted a needs assessment for teaching materials, analyzed the content to be developed, and examined student characteristics. On the other hand, researchers developed research instruments, structured learning activities, and created a systematic framework for the student worksheets in the design stage. Moving to the development stage, researchers aligned the basic competencies and achievement indicators, adapted learning activities to the principles of Realistic Mathematics Education, formulated problem-solving strategies based on Polya's approach (1985), and carried out validation assessments of the student worksheets by field experts. The validation process involved collecting both quantitative data through scaled validation sheets and qualitative feedback in the form of direct comments from experts on the provided validation sheets and the LKPD itself.

In the implementation stage, researchers conducted a series of activities involving the application of the student worksheets in the learning process. This included assessing the practicality of the worksheets and administering a post-test. The implementation of the LKPD was structured into five activities conducted over three meetings. Additionally, a pre-test was administered at the beginning of the learning process and a post-test after the implementation of the LKPD to evaluate its effectiveness in the learning process. Finally, in the evaluation stage, researchers reflected on the developed student worksheets by analyzing their validity, practicality, and effectiveness. For a clearer understanding, the ADDIE procedure utilized in this study is illustrated in Figure 1.

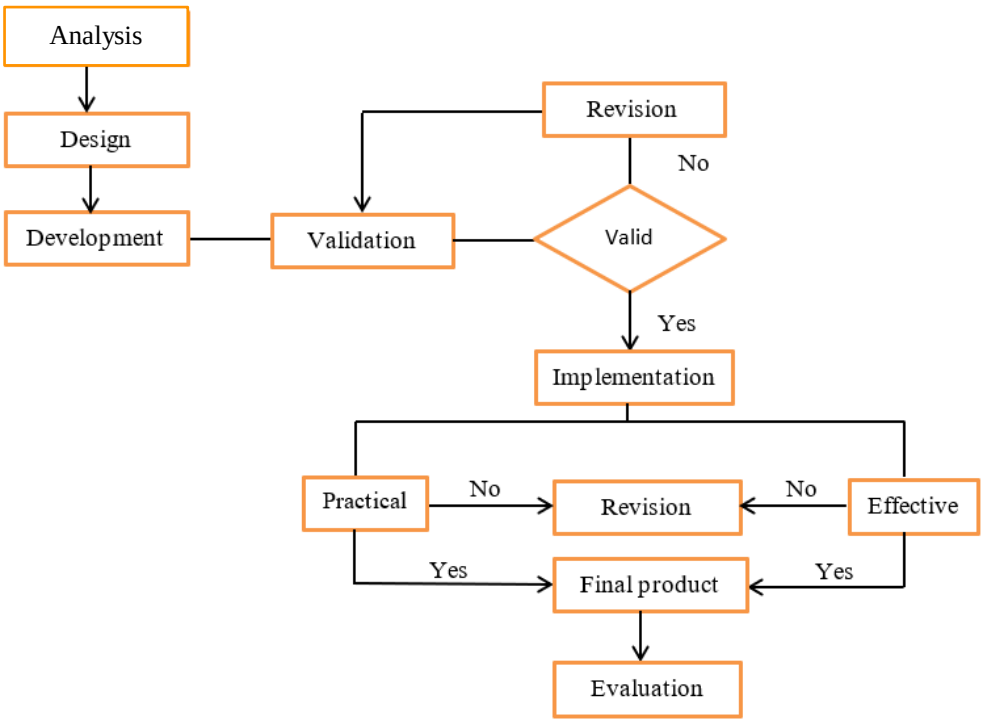

Figure 1. Research Procedure

The data collection techniques used in this study encompass both test and non-test methods. Non-test instruments include expert assessment tools, evaluations by material experts, student feedback, and observational data. The test instruments consist of a pre-assessment (pre-test) and a post-assessment (post-test), both administered in the form of 20 questions—15 multiple-choice and

5 essay questions. The effectiveness of the product is evaluated based on individual mastery, which must meet the minimum criteria, and classical mastery, which must achieve at least the "Good" standard (Ismail et al., 2020). The collected data were analyzed using descriptive analysis methods, which involved describing the entire learning process—before, during, and after the implementation of the LKPD.

RESULT AND DISCUSSION

In this study, the researchers evaluated the effectiveness of instructional materials integrated with the RME approach through the following stages: analysis, design, development, implementation, and evaluation.

Analysis Stage

In the analysis stage, the researcher evaluated several dimensions, including students' abilities, material content, curriculum, and student characteristics. The examination of students' abilities, specifically their mathematical problem-solving skills, revealed notably low initial test results, as detailed in Table 1.

Table 1. Initial Test Results of Problem-Solving Abilities

Test results	Criteria
Individual average	Very low
Classical mastery	Very poor

Table 1 illustrates that the average problem-solving ability of students is significantly below expectations, with classical mastery classified as very poor. These findings underscore the urgent need for targeted interventions to improve these skills. Developing and implementing specialized teaching materials aimed at enhancing problem-solving abilities could be an effective strategy to address this deficiency.

Table 1 also reveals significant concerns regarding students' problem-solving abilities, as evidenced by the “Very Low” average individual scores and “Very Poor” classical mastery ratings. The “Very Low” individual average suggests that students are struggling considerably with problem-solving tasks, indicating potential gaps in foundational knowledge or problem-solving strategies. This result underscores the need for targeted educational interventions, such as personalized support and revised teaching methods, to address these deficiencies and improve students' problem-solving skills.

On the other hand, the “Very Poor” classical mastery rating in Table 1 indicates that the majority of students are not meeting the expected standards for problem-solving proficiency. This points to broader systemic issues within the classroom or curriculum that may be hindering students' overall performance. To address these challenges, a comprehensive review of the curriculum and the introduction of materials that emphasize problem-solving techniques are recommended. Additionally, ongoing assessment and monitoring will be essential to track progress and refine instructional strategies to better support student development in this critical area.

The material analysis, as presented in Table 2, underscores the significant emphasis needed on number patterns to boost student achievement. The data from the final assessment of the odd semester of the 2022/2023 school year indicate that among 15 students, none were able to complete the tasks related to number patterns, while there was some progress in relations and functions (4 students) and linear equations (3 students). This stark discrepancy highlights a critical gap in students' understanding of number patterns, which is essential for developing strong problem-solving skills. The results emphasize the need for targeted instructional strategies to address this gap and enhance student performance in this area.

Table 2. Students in Completing Final Exam

Number of Students	Number Patterns	Relations and Functions	Linear Equations
15	0	4	3

In response to these findings, the researcher focused on integrating number patterns into the development of worksheets based on the Realistic Mathematics Education (RME) approach. By centering on number patterns within these worksheets, the aim is to build students' problem-solving abilities through practical, context-rich problems. This targeted approach is expected to address the identified deficiencies and improve overall student achievement in mathematical problem-solving by reinforcing foundational concepts related to number patterns.

