

The effect of the problem-based learning model with cooperative setting of numbered heads together on students' numeracy skills

Anisa Nurbaiti^{1*}, Deni Pratama²

¹Department of Mathematics Education, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

²Junior High School An-Nuriyyah Bumiayu, Brebes, Indonesia

*Correspondence: anisanurbaiti.2021@student.uny.ac.id

Abstract: Previous studies have examined PBL and cooperative learning separately, but evidence on their integration through the NHT setting to enhance students' numeracy skills remains limited. Therefore, this study aims to: (1) test the effect of the PBL model with the cooperative setting of NHT on junior high school students' numeracy skills; (2) test the effect of the expository learning model on statistics material regarding students' numeracy skills; and (3) compare the effectiveness of the PBL model with NHT and the expository model on students' numeracy skills. This quasi-experimental study used a pretest-posttest control group design conducted at a junior high school in Yogyakarta, with data collected through numeracy tests and observations and analyzed using Paired and Independent Sample T-Tests. The findings indicate that: (1) the PBL model with the cooperative setting of NHT positively affects students' numeracy skills; (2) the expository learning model on statistics material also enhances numeracy skills; and (3) the PBL model with NHT has a greater impact than the expository model on students' numeracy skills in statistics. These findings support the use of integrated PBL and cooperative learning strategies to enhance students' numeracy skills.

Keywords:

Expository, Numbered Heads Together, Numeracy, Problem-Based Learning

How to Cite: Nurbaiti, A., & Pratama, D. (2024). The effect of the problem-based learning model with cooperative setting of numbered heads together on students' numeracy skills. *Instructional Media for Mathematics*, 2(2), 1-13. <http://org/10.66161/687841>

1. Introduction

Education is a very important aspect of life, indicating that every individual has the right to receive education and is expected to develop through it. Education is a process that never ends, generally defined as the process through which individuals live and continue their lives. Education prepares humans to become useful individuals for the nation and the state (Nugroho et al., 2024).

Mathematics learning in junior high school can be a fundamental part, especially since the material studied serves as a foundation for the future. At the junior high school level, students begin to learn to think logically and critically to solve various mathematical learning problems related to everyday life. This critical thinking helps students sharpen their cognitive abilities, encouraging them to solve individual issues (Dhayanti et al., 2018; Fisher & Scriven, 2001; Lestari et al., 2023).

According to the decision letter from the Head of the Education Standards, Curriculum, and Assessment Agency of the Ministry of Education, Culture, Research, and Technology Number 033/H/KR/2022, the objectives of the mathematics subject include six important aspects: 1) mathematical understanding and procedural skills, 2) reasoning and mathematical proof, 3) mathematical problem-solving, 4) mathematical communication and representation, 5) mathematical connections, and 6) mathematical disposition. In this context, the government strives to prepare students to face the challenges of the 21st century by emphasizing the development of various skills encapsulated in four competencies known as the 4Cs: critical thinking and problem solving (students can think critically and solve problems), creativity (students possess creativity), communication skills (students have communication abilities), and the ability to work collaboratively (students can work together) (Díez-Palomar et al., 2023; Milaturrahmah et al., 2017).

Numeracy skills are a fundamental foundation for critical thinking and problem solving, as they involve data analysis, interpretation of numbers, symbols, and logic-based decision-making (Astuti et al., 2024; Kusaeri et al., 2022). Numeracy skills are one of the essential competencies for students, as they are closely related to problem-solving in everyday life, where students are required to solve problems involving numbers and data. Thus, numeracy skills will help students develop the 4C competencies. Students are also expected to be not only proficient in mathematics but also able to adapt to future challenges (Goos et al., 2019; Lee & Johnston, 2024).

The Ministry of Education and Culture, through the Directorate of Junior High Schools, considers that students at the junior high school level still lack literacy and numeracy skills. According to the PISA results in 2022 (OECD, 2023), the average scores in mathematics, reading, and science have declined compared to 2018. This can be evidenced by Indonesia's average scores in PISA, which is conducted every three years.

