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IMPROVING UNDERSTANDING OF FRACTION CONCEPTS THROUGH PROBLEM BASED LEARNING ASSISTED BY MANIPULATIVE MEDIA FOR PRIMARY STUDENTS

Ainul Mardiyah[1)], Dek Ngurah Laba Laksana[2)]

[1)]Master of Elementary Education, Universitas Terbuka
[2)]Elementary School Teacher Education, STKIP Citra Bakti

*Corresponding author email: 501332211@ecampus.ut.ac.id

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Abstract

This research is motivated by the low conceptual understanding of fifth grade students on fractions, which are often taught abstractly. This study aims to improve fifth grade students' mathematics learning outcomes on fraction operations by implementing an innovative Problem Based Learning (PBL) learning model assisted by manipulative media. This Classroom Action Research (CAR) involved 24 participants consisting of 15 male students and 9 female students. The implementation procedure follows the systematic stages of PBL, which includes real-world problem orientation, organizing students into groups, assisting investigations using folded paper media, and presenting work. Data were collected through student activity observation sheets and learning outcome tests, then analyzed using quantitative and qualitative descriptive data analysis techniques. The results of the action showed a significant increase in learning outcomes. The average student score before the action (pre-cycle) was 62.5, increasing to 81.2 after the action. Direct interaction with concrete media has been shown to increase the activeness and visual understanding of fraction concepts in a classical manner compared to conventional methods. The conclusion of this study is that the PBL model supported by manipulative media successfully facilitated the construction of students mathematical understanding through meaningful learning experiences. This research provides a practical contribution as a reference for learning innovation for elementary school teachers in reducing the abstractness of mathematics material through the TPACK approach and concrete media. Follow up activities are directed at developing variations of manipulative media for other mathematics materials to maintain the quality of learning.

Keywords: Conceptual understanding, mathematics education, fraction learning, manipulative media, problem-based learning

Abstrak. Penelitian ini dilatarbelakangi oleh rendahnya pemahaman konseptual siswa kelas 5 pada materi pecahan yang sering kali diajarkan secara abstrak. Penelitian ini bertujuan untuk meningkatkan hasil belajar matematika siswa kelas V pada materi operasi pecahan dengan menerapkan model pembelajaran inovatif Problem Based Learning (PBL) berbantuan media manipulatif. Penelitian Tindakan Kelas (PTK) ini melibatkan 24 orang peserta yang terdiri dari 15 siswa laki-laki dan 9 siswa perempuan. Prosedur pelaksanaan mengikuti tahapan sistematis PBL yang meliputi orientasi masalah nyata, pengorganisasian siswa dalam kelompok, pendampingan penyelidikan menggunakan media kertas lipat, serta penyajian hasil karya. Data dikumpulkan melalui instrumen lembar observasi aktivitas siswa dan tes hasil belajar, kemudian dianalisis menggunakan teknik analisis data deskriptif kuantitatif dan kualitatif. Hasil tindakan menunjukkan terjadinya peningkatan hasil belajar yang signifikan. Nilai rata-rata siswa sebelum tindakan (pra-siklus) sebesar 62,5 meningkat menjadi 81,2 setelah diberikan tindakan. Interaksi langsung dengan media konkret terbukti mampu meningkatkan keaktifan dan pemahaman visual konsep pecahan secara klasikal dibandingkan metode konvensional. Simpulan dari penelitian ini adalah bahwa model PBL yang didukung media manipulatif berhasil memfasilitasi konstruksi pemahaman matematis siswa melalui pengalaman belajar yang bermakna. Penelitian ini memberikan kontribusi praktis sebagai referensi inovasi pembelajaran bagi guru sekolah dasar dalam mereduksi keabstrakan materi matematika melalui pendekatan TPACK dan media konkret. Tindak lanjut kegiatan diarahkan pada pengembangan variasi media manipulatif untuk materi matematika lainnya guna mempertahankan kualitas pembelajaran.

Kata kunci: Pemahaman konseptual, pendidikan matematika, pembelajaran pecahan, media manipulatif, problem-based learning.