The curriculum analysis reveals that the school follows the 2013 curriculum, which includes essential Basic Competencies focused on number patterns, specifically Basic Competencies 3.1 and 4.1, as detailed in Table 3. Basic Competency 3.1 requires students to recognize and generalize patterns within number sequences and object configurations. This competency involves identifying and articulating recurring rules or patterns in a general sense. In contrast, Basic Competency 4.1 emphasizes applying pattern recognition to solve problems involving number sequences and object configurations, expecting students to leverage their understanding of these patterns to address more complex mathematical challenges. These competencies are designed to lay a strong foundation for students' grasp of fundamental mathematical concepts, particularly in recognizing, analyzing, and applying patterns.

The focus on Basic Competencies 3.1 and 4.1 aligns with the need for enhancing students' problem-solving skills, as evidenced by the earlier material analysis. Despite the curriculum's clear objectives, the assessment results suggest that students are not fully meeting these competencies, particularly in number patterns. This gap indicates a potential misalignment between the curriculum goals and students' actual performance. To address this, targeted instructional strategies and materials that emphasize number patterns, as reflected in the development of worksheets based on Realistic Mathematics Education (RME), could be crucial in bridging this gap and improving students' proficiency in these key areas.

Analysis of student characteristics revealed that eighth graders have limited access to communication tools such as smartphones and the internet. Gómez-García et al. (2020) found a significant correlation between students' proficiency in using the internet and smartphones and their mathematical abilities. Additionally, students rely heavily on library books for knowledge exploration,

and their problem-solving skills remain underdeveloped. Consequently, there is a need for educators to design engaging and meaningful learning experiences that can enhance problem-solving skills, supported by appropriate learning resources that facilitate skill development.

Table 3. Basic Competencies 3.1 and 4.1

Basic Competencies
3.1 Make generalizations from patterns in number sequence and object configuration sequence
4.1 Solve problems related to the pattern of number sequence and object configuration sequence

Design Stage

In the design stage, the researchers undertake the development of student worksheets (LKPD) following a thorough analysis. This stage encompasses several crucial steps to ensure that the LKPD meets educational needs:

1. Development of Research Instruments

   This includes creating tools for assessing the validity and practicality of the LKPD. These instruments are essential for objectively evaluating the quality of the developed worksheets.
2. Design of Learning Activity Steps

   These steps are aligned with the five characteristics of Realistic Mathematics Education (RME), which include presenting problems in real contexts, utilizing mathematical models, fostering a construction process, ensuring interactivity, and promoting connectivity in learning.
3. Compilation of Student Worksheets

   The LKPD is organized systematically and includes various components such as the cover, preface, core competencies, basic competencies, indicators of competency achievement, learning objectives, instructions for use, table of contents, learning activities, exercises, and bibliography. Each component is meticulously designed to support an effective and systematic learning process for students.

During the structuring of the student worksheet system, the design of the LKPD was developed with careful consideration of the characteristics of RME and the stages that support the development of students' problem-solving skills. This design was visually outlined and tested using validation tools, including content expert evaluations, media expert reviews, and user feedback. Additionally, a post-test questionnaire was prepared to measure the effectiveness of the LKPD in enhancing students' mathematical problem-solving abilities.

The LKPD's cover includes information about the material, the learning approach, the author's name, and the supervisor's name. The preface features expressions of gratitude, a brief overview of the LKPD's content, and suggestions for the media produced. The Competency Display informs students about the competencies they have achieved through the LKPD. The Learning Objectives and Instructions section provides details about the educational goals of the LKPD and how to use it. The Table of Contents facilitates easy navigation to various learning activities. The Learning Activities section contains the activities students will engage in, and the Bibliography lists the references used in the LKPD's development.

In the core section, the LKPD was designed to incorporate the five characteristics of RME: initiating activities with real-life phenomena, employing mathematical models, facilitating the construction process, promoting interactivity, and ensuring connectivity. The LKPD emphasizes problem-solving skills by guiding students through understanding the problem, developing strategies, applying these strategies, and verifying solutions. The design of the LKPD is illustrated in Figure 2.

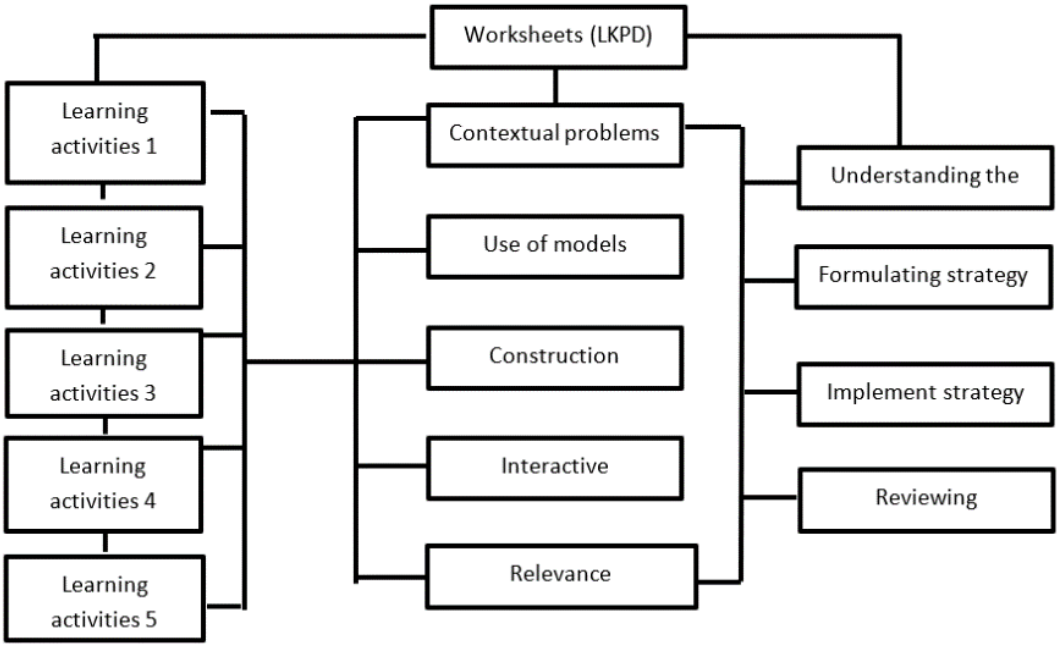

Figure 2. LKPD Design base on RME characteristics

At this stage, the researchers also developed several instruments, including test instruments and evaluation tools for the LKPD. These instruments comprised content expert sheets, media expert sheets, and user response sheets. The post-test questionnaire was utilized to assess students' problem-solving skills following their use of the LKPD. Additionally, the expert validation sheets were employed to evaluate the validity of the LKPD based on expert assessments.