Table 1. PISA Achievement in Indonesia's Numeracy Skills from 2009-2022

Year	Average Numeracy Skill Score	Rank
2009	371	61
2012	375	64
2015	386	63
2018	379	73
2022	366	70

Table 1 shows that the PISA scores have declined since 2015. These results indicate that students in Indonesia have experienced a decrease in numeracy skills, placing Indonesia at a low position in terms of numeracy proficiency. According to the Education Assessment Center of the Standards, Curriculum, and Assessment Agency of the Ministry of Education, Culture, Research, and Technology, there are three key components in numeracy skills: content, cognitive level, and context (Pusmendik, 2022).

One component that can influence learning objectives is the learning model, which, if not used appropriately, can hinder the achievement of learning goals. Learning models can assist teachers in initiating the learning process in the classroom. In some schools, learning is

still teacher-centered, and the learning approach remains expository, with teachers dominating classroom activities (Ayuwanti et al., 2021). This is in line with the research conducted by (Risdiyanti & Prahmana, 2021; Wijaya & Doorman, 2021), which found that teacher-centered learning results in students providing poor responses when receiving lessons. This response is evident from students' attitudes during the learning process. Solely teacher-centered mathematics learning causes students to sit in their seats during lessons (Ishartono et al., 2022, 2024). Such learning leads to students becoming lazy and less enthusiastic when receiving instruction. The expository model optimizes the direct delivery of material by the teacher to the students. Its aim is for students to gain a good understanding through systematic explanations. The success of education greatly depends on its implementation, particularly the role of the teacher as a guide and facilitator for students in the classroom

One learning model that can develop numeracy skills is Problem-Based Learning (PBL) (Nasoha et al., 2022). The research also shows that the PBL model can help students improve skills that fall within the components of numeracy (Nurlaily et al., 2019; Phungsuk et al., 2017; Ulya et al., 2024). The PBL model encourages students to be more active in learning, as they are invited to solve real or context-based problems. The Problem-Based Learning (PBL) model is a teaching approach that positions students as active problem solvers. In the PBL model, students are challenged to face real or simulated problems and then seek solutions by gathering information, analyzing data, and collaborating with peers

Problem-Based Learning combined with the Numbered Heads Together strategy has been conducted in previous research, making it a reference for considering the current study. One such study by Kusumaningtias et al. (2013) found that there is an influence of Problem-Based Learning (PBL) combined with the Numbered Heads Together (NHT) strategy on metacognitive, cognitive, and critical thinking skills. Critical thinking skills can support numeracy skills. Another study conducted by Minda et al. (2021) showed that the achievement of mathematical problem-solving skills and student interest in learning for those receiving PBL with NHT was better compared to those receiving expository learning. Problem-solving skills are closely related to numeracy skills as they provide the foundation for logical and analytical thinking skills needed to solve various problems in everyday life. Based on several studies conducted on the application of the problem-based learning model combined with Numbered Heads Together, it can be an effective approach to enhance students' numeracy skills in mathematics.

Based on the description above, the researcher needs to conduct a study titled "The Effect of the Problem-Based Learning Model with the Cooperative Setting of Numbered Heads Together in Mathematics Learning on the Numeracy Skills of Junior High School Students".

2. Methods

2.1 Research Approach

This study uses a quasi-experimental research type with a pretest-posttest control group design. The research is conducted by providing treatment in the form of learning to the experimental class and the control class. At the beginning of the learning process, both classes will be given a pretest to determine the students' initial abilities. Subsequently, the experimental class will receive instruction using Problem-Based Learning with the cooperative setting of Numbered Heads Together, while the control class will receive instruction through expository learning. At the end of the learning process, both classes will be given a posttest to assess the effectiveness of the treatment provided.