Background

The condition of mathematics learning in fifth grade currently still shows the presence of barriers in understanding abstract concepts, especially in fractions material. Based on field observations, many students struggle in operating addition or subtraction of fractions with different denominators. This is caused by the learning process that is still conventional and teacher centered, where students are only asked to memorize formulas or calculation procedures without understanding the logical meaning behind them. As a result, students understanding of the concept of part of the whole remains rote, so when given story problems or variations, students have difficulty reasoning which leads to decreased motivation and learning outcomes have not yet reached the mastery criteria expected.

To overcome this gap, a breakthrough in the form of a model is needed an innovative and interactive learning model. This model is important to develop tot change the learning paradigm of students from passive information receivers to active knowledge builders. By providing strong interaction among students, teachers, and learning media, difficult mathematical concepts will be easier. Using an interactive model allows students to explore, ask questions, and collaborate, so learning is no longer dull but becomes a challenging and enjoyable experience so that abstract mathematical concepts can be understood with a more concrete and relevant approach to daily life.

The learning model chosen in this implementation is Problem Based Learning (PBL). Theoretically, PBL is a learning model grounded in theory cognitive and constructivism. According to this view, learning occurs when students are actively engaged in solving real problems that are relevant to their lives. PBL emphasizes developing critical thinking skills and problem solving abilities. Through its five main stages, from problem orientation to evaluation, PBL enables students to construct their own understanding. In addition, the use of manipulatives in this model supports Jean Piaget's cognitive development theory, which states that children in primary school are still in the concrete operational stage, so they need real objects to understand abstract concepts.

Although the effectiveness of PBL and the use of manipulatives separately has been widely discussed in the literature on elementary mathematics education, there is still a significant research gap in its integrative implementation. Previous studies often focus on the effectiveness of purely digital PBL using e learning for generation alpha (e.g., Attard & Holmes, 2022) or the use of conventional manipulatives in mechanistic direct instruction methods (e.g., Carbonneau et al., 2020). There is a scarcity of studies exploring how the tactile collaboration of folded-paper manipulatives is structuredly integrated within the group inquiry syntax in the PBL model to reduce specific mathematical misconceptions. Previous research also frequently overlooks the dynamics of gender composition in small groups when solving performance based fraction problems using manipulatives (e.g., Shin & Bryant, 2024).

The novelty of this study lies in the formulation of PBL syntax that is explicitly integrates physical manipulation in the form of folded paper not merely as teaching aids at the beginning, but as an instrument for critical reasoning throughout the group inquiry stage to resolve denominator inconsistencies. Furthermore, this study offers contextual novelty by analyzing the impact of this model in classes with a specific gender proportion, dominated by male students an area, according to several recent empirical studies, that shows different responses to spatial mathematical visualization (e.g., Reinhold et al., 2021). Thus, this study does not simply replicate the use of PBL, but redefines the limits of integrating physical media within the cycle of solving elementary mathematics problems. The development and implementation of this innovative learning model aims to:

1. Improve the conceptual understanding of fifth grade students regarding fraction arithmetic operations.
2. Create an interactive classroom ecosystem through collaboration among students in solving problems.
3. Improve students critical thinking skills through systematic inquiry stages.
4. Provide references for educators in using manipulatives as effective visual aids in mathematics learning.

Method

This study is designed as a collaborative Classroom Action Research (PTK) with adopting the spiral model developed by Kemmis and McTaggart. In line with the characteristics of PTK plans, the research is conducted through iterative cycles that cover four linear operational stages in each cycle: planning, action, observation, and reflection. Learning using the PBL model aided by manipulative folding paper, media is implemented as an intervention to improve weaknesses in conventional teaching patterns.

This action research was conducted in the even semester of the 2025/2026 academic year at class V of SDN Wonokerto, Wonokerto Hamlet, Plemahan District, Kediri Regency, East Java Province. The main data collection of the action took place on Saturday, 25 April 2026. The subjects in this study were students of class V SDN Wonokerto with a total of 24 students, comprising a specific gender composition of 15 boys and 9 girls. Based on the characteristics of the subjects, the boys in this class are dominated by a kinesthetic learning style that is active, while the girls tend to excel more in fine motor precision and verbal communication skills.