Development Stage

At this stage of development, the LKPD (Lembar Kerja Peserta Didik) was created following a carefully designed blueprint to align with educational goals. The researchers utilized the Canva application to ensure the visual appeal and engagement of the LKPD, aiming to enhance student interaction and motivation. The LKPD was then rigorously evaluated for validity by content and media experts using validated assessment instruments. A product is considered valid if it meets the "good" criteria established for both content quality and media presentation. The evaluation indicated that the LKPDs met these criteria, affirming their validity and appropriateness from both perspectives. This validation process ensures that the LKPDs are well-designed and effective tools for educational use.

The evaluation feedback, detailed in Table 4, provided several constructive comments and suggestions for improving the LKPD. One primary recommendation was to include explicit learning objectives, which are crucial for guiding students' focus and ensuring that the learning activities align with the intended educational outcomes. Additionally, the feedback noted duplicate indicators in the

indicator section, which needed to be corrected to avoid confusion and ensure clarity in instructional goals.

Another significant point from the feedback was the need to revise the initial context of learning activities. For instance, the content expert suggested replacing the branch growth scenario in Learning Activity 1 with a more relevant context, such as the increase in the radius or diameter of a tree annually. This adjustment would make the problem more meaningful and applicable to students' real-life experiences. Similar recommendations were made for other learning activities, emphasizing the importance of providing realistic and relatable contexts to engage students effectively.

Table 4. Comments and Suggestions

No	Comments and Suggestions
1	Please add learning objectives. In the indicator section, there are duplicate indicators (square pattern and rectangle).
2	In learning activity 1, the content expert suggests providing a truly realistic initial situation that is meaningful to students. The initial problem presented in learning activity 1 about branch growth per month on a tree, upon further investigation, should actually involve the increase in radius or diameter of the tree annually. Therefore, using branch growth as the initial context is considered less appropriate.
3	In learning activity 2, it would be better if one context could consist of several questions. Questions could be further developed. For example, add information in seconds/minutes, so that questions like "At minute n, what color light appears?" can be asked. This context is important for students to learn rationalization when stuck in traffic, predicting how long it will take to exit based on a specific distance.
4	In learning activity 3, experts recommend providing situations that are truly realistic.
5	In learning activity 4, in terms of constructing the LKPD, ensure that student self-developed models are not intervened with (to produce a variety of answers). It would be beneficial to consult references such as books on mathematics in context.
6	In learning activity 5, special attention should be given to the use of images in problems. Images that are too small or irrelevant to the problem information should be removed or made more relevant.
7	In the practice activity levels, the difficulty of the problems should be increased (graded), so that they can effectively measure students' problem-solving abilities, as indicated in the title.
8	In the references section, consider adding references from external sources, especially books on Realistic Mathematics Education (RME), to clearly demonstrate that this LKPD development is based on credible sources.

The experts also highlighted the need for improvements in the structure and content of the learning activities. For Learning Activity 2, the suggestion was to consolidate contexts into single, more comprehensive questions, which would facilitate deeper understanding and application. For Learning Activity 3, experts recommended providing situations that are genuinely realistic to enhance student engagement. In Learning Activity 4, the feedback stressed the importance of allowing students to develop their own models without undue intervention and consulting relevant references to support this approach. For Learning Activity 5, the advice was to improve the relevance and size of images used in problems to ensure they effectively convey the intended information.

In response to this feedback, significant revisions were made to the LKPD, addressing the comments and suggestions provided by the experts. Enhancements included refining learning objectives, adjusting learning activities for greater realism and clarity, increasing problem difficulty, and incorporating additional references. These revisions aim to ensure that the LKPD not only meets

educational standards but also provides a more effective and engaging learning experience for students. The updated LKPD is expected to better support students' problem-solving skills and align with best practices in educational content design, ultimately contributing to improved learning outcomes. The outcomes of the design and development process for the LKPD are illustrated in Figure 3.

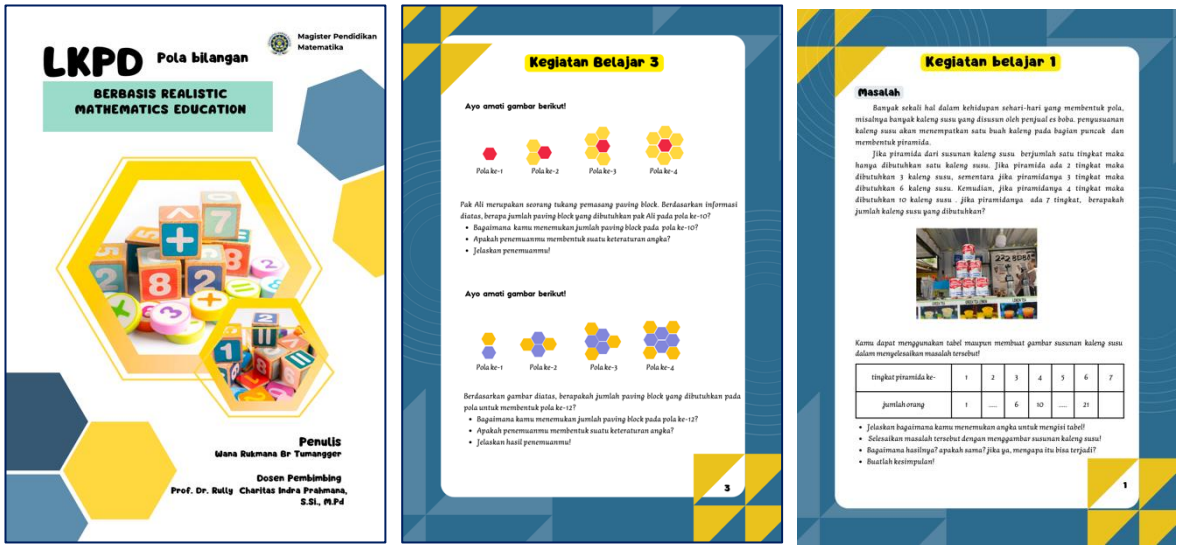

Figure 3. LKPD's Design

During the development phase, the LKPD was implemented across three learning sessions to assess its effectiveness and gather feedback on its usability. In the first session, students engaged with Learning Activities 1 through 3, each designed to build on the concepts of pattern recognition and problem-solving skills. The activities were crafted to encourage students to explore and apply their understanding of number patterns through a variety of tasks. The goal of this session was to evaluate how well the LKPD facilitated student engagement and learning and to identify any areas for improvement.