2.2 Population and Sample

The population in this study consists of all eighth-grade students at SMP N 5 Depok in the even semester of the 2024/2025 academic year. The sample in this study consists of two classes. Class VIII B serves as the experimental class that receives instruction using the Problem-Based Learning model, while Class VIII D serves as the control class that receives instruction through the expository learning model. This study is conducted in both the experimental and control classes that had the same initial abilities.

2.3 Research Instrument

Numeracy ability tests are conducted to collect data on students' numeracy skills in the experimental and control classes. The numeracy ability tests are administered twice, namely as a pretest and a posttest. The pretest is conducted to determine the initial condition of students' numeracy skills before the learning process in both the experimental and control classes, while the posttest is conducted to assess the final condition of students' numeracy skills after the learning process. This test is designed to assess numeracy skills. The indicators of numeracy ability are shown in Table 2.

Table 2. Indicator of Numeracy Ability

No	Indicator
1	Using various forms of symbols and numbers to solve problems in different life contexts.
2	Conducting analysis of the information presented in the form of tables, graphs, or diagrams.
3	Verifying statements with appropriate steps and conclusions

The numeracy ability pretest and posttest instruments were trialed in the experimental class to determine their reliability. Based on the categorization using Guildford's criteria (Novikasari, 2017), the reliability of the pretest-posttest instrument was 0.767, which falls within the reliable category. This means that the test instrument is reliable.

The observation sheet for the implementation of learning is used to assess the execution of the learning procedures in the experimental and control classes. The observation sheet consists of two types: one for the implementation of learning in the experimental class,

which includes the steps of Problem-Based Learning with the cooperative Numbered Heads Together, setting and another for the implementation of expository learning in the control class, which includes the steps of expository learning. The observation sheet is filled out by the observer with the alternative answer "Yes" if the observed aspect is implemented and "No" if the observed aspect is not implemented.

2.4 Data Analysis

Descriptive analysis is used to represent data from the pretest and posttest on students' numeracy skills in both the experimental and control classes. The results obtained will be described using statistical measures, namely the lowest and highest scores, the average, and the standard deviation. The criterion used in this study is that the average posttest score of students who received problem-based learning in a cooperative numbered heads together setting is higher than that of students who received expository learning. Inferential analysis is also used to analyze data regarding students' numeracy skills. The data analysis methods used to test the research hypotheses are the Paired-Sample T-Test and the Independent-Sample T-Test.

3. Results and Discussion

3.1 Learning Implementation

The learning implementation in this study was directly observed. During the research process, the observer monitored the implementation of the learning by completing an observation sheet. The purpose of using this observation sheet was to observe various aspects of the ongoing learning activities. The observation sheets used in the experimental and control classes were different. The observation sheet for the experimental class included the steps of the problem-based learning process with a cooperative learning setting of the numbered heads together type, while the observation sheet for the control class contained the steps of the expository learning process. The results of the learning implementation in both the experimental and control classes are presented in Table 3.

Table 3. Learning Implementation Results

Learning Session	Percentage of Learning Implementation	
	Experimental Class	Control Class
1	100%	90.9%
2	100%	100%
3	100%	100%
Average	100%	96.9%

Based on Table 3, the average percentage of learning implementation in the experimental class was 100%, while in the control class it reached 96.9%. This indicates that the learning process in the experimental class, which followed the steps of problem-based learning with a cooperative learning setting of the numbered heads together type, as well as

in the control class, which followed the steps of expository learning, was carried out very well.

3.2 Student's Numeracy Ability

Based on the pretest and posttest data, it can be observed that there was a development in students' numeracy skills, which indicates the influence of the learning methods used and helps in determining the appropriate learning model needed by the students. The pretest and posttest data in this study are presented in the Table 4.