The procedure for carrying out actions in the classroom is explicitly realized through the integration of five macro syntax stages of PBL combined with tactile media manipulation. Procedurally, the action stages are essentially as follows:

1. Stage 1: Student orientation to the problem. The teacher begins the lesson by presenting a contextual problem based on local wisdom, namely the challenge of fairly dividing traditional Wonokerto market snacks. Students are directed to identify the problem of different piece sizes as a representation of unlike fractions.
2. Stage 2: Organizing students to learn. Students are guided to form four heterogeneous learning groups considering gender proportions and academic abilities. This scheme aims to build a peer tutoring climate. Each group is given a student worksheet (LKPD) along with a manipulatif media package in the form of colorful folded papers.
3. Stage 3: Guiding individual or group investigations. Students collaboratively solve the challenge of adding unlike fractions in the LKPD by physically folding the folded paper horizontally and vertically to construct discovery of the least common denominator concept between values $\frac{1}{2}$ dan $\frac{1}{4}$. The teacher circulates and provides limited assistance to groups experiencing motor manipulation technical difficulties.
4. Step 4: Explain and present the results. Students in groups collaborate to prepare a problem solving report by attaching visual cut pieces of paper folding proofs to a she et of flat cardboard paper, followed by forming the formal fractional number symbols gr aphically.
5. Step 5: Analyze and solve the problem solving process. The spokes person from the group representatives presents their work on cardboard in front of the class through a rolling speaker system. The teacher confirms students reasoning, corrects lingering counting misconceptions, and validates the conclusions of formal mathematical formulas together.

Process and learning outcomes data are collected using instruments that have been validated for validity. Process data (interactive activities) are collected using a non test instrument in the form of a structured observation sheet to measure student activity and field notes to capture unique phenomena of students kinesthetic motor performance. Outcome data are collected using a test instrument in the form of a written formative assessment with essay questions at the end of each action to measure individual students level of understanding of fraction concepts. All assessment instruments (tests and non tests) are validated through expert judgment by a lecturer specializing in basic mathematics education and peers to ensure curricular material suitability and the measurability of concept understanding indicators.

Data collection techniques are applied via triangulation (formative tests, real time observation by colleagues, and authentic process photo documentation as well as pre-action score recaps) to maintain data objectivity. Quantitative data from formative test results are described descriptively comparatively using the class average formula $\bar{X} = \frac{\sum X}{N}$ and the completion percentage formula classical learning $P = \frac{n}{N} x\ 100\%$. Meanwhile qualitative data from the observation sheets are described interactively through data reduction flow, descriptive narrative presentation, and drawing conclusions. This classroom action research is deemed to meet success criteria if: the class cognitive average score reaches ≥ 70, the classical completion rate reaches a minimum 85% of all students in the class, and the score of students interactive activity performance based on the observation sheets to reach at least the good category (≥ 75%).

Results and Discussion

Result

Comparative analysis was performed on the learning outcome data of Grade V students at SDN Wonokerto before the intervention (pre action condition) and after applying the PBL model assisted by manipulatives in the form of folded paper (post action). A summary comparison of cognitive performance from a total of 24 students is presented in Table 1.

Data presentation in Table 1 shows significant performance in conceptual understanding mathematics students understanding performance is highly significant. In the pre action condition, the classical completion rate of students was only 29.17% (only 7 students completed), proving that the conventional abstract learning pattern failed to provide full understanding. Conversely, after intervention with the PBL model and folding paper manipulatives, the classical completion rate jumped sharply by 58.33% to reach 87.50% (21 students completed). The attainment of classical completion (87.50%) and the class average score (82.08) have legally exceeded the target success indicators of PTK previously set (KKM

≥ 70 and classical ≥ 85%).