1. Learning Activity 1

   Students observed a phenomenon where milk cans were arranged to form a pyramid. This activity was designed to help students identify and analyze patterns within a visually engaging context. By solving related problems using tables and graphs, students had the opportunity to apply their own methods for pattern recognition. This open-ended approach aimed to foster critical thinking and problem-solving skills, as students explored different ways to find and represent patterns in tables and graphs.

2. Learning Activity 2

   Learning Activity 2 built on the skills acquired in the first activity by guiding students to identify patterns in numerical form. The activity required students to apply their understanding from Activity 1 to solve new problems, reinforcing their learning and helping them transfer their skills to different contexts. This progression was intended to deepen students' comprehension of pattern recognition and enhance their ability to apply these concepts in various mathematical scenarios.

3. Learning Activity 3

   Students were tasked with arranging several arrays of objects to determine the sequences of numbers formed. This activity was designed to help students visually and conceptually understand numerical sequences and their patterns. By manipulating and analyzing these arrays, students could better grasp the relationships between numbers and their arrangements, further developing their problem-solving skills in a hands-on manner.

The learning activities from the first session of the LKPD implementation are depicted in Figure 4. This visual representation provides insight into how the activities were structured and presented to students. Analyzing the effectiveness of these activities and gathering feedback from students can offer valuable information on how well the LKPD supports their learning and whether any adjustments are needed to improve its design and impact.

Figure 4. The First Session of Product Implementation

In the second session of LKPD implementation, students advanced to Learning Activities 4 and 5, which were designed to build upon the skills developed in the first session. These activities aimed to further deepen students' understanding of patterns and problem-solving through collaborative and individual tasks. The second session focused on enhancing students' ability to apply mathematical concepts in more complex scenarios, as well as gathering feedback on the LKPD's effectiveness and usability.

1. Learning Activity 4

   Learning Activity 4 involved group discussions where students addressed problems related to the construction of Learning Activity 3. This collaborative approach was intended to encourage students to share their insights and strategies, fostering a deeper understanding of the problems by examining them from multiple perspectives. Group discussions also aimed to develop students' communication skills and ability to work collaboratively, which are essential aspects of problem-solving in mathematics.

2. Learning Activity 5

   Students generalized sequences related to square numbers, rectangles, triangles, and arithmetic series. This activity was designed to help students extend their understanding of numerical sequences and apply it to various mathematical contexts. By exploring these sequences and their sums, students were expected to refine their problem-solving skills and gain a more comprehensive grasp of mathematical patterns and relationships.

Additionally, students provided feedback on the LKPD during this session. This feedback was crucial for assessing the effectiveness of the learning activities and identifying areas for improvement. Gathering students' perspectives on the LKPD allowed researchers to understand how well the activities supported their learning and whether any adjustments were needed to enhance the overall educational experience. The activities undertaken by the students during the second session are illustrated in Figure 5.

Figure 5. Student activities in the second meeting

This visual representation offers a snapshot of how the activities were implemented and how students interacted with the LKPD. Analyzing these illustrations, alongside student feedback, provides valuable insights into the strengths and areas for improvement in the LKPD, helping to refine its design and ensure it meets the educational goals effectively.

After students completed the LKPD practicality questionnaire, the researchers analyzed the data to evaluate the product's practicality. The criterion for practicality is that a product should meet the "good" criteria or higher. The analysis of students' responses, detailed in Table 5, revealed that the LKPD achieved a total score of 1479 from 20 students, resulting in an average score of 73.9. This score falls within the "very good" category, indicating that the LKPD was highly practical and well-received by students.

Table 5. Student Responses

Total Score	1479
Number of Students	20
Average Score	73,9
Criteria	Very Good

The high average score of 73.9 reflects positive student feedback regarding the LKPD's practicality. This suggests that students found the LKPD to be a useful and effective tool in their learning process. The "very good" rating indicates that the LKPD met or exceeded students' expectations in terms of usability, engagement, and overall effectiveness in supporting their learning objectives.

In the third session, students participated in a post-test to assess the effectiveness of the RME-based LKPD in enhancing their problem-solving skills. This evaluation aimed to measure any improvements in students' problem-solving abilities resulting from their engagement with the LKPD. By comparing pre-test and post-test results, the researchers intended to gauge the impact of the LKPD on students' performance and determine its effectiveness in achieving the desired educational outcomes.

The students' activities during the third session focused on completing the problem-solving skills test. This test provided a quantitative measure of the LKPD's effectiveness in improving students' problem-solving skills. Analyzing these results will help in understanding how well the LKPD facilitated skill development and whether the integration of Realistic Mathematics Education (RME) principles successfully contributed to enhancing students' problem-solving abilities.

Overall, the combination of positive practicality scores and post-test performance will offer a comprehensive evaluation of the LKPD's effectiveness. By integrating student feedback and test results, the researchers can identify strengths and areas for improvement in the LKPD, ensuring that it effectively supports and enhances students' mathematical problem-solving skills. This iterative process of evaluation and refinement is crucial for optimizing educational tools and achieving the best possible outcomes for students.

In the third session held on August 5, 2023, students underwent a post-test designed to evaluate the impact of the RME-based LKPD on their problem-solving skills as shown in Figure 6. The test results demonstrated that a significant majority, 85% of the students, achieved scores of 70 or above, with an average post-test score of 81.8. This notable achievement suggests that the RME-based LKPD was effective in improving students' problem-solving abilities. The substantial increase in the average score reflects the effectiveness of integrating Realistic Mathematics Education principles into the worksheets, particularly in the context of number patterns. This improvement underscores the potential of RME to bridge the gap between theoretical knowledge and practical problem-solving skills by contextualizing mathematical concepts within real-life scenarios.

Further analysis of these results indicates that the RME-based LKPD not only boosted individual student performance but also likely contributed to a more profound understanding of mathematical patterns and relationships. The high proportion of students meeting or exceeding the minimum competency threshold highlights the potential of the RME approach to address existing

gaps in problem-solving skills. Given that the LKPD facilitated a more engaging and contextually relevant learning experience, it appears to have successfully fostered critical thinking and application skills. These findings suggest that adopting RME-based materials could be a valuable strategy for enhancing mathematical problem-solving abilities, thereby offering a promising approach for educational practices aimed at improving students' overall mathematical competence.