Table 4. Data on Pretest and Posttest Results of Students' Numeracy Ability

Description	Experimental Class		Control Class	
	Pretest	Posttest	Pretest	Posttest
Number of Students	32	32	32	32
Maximum Score	62.50	100.00	62.50	100.00
Minimum Score	25.00	66.67	12.50	54.17
Variance	81.13	78.96	142.73	101.63
Standard Deviation	9.00	8.88	11.94	10.08
Average	46.61	8.55	44.53	74.08

Based on the data in Table 4, it is shown that there was an improvement in numeracy skills after the treatment was given. The experimental class, which received instruction using the Problem-Based Learning model with a cooperative setting of the Numbered Heads Together type, achieved an average posttest score of 82.55. In comparison, the control class, which received expository instruction, had an average posttest score of 74.08. From the average pretest and posttest results of both classes, it was found that the test score for measuring students' numeracy skills increased by 35.94 in the experimental class and by 29.55 in the control class. Therefore, the experimental class demonstrated a greater improvement in numeracy skills compared to the control class.

This research was conducted using a Pretest-Posttest Control Group Design with the following objectives: (1) to examine the effect of the Problem Based Learning model with a Cooperative setting of the Numbered Head Together type on the numeracy skills of junior high school students; (2) to investigate the effect of the expository learning model on statistical material on the numeracy skills of junior high school students; (3) to compare the effectiveness of the Problem Based Learning model with a Cooperative setting of the Numbered Head Together type and the expository learning model on statistical material in terms of the numeracy skills of junior high school students.

3.3 Effect of the PBL with a Cooperative Setting of the NHT on the Numeracy Skills

The results of the Paired Sample T-Test indicate that H_0 is rejected, which means that the average posttest score for numeracy skills is higher than the average pretest score. Based on these results, the criterion for influencing numeracy skills is met. Thus, there is an effect of the Problem-Based Learning model with a Cooperative setting of the Numbered Heads Together type on the numeracy skills of junior high school students. The conclusion of this study is in line with the research conducted by Wahyuni & Septiati (2024), which concluded

that there is an effect of the Problem-Based Learning model on the numeracy literacy skills of junior high school students through story problems.

The effect of the Problem-Based Learning model with a Cooperative setting of the Numbered Heads Together type on students' numeracy skills is also supported by the increase in scores from pretest to posttest. Based on Table 14, it is known that the average score of the experimental class increased from 46.61 to 82.55, resulting in an average increase of 35.94 points in the pretest scores. These results are consistent with the research conducted by Masliah et al. (2023), which concluded that the Problem-Based Learning model is effective in improving the literacy and numeracy skills of students in elementary school.

These results are also supported by the research of Noorhidayati et al. (2018), which shows that the combination of the PBL and NHT learning models can develop students' performance skills. The Cooperative learning model of the Numbered Head Together (NHT) type creates a conducive environment for developing performance skills as students engage in the Problem-Based Learning (PBL) process. Additionally, students taught through the application of the combination of PBL and NHT models, assigned to heterogeneous study groups, can establish interpersonal interactions with peers who have different knowledge and backgrounds. Students are challenged to select the best materials and solutions for real-life problem-solving cooperatively within the PBL and NHT learning environment, and to draw ideas on worksheets. In this way, students discover new ways to represent and generalize their experiences.

The Problem-Based Learning model with a Cooperative setting of the Numbered Heads Together type encourages students to be more active, engaged, and invested in their own learning process. This aligns with the opinion of Maulana et al. (2020); Ramadhani et al. (2020); Zetriuslita & Ariawan (2021), which states that the application of the PBL model combined with the NHT strategy can enhance motivation or drive for individuals to achieve their goals, where a person will succeed in learning if they have a desire to learn, marked by the growth of enthusiasm for learning, feeling happy, and being eager to learn. This also enhances the spirit of cooperation among students within their groups. When faced with a real problem, students are invited to think, discuss, and seek solutions together with their group members. This process enables them not only to memorize theories but also to truly understand what they are learning and how it can be applied in everyday life.