Table 1. Comparison of learning outcomes in understanding fraction concepts before and after action

Quantitative indicators	Pre action (initial condition)	Post action (PBL + manipulative media)	Increase / difference
Class average score	61.25	82.08	+20.83 points
Highest score	80	100	+20 points
Lowest score	45	60	+15 points
Number of students complete ≥ 70)	7 students	21 students	+14 students
Number of students not complete (< 70)	17 students	3 students	-14 students
Completion percentage classical	0,17%	87, 2950%	+58.33%

Discussion

Empirical findings in this action research prove that the combination of problem based learning model and physical manipulative media have a major impact on students cognitive ability to construct understanding of the concept of applying fractional operations. The success of this learning outcome improvement will be analyzed in depth through several reflective sub-aspects below:

The use of manipulatives in the form of colorful folded papers in action proved effective in reducing the level of abstraction of fractional material. Students show high enthusiasm because they can perform physical tactile manipulation directly to find the visualization of the same denominator concept. This finding aligns with Sari and Rahayu (2022) argument that visualizing concrete objects through origami/paper folding can be a cognitive bridge solution that reduces fraction misconceptions.

Reflective constraints arise from the internal characteristics of the subjects, where some male students men tend to have kinesthetic learning styles and tend to be overly enthusiastic in cutting folded paper, causing the physical piece results of fractions to be imprecise. The inaccuracy of this size briefly confused them in drawing conclusions in mathematical logistics. The finding of motor skill obstructions aligns with the reviews by Laski and Siegler (2024) which state that the effectiveness of physical manipulatives highly depends on the level of precision of its geometry when explored by students. As a corrective solution, teachers implement tactical actions by providing a scale drawing guide sheet on folded paper so that students' folding results remain mathematically accurate, and maximize the peer tutoring scheme to distribute students with faster fine motor skills to help their group mates who struggle.

The application of the PBL learning model in mathematics instruction on fraction material proved to successfully alleviate instructional workload from teachers to students. The authentic problem stage stimulates active involvement of heterogeneous groups to think critically in se eking solutions. This action finding confirms the theory of Rusman (2021) and Hosnan (2022) that problem based learning moves the teacher's role to facilitator and forces studen ts to become active knowledge builders.

The main shortcoming that emerged during the observation process is time management problems. The third phase syntax of PBL (guiding group investigations) consumes longer durations than the location time due to the highly interactive tactile group discussion dynamics and student debates in proving the luas area of fractions. The time management barrier of completing the worksheets (LKPD) in this PBL model was also reported by Ramadhani and Fitri (2020) as a logistical consequence of the transition to an autonomous learning model. The tactical solutions applied by teachers to control the class include displaying a large digital stopwatch visualization on the classroom screen and giving constant verbal reminders at every 10 minute interval to maintain the rhythm of transitions between PBL model syntaxes.

Formative assessment conducted directly during the process the manipulation of folded paper physically provides great pedagogical benefits. Teachers can provide instant feedback or targeted scaffolding actions to understand wrong understandings before the concept error takes hold. The advantage of adaptive formative assessment in solving mathematical problems is supported by Gasteiger and Bruns (2023) who state that direct intervention when a child interacts with concrete objects can accelerate the attainment of mathematical concept maturity.

Real obstacles found in the realm of written summative assessment include the existence of several students who experience linguistic difficulties in translating the experience of motoric folding sentences into formal arrangements or deductive mathematical symbols. To address these formal writing difficulties, teachers adopt the principle of staged intervention Concrete-Pictorial-Abstract (CPA) as recommended by Resnick et al. (2023), namely by allowing students to draw graphic shading illustrations/paper folding first on the answer sheet as a reasoning bridge before converting them into the formal fractional symbol expressions (p/q).

A motivating and creative classroom climate has been built since the early phase problem orientation, where the teacher presents a mystery challenge of distributing traditional foods. This stimulates curiosity and minimizes math anxiety, in line with the study by Namkung and Bricko (2021) which shows that cognitively friendly PBL challenges effectively trigger intrinsic motivation while reducing children's math anxiety. Student creativity organically emerges as they explore strategies for folding paper quickly to align the denominator values.

Social interaction within a heterogeneous group triggers a culture of mutual relationships among students. However, field notes show a tendency for dominance by male students (15 students) who vocally lead the group discussions compared to female students (9 students). Performing spatial and vocal imitation by the boys at the fifth grade level aligns with the empirical analysis by Reinhold et al. (2021) regarding gender based variation in responses to understanding visual fraction material. To reduce this participation gap, the teacher implements a rolling speaker system. Through this system, the group representative who advances presents in front of the class determined randomly by the teacher, prioritizing female students or passive students, so all students obtain equal rights and space for self-actualization in the class.