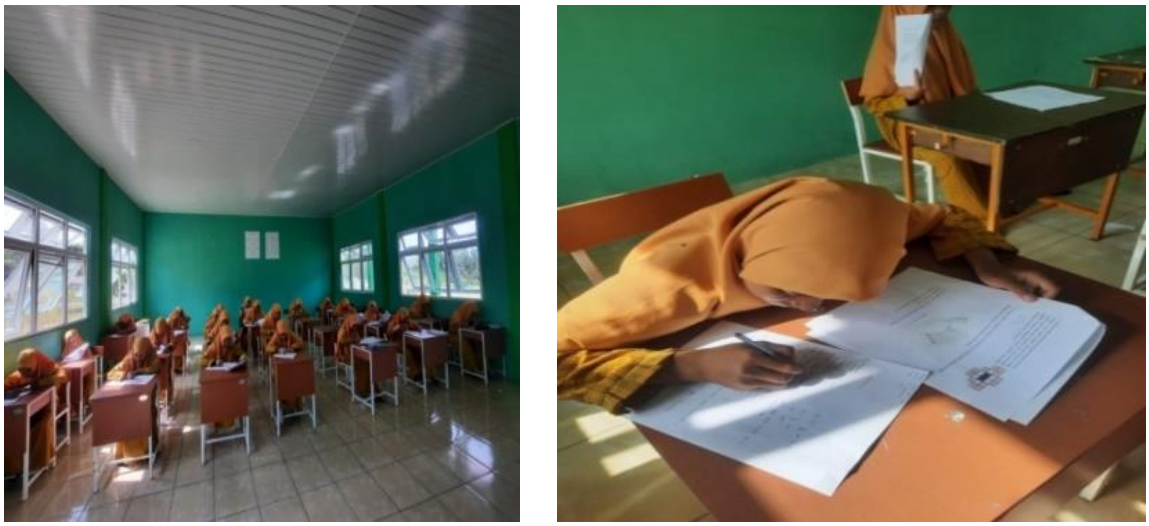

Figure 6. Students took the post-test

The results from the post-test, as detailed in Table 6, indicate a notable improvement in individual student performance. The average completeness of students' problem-solving skills was 81.8, with 17 students scoring 70 or above, and 3 students scoring below 70. The total score for the 17 students who met or exceeded the threshold was 1636.75, reflecting their successful achievement of the criteria for completion. This high average score, coupled with the fact that 85% of students met the minimum competency score or in Indonesia it's called "Kriteria Ketuntasan Minimal" (KKM), suggests that the RME-based LKPD effectively enhanced students' problem-solving skills in number patterns.

Table 6. The results of Individual Completion of Learners

No	Criteria	Number of Students	Total Score	Average	Conclusion
1	Completed	17	1636.75	81.83	Completed
2	Uncompleted	3			

The results underscore the effectiveness of the RME-based LKPD in fostering students' mathematical problem-solving abilities. The significant percentage of students who achieved scores above the threshold demonstrates that the intervention successfully addressed the educational objectives. With 85% of students scoring ≥ 70 and an average post-test score of 81.8, it can be concluded that the RME-based LKPD was effective in improving students' performance. This effectiveness highlights the value of using Realistic Mathematics Education principles in developing instructional materials that connect mathematical concepts to real-life scenarios, thereby enhancing students' understanding and application of mathematical problem-solving skills.

The analysis of students' problem-solving abilities, as presented in Table 7, indicates a favorable outcome regarding the effectiveness of the RME-based LKPD. The data reveals that the majority of students fall into the "High" and "Very High" categories of problem-solving ability. Specifically, 15 students were classified as having "High" problem-solving ability with an average score of 81.83, while 2 students demonstrated "Very High" problem-solving skills. Additionally, 3 students were categorized under "Medium" problem-solving ability, but their average score still falls within the high range.

Table 7. Analysis of problem-solving ability results

No	Criteria	Number of Students	Average	Conclusion
1	Medium	3		
2	High	15	81.83	High
3	Very High	2		

Table 7 shows that the overall distribution of students' problem-solving abilities suggests that the RME-based LKPD effectively elevated students' problem-solving skills to a high level. The concentration of students in the "High" and "Very High" categories demonstrates that the intervention successfully improved their ability to solve problems. The average problem-solving ability of students being classified as "High" indicates that the RME-based LKPD is an effective tool for enhancing mathematical problem-solving skills, achieving a significant impact on students' abilities in the context of number patterns. This positive outcome underscores the value of integrating real-life contexts into learning materials, as promoted by the RME approach, in advancing students' problem-solving competencies.

Evaluation Stage

The evaluation of students' problem-solving performance, categorized into three levels based on post-test results, reveals that the RME-based LKPD has had a significant impact on students' problem-solving abilities. According to the findings, 3 students (15%) fell into the moderate category, 15 students (75%) were categorized as high, and 2 students (10%) achieved a very high level of problem-solving ability. This distribution demonstrates a strong overall improvement in students' problem-solving skills, with a substantial majority (75%) reaching the high category. The presence of students in the very high category indicates that the intervention was effective in elevating problem-solving abilities to an advanced level for some learners.

Additionally, the evaluation of the LKPD's practicality showed that students provided a "very good" response to the material. This positive feedback indicates that students not only valued the RME-based LKPD but were also able to use it effectively and independently. The high level of student satisfaction with the LKPD suggests that it supports independent learning and facilitates the development of problem-solving skills. Overall, the RME-based LKPD proves to be an effective educational tool, enhancing students' problem-solving abilities while also being well-received and utilized by the students themselves.

Discussion

The study underscores the efficacy of the Realistic Mathematics Education (RME) approach in significantly enhancing students' ability to learn independently. Sembiring et al. (2008) assert that integrating RME into teaching materials facilitates a more autonomous learning experience for students. This claim is supported by Dinglasan et al. (2023), who observed that students engaged with RME exhibited improved learning outcomes. However, despite these positive results, the post-test data reveal that students did not fully utilize the RME-based LKPD developed for this study. This gap suggests that while students appreciated the materials, they required additional guidance to maximize their benefits, a need aligned with Sudrajat et al. (2022), who highlighted the importance of teacher support in effectively developing problem-solving skills.

The study employed the ADDIE model to develop the LKPD focused on number patterns, providing a structured framework for instructional design. The Analysis stage involved evaluating eighth-grade students' mathematical problem-solving abilities through a test administered in the second semester. The results highlighted a troubling deficiency in problem-solving skills, with average scores falling short of the KKM set by the school. Only one student achieved a score meeting or exceeding the KKM level. These findings resonate with Marchy et al. (2022), who reported similarly low problem-solving abilities among students, indicating a widespread challenge in this area.

Material development was based on a detailed analysis of end-of-semester assessments from the previous semester, which included 20 questions—15 multiple-choice and 5 essay questions. The in-depth analysis of the essay questions revealed that students struggled significantly with understanding and solving number patterns. Despite all students attempting these questions, they were unable to answer them correctly, reflecting difficulties in comprehending and generalizing number patterns. Phonapichat et al. (2014) and Firdaus et al. (2021) identified similar issues, suggesting that difficulties with number patterns contribute to poor overall problem-solving performance. Consequently, the developed LKPD was specifically tailored to address these challenges.