Unisty et al. (2021) also argue that problem-based learning (PBL) combined with numbered heads together (NHT) can enhance students' interest in learning. NHT is well-suited to be paired with PBL because it encourages students to be able to solve the problems being studied and to always be ready to present their thoughts in front of the class. In its implementation, the Cooperative learning model of the Numbered Heads Together (NHT) type emphasizes the strength of collaborative thinking in problem-solving.

3.4 The Effect of the Expository Learning Model on the Numeracy Skills

The results of the Paired Sample T-Test indicate that H_0 is rejected, which means that the average post-test score in numeracy skills is higher than the average pre-test score. Based on

these results, the criteria for influencing numeracy skills are met. Thus, it can be concluded that the expository learning model influences the numeracy skills of junior high school students.

The influence of the expository learning model on students' numeracy skills is also reinforced by the increase in scores from the pretest to the posttest. Based on Table 14, it is known that the average score of the control class increased from 44.53 to 74.08, with an average increase of 29.55 from the pretest to the posttest. The effect of the expository learning model on the numeracy skills of 8th grade junior high school students cannot be separated from the teacher's role during the question-and-answer sessions. These results are in line with the study by Nugroho et al. (2024), which stated that the expository strategy is highly effective for teaching concepts and skills to children. The expository learning model is a model that focuses on delivering lesson content directly to students, allowing them to master it so that learning objectives can be achieved optimally. It is considered the most effective and efficient method for instilling meaningful learning.

The expository learning model is an instructional approach that emphasizes the verbal delivery of material by a teacher to a group of students, with the aim of enabling students to master the subject matter optimally (Bramantha, 2021). This type of instruction is suitable for students who are still passive learners, as they only need to listen to and pay attention to the teacher's explanation. However, this model is entirely teacher-centered, which results in students being less active during the learning process.

3.5 Comparison of the Effects of the PBL with a Cooperative Setting of the NHT and the Expository Learning Model on the Numeracy Skills.

The results of the posttest data analysis on students' numeracy skills in the statistics material for both the experimental and control classes using the Independent Sample T-Test showed a significance value of $0.001 < 0.005$ and a calculated t-value greater than the critical t-value, namely $3.563 > 1.69552$. These results indicate that H_0 is rejected, which means that the average posttest score in numeracy skills on the statistics material of students taught using the Problem-Based Learning model with a cooperative setting of the Numbered Heads Together type is higher than that of students taught using the expository learning model. This also means that the Problem-Based Learning model with the cooperative Numbered Heads Together setting has a greater effect compared to the expository learning model on students' numeracy skills in the statistics material. This conclusion is in line with the findings of which state that students who receive the Problem-Based Learning model integrated with Numbered Heads Together perform better than those who are taught using conventional learning models.

The superiority of the Problem-Based Learning model with a cooperative Numbered Heads Together setting compared to the expository learning model is also supported by the average posttest scores of both classes. The average posttest score in the experimental class, which applied the Problem-Based Learning model with the cooperative Numbered Heads Together setting, was 82.55. Meanwhile, the average posttest score in the control class, which

applied the expository learning model, was 74.08. The average posttest score of the experimental class was higher than that of the control class by 8.41 points. Based on the average pretest and posttest scores of both classes, the increase in test scores measuring students' numeracy skills in the experimental class was 35.94, while in the control class it was 29.55. Therefore, the experimental class demonstrated a greater improvement in numeracy skills compared to the control class. These results are also in line with the study by Rahmawati & Gusmania (2017) which reported that posttest scores increased from 70 to 80 using the cooperative learning model of the Numbered Heads Together type.

The difference in posttest scores of numeracy skills is attributed to the different characteristics of the learning models applied. The experimental class used the Problem-Based Learning model with a cooperative Numbered Heads Together setting, in which the learning process is student-centered and provides a more meaningful learning experience. The PBL and NHT models can be integrated and complement each other. They are compatible because both involve student activities in group discussions. The advantage of PBL lies in the use of contextual problems to be solved, which trains students to construct their own understanding. Meanwhile, the strength of NHT is that students do not know in advance who will present, as the numbers are chosen randomly, requiring every student to be prepared (Navela et al., 2023; Setyaningsih & Utami, 2021).