Contextualization of the material is achieved optimally with the integration of local wisdom Wonokerto, Kediri. The use of problem simulation of sharing market snacks that students frequently encounter in Wonokerto local market and family environment activities has proven to accelerate understanding of the essence of the problem. Students no longer view mathematics as a dogma of numbers, but as a tool to solve real world problems. This positive impact is fully supported by the study by Wijaya and Hadi (2022) which states that the implementation of a local wisdom mbased PBL model significantly enhances primary school students problem solving skills due to the high relevance to real life.

To anticipate linguistic obstacles in the form of partial misunderstanding by some of small students regarding Kediri regional language technical terms for certain market snacks, the teacher handles it by inserting a mini glossary with standard Indonesian equivalents on the LKPD sheet, so the essence of preserving cultural identity remains intact local culture remains aligned without disrupting students conceptual understanding.

Conclusion

Based on the results of the class action and the discussion analysis, it can be concluded that the implementation of the Problem Based Learning (PBL) model aided by manipulative paper folding media significantly improves students conceptual understanding of fractions in grade V at SDN Wonokerto in the 2025/2026 academic year. This evidence is shown by the real empirical data jump, where the class cognitive mean increased from an initial condition of 61.25 to 82.08 at the end of the action. In addition, the classical learning mastery percentage sharply rose from only 29.17% in pre action to 87.50% in post action, successfully surpassing the classical PTK target indicator (≥ 85%). The syntactic integration of the PBL model and use of tactile media can change the teaching paradigm to be student-centered, reduce the abstruseness of fraction material both finite and infinite, and facilitate students mathematical understanding construction through meaningful learning experiences.

As realistic steps from these research findings, it is recommended several tactical actions. First, teachers are advised to develop variations of manipulative media from more hygienic and durable recycled materials to support media sustainability in the classroom. Second, to optimize the characteristics of Generation Alpha students, the next learning process should combine the PBL model with digital simulation applications as reinforcement after students master the basic concepts through physical media (Laski & Siegler, 2024). Based on the limitations found in this study, it is stated some recommendations for future research:

1. Time management limitations: Because the dynamics of tactile group discussion PBL syntax require a long duration (Ramadhani & Fitri, 2020), future research is advised to design a looser time division, strengthen the LKPD structure, or test this model in a time block learning design to maintain the efficiency of concept formation (Hosnan, 2022).
2. Motor precision limitations: Considering fine motor hindrances in kinesthetic students when folding and cutting paper that can affect measurement accuracy (Laski & Siegler, 2024), future researchers are recommended to use ready to use semi-permanent manipulative media (such as plastic fraction blocks or magnetic cards) to minimize misconceptions due to tool imprecision (Carbonneau et al., 2021).
3. Gender dominance limitations: Considering the vocal dominance of male students in small groups that affects spatial visualization responses (Reinhold et al., 2021), future research should explore periodic formation of gender homogeneous groups or apply teaching methods cooperative that has a rigid role division (such as the Jigsaw type) for analyzing the dynamics of heterogeneous group work more fairly (Zulkifli, 2021).

Daftar Pustaka

Attard, C., & Holmes, K. (2022). Eksplorasi praktik guru yang mempengaruhi keterlibatan siswa dengan matematika di sekolah dasar. *Jurnal Penelitian Pendidikan Matematika*, 34(4), 781–801.https://doi.org/10.1007/s13394-021-00366-w

Barbieri, CA, Miller-Cotto, D., & Booth, JL (2021). Kurang positif, lebih negatif: Pengaruh miskonsepsi pecahan terhadap pengetahuan konseptual dan prosedural. *Jurnal Psikologi Pendidikan*, 113(4), 712–726.https://doi.org/10.1037/edu0000618