The materials developed aimed to enhance students' competencies in generalizing series, including square, rectangular, and triangular numbers, as well as determining the nth term of an arithmetic series. Khalid et al. (2020) emphasize that integrating mathematical concepts into everyday contexts effectively improves problem-solving skills. By linking mathematics to real-life scenarios, students gain a more meaningful understanding of how mathematical concepts apply to their daily lives, as highlighted by Risdiyanti et al. (2024). The RME approach supports this connection by encouraging exploration, questioning, and discussion of mathematical ideas within real-world contexts (Maryati & Prahmana, 2021; Maisyarah & Prahmana, 2020; Prahmana et al., 2023). This contextualized approach helps students develop effective problem-solving strategies and solutions (Muncarno & Astuti, 2018).

The effectiveness of the RME-based LKPD was evaluated through a performance test, which classified students' problem-solving abilities as "good." The classical completion rates indicated that students achieved scores above the KKM, with a completion rate of 100%. This outcome is consistent with the findings of Hasibuan et al. (2019), who demonstrated that RME-based LKPDs can effectively

enhance students' mathematical problem-solving skills. The success of the RME-based LKPD in improving student performance on the topic of number patterns underscores its effectiveness as a teaching tool.

The study emphasizes the importance of tailoring curriculum and teaching methods to align with students' characteristics and learning environments. The RME-based LKPD offers a practical and contextualized model for mathematics teaching materials, designed to engage students more actively in their learning process (Octaria et al., 2023). By fostering a learning environment that supports critical, analytical, and creative thinking skills, the RME approach facilitates a deeper and more meaningful engagement with mathematical concepts (Sutarni et al., 2024).

Given the findings, educators should consider integrating real-world contexts into their teaching materials to enhance student engagement and problem-solving abilities. Aligning with the RME philosophy, this approach helps students relate abstract mathematical concepts to practical applications in their daily lives. By incorporating activities that connect mathematical problems to real-life scenarios, educators can improve students' understanding and application of mathematical concepts.

Furthermore, the study highlights the need for scaffolded support and guidance from teachers. Since students did not fully utilize the RME-based materials independently, it is crucial for educators to provide structured assistance and feedback throughout the learning process (Erita et al., 2022). Implementing instructional strategies that offer gradual support, along with opportunities for collaborative learning, can help students develop their problem-solving skills more effectively (Rojas et al., 2021).

Ongoing professional development for educators is also essential to successfully implement the RME approach (Khairunnisak et al., 2024). Training programs should focus on the principles of RME, the design of contextualized teaching materials, and strategies for providing effective scaffolded support (Reinke & Casto, 2022). Therefore, enhancing teachers' understanding and skills related to RME will enable them to better support students and improve the overall quality of mathematics instruction.

Finally, the study reaffirms the value of the RME approach in enhancing mathematics education through contextualized learning and targeted materials. While the RME-based LKPD demonstrated effectiveness in improving problem-solving skills, the need for teacher support and professional development highlights areas for further improvement (Febriyani et al., 2024). By integrating these recommendations, educators can enhance mathematics instruction, support students in developing robust problem-solving abilities, and fully realize the potential of the RME approach.

CONCLUSION

This study successfully developed and evaluated a student worksheet (LKPD) based on the Realistic Mathematics Education (RME) approach, with a specific focus on number pattern material. The thorough evaluation by material and media experts confirmed the validity, practicality, and effectiveness of the LKPD. The trials and post-tests demonstrated significant improvements in

students' mathematical problem-solving skills, indicating that the RME-based LKPD is a valuable educational tool. These results underscore the potential of contextualized learning materials to enhance students' abilities in solving mathematical problems by making abstract concepts more relatable and accessible.

Despite the promising findings, the study is constrained by several limitations that warrant consideration. The research was conducted with a limited sample, focusing solely on one school and one educational level, which may affect the generalizability of the results. Additionally, the relatively short duration of the study might not fully capture the long-term impact of the LKPD on students' learning outcomes. These limitations suggest that while the initial results are encouraging, a broader and more extended research approach is needed to validate and extend these findings across different educational contexts and over time.

Future research should address these limitations by exploring the long-term effects of RME-based LKPDs on students' mathematical abilities. Expanding the sample to include multiple schools and educational levels would enhance the generalizability of the findings and provide a more comprehensive understanding of the LKPD's effectiveness. Comparative studies could offer insights into how the RME-based materials perform across various educational settings, potentially leading to refinements that improve their applicability and impact.

Moreover, future studies should focus on refining the development and implementation processes of RME-based LKPDs. Incorporating feedback from a diverse range of educators and students can enhance the design and functionality of the worksheets, ensuring they address varying learning needs and preferences. Additionally, exploring the integration of complementary pedagogical strategies could provide new avenues for improving mathematical problem-solving skills and overall student engagement with the subject.

In summary, while this study highlights the effectiveness of RME-based LKPDs in improving students' problem-solving skills, it also emphasizes the need for further research to address the identified limitations. By expanding the research scope and incorporating diverse educational contexts, future studies can build on these findings to create more robust and adaptable educational tools. This ongoing effort will contribute to advancing mathematics education and enhancing learning outcomes for a broader range of students, aligning with the goals of improving educational practices and fostering student success in mathematics.

ACKNOWLEDGEMENT

The authors are thankful to the Deanship of Graduate Studies and Scientific Research at University of Bisha for supporting this work through the Fast-Track Research Support Program.

REFERENCES

Anggraini, R. S., & Fauzan, A. (2020). The Effect of Realistic Mathematics Education Approach on Mathematical Problem-Solving Ability. *Edumatika: Jurnal Riset Pendidikan Matematika, 3*(2), 94-102. https://doi.org/10.32939/ejrpm.v3i2.595

Asnawi, M. H., Annisa, H., Ulum, M. M., Arofah, N. L., & Hendrawati, N. E. (2022). Ethnomathematics Exploration at Agung Jami' Malang Mosque in Improving Students' Mathematic Problem-Solving Ability. *IndoMath: Indonesia Mathematics Education,* 5(1), 13-21.