On the other hand, the control class used the expository learning model, which is teacher-centered, where students mainly listen to the teacher's explanations, and some students do not pay attention. This is consistent with the study by Fajriah & Asiskawati (2016), which found that teacher-centered learning results in less positive student responses during lessons. These responses were observed through students' attitudes during the learning process. Solely teacher-centered mathematics learning causes students to remain seated throughout the lesson, leading to a lack of motivation and enthusiasm. This contributes to the difference in the impact on students' numeracy skills in the statistics material between the experimental and control classes, as seen in the posttest results. Therefore, it can be concluded that the Problem-Based Learning model with the cooperative Numbered Heads Together setting has a greater influence than the expository learning model on numeracy skills in statistics material.

4. Conclusion

Based on the research findings and discussion, the following conclusions were drawn: (1) The Problem-Based Learning model with a cooperative Numbered Heads Together setting in statistics material has an effect on junior high school students' numeracy skills; (2) The expository learning model in statistics material also has an effect on junior high school students' numeracy skills; (3) The Problem-Based Learning model with a cooperative Numbered Heads Together setting is more effective than the expository learning model in improving students' numeracy skills in statistics material.

The Problem-Based Learning model with a cooperative Numbered Heads Together setting can be used as an alternative to enhance students' numeracy skills. This study may

serve as a reference or consideration for future research. It is recommended that future studies conduct similar research by applying the Problem-Based Learning model with a cooperative Numbered Heads Together setting to different topics, grade levels, and school levels to strengthen the empirical evidence and support the theoretical validity related to learning and numeracy skills.

Acknowledgments

The authors would like to thank Universitas Negeri Yogyakarta 2024 for its support of this study.

Declarations

- Author Contribution : AN: Conceptualization, Investigation, Data Curation, Writing - Original Draft; DP: Writing - Review & Editing
- Funding Statement : The authors received no financial support for the research, authorship, and/or publication of this article
- Conflict of Interest : The authors declare no conflict of interest
- Additional Information : -

References

- Astuti, E. P., Wijaya, A., & Hanum, F. (2024). Characteristics of junior high school teachers' beliefs in developing students' numeracy skills through ethnomathematics-based numeracy learning. *Journal of Pedagogical Research*, 8(1), 244–268. <https://doi.org/10.33902/JPR.202423405>
- Ayuwanti, I., Marsigit, & Siswoyo, D. (2021). Teacher-student interaction in mathematics learning. *International Journal of Evaluation and Research in Education*, 10(2), 660–667. <https://doi.org/10.11591/ijere.v10i2.21184>
- Bramantha, H. (2021). Perbedaan Kemampuan Berpikir Kritis Siswa Menggunakan Model Pembelajaran Ekspositori Dengan Model Pembelajaran Inquiry Berbantuan Media Video. *Education Journal: Journal Educational Research and Development*, 5(2), 195–202. <https://doi.org/10.31537/ej.v5i2.515>
- Dhayanti, D., Johar, R., & Zubainur, C. M. (2018). Improving Students' Critical and Creative Thinking through Realistic Mathematics Education using Geometer's Sketchpad. *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, 3(1), 25–35. <https://doi.org/10.23917/jramathedu.v3i1.5618>
- Díez-Palomar, J., Ramis-Salas, M., Močnik, I., Simonič, M., & Hoogland, K. (2023). Challenges for numeracy awareness in the 21st century: making visible the invisible. *Frontiers in Education*, 8(November), 1–14. <https://doi.org/10.3389/feduc.2023.1295781>