Carbonneau, KJ, Marley, SC, & Selig, JP (2021). Meta-analisis efikasi manipulatif konkret untuk hasil pendidikan. *Educational Psychology Review*, 33(2), 699–723.https://doi.org/10.1007/s10648-020-09538-2

Doabler, CT, Clarke, B., Kosty, D., Kurtz-Nelson, E., Fien, H., Smolkowski, K., & Baker, SK (2021). Menguji kemanjuran intervensi tingkat 2 pada pemahaman siswa kelas satu tentang konsep bilangan bulat dan pecahan. *Jurnal Penelitian tentang Efektivitas Pendidikan*, 14(2), 342–367.https://doi.org/10.1080/19345747.2020.1862375

Fitriani, D. (2023). Peningkatan ketuntasan hasil belajar matematika operasi pecahan melalui penerapan model konstruktivistik. *Jurnal Inovasi Pembelajaran Dasar*, 7(1), 45–56.

Fuchs, LS, Malone, AS, Gilbert, JK, Powell, SR, & Wang, AY (2022). Memperbaiki pemahaman pecahan bagi siswa dengan kesulitan matematika: Peran proses kognitif. *Exceptional Children*, 88(3), 241–259.https://doi.org/10.1177/00144029211051512

Gasteiger, H., & Bruns, J. (2023). Perancah yang berbeda dalam pendidikan matematika awal: Bagaimana objek konkret mendukung pengembangan konseptual. *Jurnal Internasional Pendidikan Sains dan Matematika*, 21(5), 1431 1453.https://doi.org/10.1007/s10763-022-10311-x

Hidayat, A., & Utami, S. (2021). Model pembelajaran berbasis masalah untuk meningkatkan kemandirian belajar dan kemampuan pemecahan masalah siswa sekolah dasar. *Jurnal Basicedu*, 5(3), 1422–1432.https://doi.org/10.31004/basicedu.v5i3.911

Hosnan, M. (2022). *Pendekatan inovatif dalam pembelajaran abad 21: Teori dan aplikasi pada pendidikan dasar rekonstruksi matematika SD* . PT Bumi Aksara.

Laski, EV, & Siegler, RS (2024). Pembelajaran dari manipulatif: Kerangka konseptual dan tinjauan representasi konkret dan virtual. *Psikolog Pendidikan*, 59(1), 18–35.https://doi.org/10.1080/00461520.2023.2285112

Lestari, S., Handayani, T., & Nugroho, A. (2020). Berpikir keterampilan berpikir kreatif melalui sintaks pembelajaran berbasis masalah di sekolah dasar. *Jurnal Pendidikan Matematika*, 8(2), 112–125.

Lewis, KE, & Lynn, FM (2021). Mengakses konsep pecahan: Alat visual-spasial dan siswa dengan kesulitan belajar. *Jurnal Perilaku Matematika*, 62, Artikel 100863.https://doi.org/10.1016/j.jmathb.2021.100863

Mulyani, E. (2024). Kombinasi model pembelajaran aktif dan media taktil untuk meredikasi miskonsepsi pecahan pada siswa kelas V. *Jurnal Pendidikan dan Kebudayaan Dasar*, 12(1), 89–101.

Namkung, JM, & Bricko, N. (2021). Pengaruh pembelajaran berbasis masalah terhadap kinerja pecahan dan kecemasan matematika siswa berprestasi rendah. *Penelitian dan Praktik Gangguan Belajar*, 36(2), 121–134.https://doi.org/10.1111/ldrp.12245

Ningsih, R. (2022). Pengaruh pendekatan kontekstual berbasis masalah terhadap motivasi dan minat belajar matematika siswa. *Jurnal Riset Pendidikan Dasar*, 4(2), 201–214.