http://dx.doi.org/10.30738/indomath.v5i1.13
Branch, R. M. (2009). *Instructional design: The ADDIE approach*. Springer. https://doi.org/10.1007/978-0-387-09506-6
Dinglasan, J. K. L., Caraan, D. R. C., & Ching, D. A. (2023). Effectiveness of Realistic Mathematics Education Approach on Problem-Solving Skills of Students. *International Journal of Educational Management and Development Studies, 4*(2), 64–87. https://doi.org/10.53378/352980
Erita, S., Utami, E. S. D., & Ningsih, F. (2022). Realistic mathematic education-based student worksheet to improve students' mathematical reasoning on circle material. *Indonesian Journal of Science and Mathematics Education, 5*(2), 210-223. http://dx.doi.org/10.24042/ijsme.v5i2.11249
Febriyani, A., Habudin, & Rachmiati, W. (2024). Development of Realistic Mathematics Education-based learner worksheets (LKPD) to enhance higher-order thinking skills in grade IV students of SD/MI. *Journal of Research on Mathematics Instruction (JRMI)*, *5*(2), 54-63. https://doi.org/10.33578/jrmi.v5i2.95
Firdaus, A. M., Juniati, D., & Wijayanti, P. (2021). Investigating middle school students generalization of number pattern based on learning style. *Turkish Journal of Computer and Mathematics Education, 12*(6), 2624-2632. https://doi.org/10.17762/turcomat.v12i6.5709
Franestian, I. D., & Wiyono, A. (2020). Analysis problem solving skills of student in Junior High School. *Journal of Physics: Conference Series, 1440*(1), 012089. http://dx.doi.org/10.1088/1742-6596/1440/1/012089
Gómez-García, M., Hossein-Mohand, H., Trujillo-Torres, J. M., Hossein-Mohand, H., & Aznar-Díaz, I. (2020). Technological factors that influence the mathematics performance of secondary school students. *Mathematics, 8*(11), 1935. https://doi.org/10.3390/math8111935
Hadi, H., Juandi, D., & Rusdiana, D. (2023). Problem Solving Ability Analysis: Systematic Literature Review. *Journal of Mathematics and Mathematics Education, 13*(1), 33-43. https://doi.org/10.20961/jmme.v13i1.73819
Hafid, H., Syamsuddin, A., & Sulfasyah, S. (2022). The Effect of Realistic Mathematics Approach on Mathematical Problem-Solving Ability of Elementary School Students. *Pedagogik Journal of Islamic Elementary School, 5*(2), 145–156. https://doi.org/10.24256/pijies.v5i2.2973
Hasibuan, A. M., Saragih, S., & Amry, Z. (2019). Development of Learning Materials Based on Realistic Mathematics Education to Improve Problem Solving Ability and Student Learning Independence. *International Electronic Journal of Mathematics Education, 14*(1), 243-252. https://doi.org/10.29333/iejme/4000
Inci, A. M., Peker, B., & Kucukgencay, N. (2023). Realistic mathematics education. In O. Cardak & S. A. Kiray (Eds.), *Current Studies in Educational Disciplines 2023* (pp. 66-83). ISRES Publishing.
Ismail, R. N., Arnawa, I. M., & Yerizon, Y. (2020). Student worksheet usage effectiveness based on realistic mathematics educations toward mathematical communication ability of junior high school student. *Journal of Physics: Conference Series, 1554*(1), 012044. https://doi.org/10.1088/1742-6596/1554/1/012044
Ismunandar, D., Gunadi, F., Taufan, M., Mulyana, D., & Runisah. (2020). Creative thinking skill of students through realistic mathematics education approach. *Journal of Physics: Conference Series, 1657*(1), 012054. https://doi.org/10.1088/1742-6596/1657/1/012054
Khairunnisak, C., Johar, R., Maulina, S., Zubainur, C. M., & Maidiyah, E. (2024). Teachers' understanding of realistic mathematics education through a blended professional development workshop on designing learning trajectory. *International Journal of Mathematical Education in Science and Technology, 55*(4), 805-828. https://doi.org/10.1080/0020739X.2022.2038800
Khalid, M., Saad, S., Abdul Hamid, S. R., Ridhuan Abdullah, M., Ibrahim, H., & Shahrill, M. (2020). Enhancing creativity and problem-solving skills through creative problem solving in teaching mathematics. *Creativity Studies, 13*(2), 270–291. https://doi.org/10.3846/cs.2020.11027
Khasanah, M., Khalil, I. A., & Prahmana, R. C. I. (2023). An inquiry into ethnomathematics within the framework of the traditional game of Congklak. *Journal of Honai Math, 6*(2), 175-188. https://doi.org/10.30862/jhm.v6i2.553
Luzano, J. (2023). The Interplay of Conceptual Understanding and Problem-Solving Competence in Mathematics. *International Journal of Multidisciplinary Approach and Studies, 10*(2), 89-97. http://ijmas.com/upcomingissue/08.02.2023.pdf
Maisyarah, S., & Prahmana, R. C. I. (2020). Pembelajaran luas permukaan bangun ruang sisi datar menggunakan pendekatan pendidikan matematika realistik Indonesia. *Jurnal Elemen, 6*(1), 68-88. http://dx.doi.org/10.29408/jel.v6i1.1713

Malasari, P. N., & Awofala, A. O. (2022). Emotional Quotient and Students' Mathematical Problem-Solving Proficiency: A Meta-Analysis. *IndoMath: Indonesia Mathematics Education, 5*(2), 135-144. http://dx.doi.org/10.30738/indomath.v5i2.30

Marchy, F., Murni, A., Kartini, K., & Muhammad, I. (2022). The Effectiveness of Using Problem-Based Learning (PBL) in Mathematics Problem-Solving Ability for Junior High School Students. *AlphaMath: Journal of Mathematics Education, 8*(2), 185-198. https://doi.org/10.30595/alphamath.v8i2.15047

Maryati, & Prahmana, R. C. I. (2021). Learning trajectory of dilation and reflection in transformation geometry through the motifs of bamboo woven. *Jurnal Didaktik Matematika, 8*(2), 134-147. https://doi.org/10.24815/jdm.v8i2.21283

Montague, M., Warger, C., & Morgan, T. H. (2000). Solve it! Strategy instruction to improve mathematical problem solving. *Learning Disabilities Research & Practice, 15*(2), 110-116. https://doi.org/10.1207/SLDRP1502_7

Muncarno, & Astuti, N. (2018). Pengaruh Pendekatan RME terhadap Hasil Belajar Matematika. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 7*(1), 103-114. http://dx.doi.org/10.24127/ajpm.v7i1.1356

Ndiung, S., Jehadus, E., & Apsari, R. A. (2021). The effect of Treffinger creative learning model with the use RME principles on creative thinking skill and mathematics learning outcome. *International Journal of Instruction, 14*(2), 873-888. https://doi.org/10.29333/iji.2021.14249a

Negara, H. R. P., Ibrahim, M., Kurniawati, K. R. A., Firdaus, A., Maulidina, R., & Saifudin, M. (2021). The effect of the Realistic Mathematic Education (RME) learning model on students' mathematical problem solving abilities: A meta-analysis. *Justek: Jurnal Sains dan Teknologi, 4*(1), 40-51. https://doi.org/10.31764/justek.v4i1.4517

Nurnaningsih, L., Prahmana, R. C. I., & Yunianto, W. (2024). The integration of Ethno-RME in MatCityMap application to support students' learning of system of linear equations: A case of Mangkujo Math Trail. *Journal of Honai Math, 7*(1), 155-176. https://doi.org/10.30862/jhm.v7i1.599

Nurqamar, D., & Nur, I. R. D. (2022). Comparative Study of Indonesian Students' Mathematical Literacy Abilities with Other Countries in Terms of PISA Type HOTS. *Eduma: Mathematics Education Learning and Teaching, 11*(1), 45-56. https://doi.org/10.24235/eduma.v11i1.9924

Octaria, D., Zulkardi, & Putri, R. I. I. (2023). Systematic Literature Review: How students learn linear programming with realistic mathematics education?. *International Journal of Trends in Mathematics Education Research, 6*(1), 41-46. https://doi.org/10.33122/ijtmer.v6i1.174

OECD. (2023). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Paidi, P., Mercuriani, I. S., & Subali, B. (2020). Students' competence in cognitive process and knowledge in biology based on curriculum used in Indonesia. *International Journal of Instruction, 13*(3), 491-510. https://doi.org/10.29333/iji.2020.13334a

Pangestuti, S., Prahmana, R. C. I., & Fran, F. A. (2024). Unlocking mathematical marvels: Exploring number patterns in the Rangku Alu traditional game. *Jurnal Elemen, 10*(2), 441-458. https://doi.org/10.29408/jel.v10i2.25621

Phonapichat, P., Wongwanich, S., & Sujiva, S. (2014). An Analysis of Elementary School Students' Difficulties in Mathematical Problem Solving. *Procedia - Social and Behavioral Sciences, 116*, 3169–3174. https://doi.org/10.1016/j.sbspro.2014.01.728

Polya, G. (1985). *How to solve it: A new aspect mathematical method*. Princeton University Press. https://math.hawaii.edu/home/pdf/putnam/PolyaHowToSolveIt.pdf

Prahmana, R. C. I., Arnal-Palacián, M., Risdiyanti, I., & Ramadhani, R. (2023). Trivium curriculum in Ethno-RME approach: An impactful insight from ethnomathematics and realistic mathematics education. *Jurnal Elemen, 9*(1), 298-316. https://doi.org/10.29408/jel.v9i1.7262

Purwitaningrum, R., & Prahmana, R. C. I. (2021). Developing instructional materials on mathematics logical thinking through the Indonesian realistic mathematics education approach. *International Journal of Education and Learning, 3*(1), 13–19. https://doi.org/10.31763/ijele.v3i1.178

Radmehr, F. & Vos, P. (2020). Issues and challenges of 21st century assessment in mathematics education. In L. Leite, E. Oldham, A. S. Afonso, F. Viseu, L. Dourado, H. Martinho (Eds.), *Science and mathematics education for 21st century citizens: Challenges and ways forward* (pp. 437–462). Nova Science Publishers. https://www.researchgate.net/profile/Pauline-Vos-2/publication/359236552_Issues_and_Challenges_of_21st_Century_Assessment_in_Mathematics_Education/links/62309be70837bf2b9ed957d3/Issues-and-Challenges-of-21st-Century-Assessment-in-Mathematics-Education.pdf

Reinke, L. T., & Casto, A. R. (2022). Motivators or conceptual foundation? Investigating the development of teachers' conceptions of contextual problems. *Mathematics Education Research Journal, 34*(1), 113-137. https://doi.org/10.1007/s13394-020-00329-8

Risdiyanti, I., Zulkardi, Putri, R. I. I., Prahmana, R. C. I., & Nusantara, D. S. (2024). Ratio and proportion through realistic mathematics education and Pendidikan matematika realistik Indonesia approach: A systematic literature review. *Jurnal Elemen, 10*(1), 158-180. https://doi.org/10.29408/jel.v10i1.24445

Rojas, M., Nussbaum, M., Chiuminatto, P., Guerrero, O., Greiff, S., Krieger, F., & Van Der Westhuizen, L. (2021). Assessing collaborative problem-solving skills among elementary school students. *Computers & Education, 175*, 104313. https://doi.org/10.1016/j.compedu.2021.104313

Sembiring, R. K., Hadi, S., & Dolk, M. (2008). Reforming mathematics learning in Indonesian classrooms through RME. *ZDM, 40*, 927-939. https://doi.org/10.1007/s11858-008-0125-9

Sudrajat, Mahmudi, A., & Setyorini, A. I. (2022). Pengembangan LKPD berorientasi hots untuk memfasilitasi kemampuan pemecahan masalah non-rutin siswa. *AKSIOMA: Jurnal Program Pendidikan Matematika, 11*(4), 3432–3443. http://dx.doi.org/10.24127/ajpm.v11i4.6100

Sutarni, S., Sutama, S., Prayitno, H. J., Sutopo, A., & Laksmiwati, P. A. (2024). The development of realistic mathematics education-based student worksheets to enhance higher-order thinking skills and mathematical ability. *Infinity Journal, 13*(2), 285-300. https://doi.org/10.22460/infinity.v13i2.p285-300

Szabo, Z. K., Körtesi, P., Guncaga, J., Szabo, D., & Neag, R. (2020). Examples of problem-solving strategies in mathematics education supporting the sustainability of 21st-century skills. *Sustainability (Switzerland), 12*(23), 1–28. https://doi.org/10.3390/su122310113

Ukobizaba, F., Nizeyimana, G., & Mukuka, A. (2021). Assessment Strategies for Enhancing Students' Mathematical Problem-solving Skills: A Review of Literature. *Eurasia Journal of Mathematics, Science and Technology Education, 17*(3), 1–10. https://doi.org/10.29333/ejmste/9728

Van den Heuvel-Panhuizen, M., Drijvers, P. (2020). Realistic Mathematics Education. In: Lerman, S. (eds) *Encyclopedia of Mathematics Education* (pp. 713-717). Springer. https://doi.org/10.1007/978-3-030-15789-0_170

Yurkofsky, M. M., Peterson, A. J., Mehta, J. D., Horwitz-Willis, R., & Frumin, K. M. (2020). Research on continuous improvement: Exploring the complexities of managing educational change. *Review of Research in Education, 44*(1), 403-433. https://doi.org/10.3102/0091732X20907363

Zulkardi, Putri, R. I. I., Wijaya, A. (2020). Two Decades of Realistic Mathematics Education in Indonesia. In: van den Heuvel-Panhuizen, M. (eds) *International Reflections on the Netherlands Didactics of Mathematics* (pp. 325–340). ICME-13 Monographs. Springer. https://doi.org/10.1007/978-3-030-20223-1_18