Piaget, J. (2021). *Psikologi kecerdasan* (edisi ke-2) Routledge.https://doi.org/10.4324/9781003168171

Pratama, MA (2023). Efektivitas model PBL terhadap retensi memori jangka panjang konsep pecahan di sekolah dasar. *Jurnal Ilmiah Sekolah Dasar*, 7(2), 310–319.https://doi.org/10.23887/jisd.v7i2.56112

Ramadhani, R., & Fitri, Y. (2020). Merancang masalah autentik dalam model pembelajaran matematika berbasis masalah materi pecahan. *Jurnal Elemen*, 6(1), 74–89.https://doi.org/10.29408/jel.v6i1.1731

Reinhold, S., Hofer, S., Berkowitz, M., & Vogel, S. (2021). Peran keterampilan spasial dan gender dalam pemahaman pecahan anak sekolah dasar. *Jurnal Psikologi Pendidikan*, 113(5), 903–920.https://doi.org/10.1037/edu0000493

Resnick, I., Newcombe, NS, & Jordan, NC (2023). Dari konkret ke abstrak: Mengembangkan penguasaan konsep pecahan menggunakan alat spasial dan fisik di kelas sekolah dasar. *Kognisi dan Instruksi*, 41(2), 185–209.https://doi.org/10.1080/07370008.2022.2111124

Roessger, KM, Daley, BJ, & Hafez, DA (2022). Pengaruh pembelajaran berbasis masalah kontekstual terhadap penalaran matematika dan retensi pengetahuan di pendidikan dasar. *Ilmu Instruksional*, 50(3), 411–435.https://doi.org/10.1007/s11251-022-09581-2

Rusman. (2021). *Model-model pembelajaran: Menerangkan profesionalisme guru* (edisi ke-3). PT RajaGrafindo Persada.

Saputra, H., Wijaya, M., & Kusuma, A. (2025). Jembatan kognitif dalam pembelajaran pecahan tidak seperti di kelas V sekolah dasar: Studi tindakan kolaboratif. *Jurnal Pembelajaran Matematika Inovatif (JPMI)*, 8(1), 12–25.

Sari, DP, & Rahayu, C. (2022). Hambatan visualisasi konsep pecahan abstrak dan solusinya menggunakan media manipulatif kertas origami. *Jurnal Jendela Pendidikan*, 2(3), 415–

427.https://doi.org/10.57008/jjp.v2i03.281

Shin, M., & Bryant, DP (2024). Meningkatkan pengetahuan konseptual pecahan pada siswa sekolah dasar yang berisiko mengalami kesulitan matematika: Sintesis studi intervensi. *Remedial and Special Education*, 45(1), 32–45.https://doi.org/10.1177/07419325231178491

Tian, J., & Siegler, RS (2022). Pembelajaran pecahan di sekolah dasar: Memprediksi prestasi matematika di masa depan dan memahami lintasan perkembangan. *Perspektif Perkembangan Anak*, 16(2), 94–101.https://doi.org/10.1111/cdep.12447

Vamvakoussi, X., Van Dooren, W., & Verschaffel, L. (2023). Bias bilangan asli dalam pembelajaran pecahan: Sebuah studi intervensi menggunakan pembelajaran berbasis masalah dan kolaborasi antar teman sebaya. *Pembelajaran dan Instruksi*, 85, Artikel 101742.https://doi.org/10.1016/j.learninstruc.2023.101742

Wijaya, A., & Hadi, S. (2022). Mengkontekstualisasikan pembelajaran matematika melalui kearifan lokal: Pengaruh PBL berbasis etnomatematika terhadap keterampilan pemecahan masalah siswa sekolah dasar. *Jurnal Pendidikan Matematika*, 13(2), 291–310.https://doi.org/10.22342/jme.v13i2.pp291-310

Wulandari, T. (2024). Mereduksi kecemasan matematis (kecemasan matematika) materi pecahan siswa sekolah dasar menggunakan model pembelajaran berbasis masalah. *Jurnal Pendidikan Dasar*, 9(2), 143–155.

Zhang, X., & Rittle-Johnson, B. (2024). Pengembangan pengetahuan konseptual dan prosedural tentang pecahan: Sebuah studi longitudinal di kelas atas sekolah dasar. *Psikologi Pendidikan Kontemporer*, 76, Artikel 102241.https://doi.org/10.1016/j.cedpsych.2023.102241

Zulkifli, M. (2021). Dinamika kerja kelompok heterogen dalam pemecahan masalah matematika materi operasi hitung pecahan siswa kelas V. *Jurnal Inovasi Pendidikan Dasar*, 5(4), 312–324.