- Fajriah, N., & Asiskawati, E. (2016). Kemampuan Berpikir Kreatif Siswa dalam Pembelajaran Matematika Menggunakan Pendekatan Pendidikan Matematika Realistik di SMP. *EDU-MAT Jurnal Pendidikan Matematika*, 3(22), 1–23.
- Fisher, A., & Scriven, M. (2001). *Critical thinking*. Cambridge University.
- Goos et al. (2019). *Numeracy Across the Curriculum: Research-Based Strategies for Enhancing Teaching and Learning*. Routledge.
- Ishartono, N., Nurcahyo, A., Waluyo, M., Prayitno, H. J., & Hanifah, M. (2022). Integrating GeoGebra into the flipped learning approach to improve students' self-regulated learning during the covid-19 pandemic. *Journal on Mathematics Education*, 13(1), 69–86. <https://doi.org/10.22342/jme.v13i1.pp69-86>
- Ishartono, N., Razak, R. binti A., Kholid, M. N., Arlinwibowo, J., & Afiyah, A. N. (2024). Integrating Steam into Flip Flop Model to Improve Students' Understanding on Composition of Functions During Online Learning. *Infinity Journal*, 13(1), 45–60. <https://doi.org/10.22460/infinity.v13i1.p45-60>
- Kusaeri, K., Dwisanti, C., Yanti, A., & Ridho, A. (2022). Indonesian Madrasah Competency Assessment: Students' numeracy based on age. *Beta: Jurnal Tadris Matematika*, 15(2), 148–156. <https://doi.org/10.20414/betajtm.v15i2.558>
- Kusumaningtias, A., Zubaidah, S., & Indriwati, S. E. (2013). Pengaruh Problem Based Learning dipadu Strategi Numbered Heads Together terhadap Kemampuan Metakognitif, Berpikir Kritis, dan Kognitif Biologi Siswa Kelas XI SMA Negeri 5 Malang. (TESIS). *Jurnal Penelitian Kependidikan*, 3(January), 33–47.
- Lee & Johnston. (2024). The mediating effect of growth mindset on differentiated counseling services and numeracy achievement. *Educational Researcher*, 53(2), 97–109. <https://doi.org/https://doi.org/10.3102/0013189X231234567>
- Lestari, R., Prahmana, R. C. I., Chong, M. S. F., & Shahrill, M. (2023). Developing Realistic Mathematics Education-Based Worksheets for Improving Students' Critical Thinking Skills. *Infinity Journal*, 12(1), 69–84. <https://doi.org/10.22460/infinity.v12i1.p69-84>
- Masliah, L., Nirmala, S. D., & Sugilar, S. (2023). Keefektifan Model Pembelajaran Problem Based Learning (PBL) terhadap Kemampuan Literasi dan Numerasi Peserta Didik di Sekolah Dasar. *Jurnal Basicedu*, 7(1), 1–10. <https://doi.org/10.31004/basicedu.v7i1.4106>
- Maulana, G., Zaenuri, & Junaedi, I. (2020). Pattern of Problem Solving Skill Reviewed Based on Student Cognitive Style After Experienced Problem Based Learning Model with Ethnomathematics Nuances. *Journal of Primary Education*, 9(2), 209–2019. <https://journal.unnes.ac.id/sju/jpe/article/view/37507>

- Milaturrahmah, N., Mardiyana, & Pramudya, I. (2017). Science, technology, engineering, mathematics (STEM) as mathematics learning approach in 21st century. *AIP Conference Proceedings*, 1868. <https://doi.org/10.1063/1.4995151>
- Minda, R., Anwar Hadi FS, C., & Jaenudin, J. (2021). Penerapan Model PBL Menggunakan NHT untuk Meningkatkan Kemampuan Pemecahan Masalah dan Minat Belajar Siswa. *Jurnal Pendidikan Matematika Dan Sains*, 9(1), 19–26. <https://doi.org/10.21831/jpms.v9i1.26783>
- Nasoha, S. R., Araiku, J., Pratiwi, W. D., & Yusup, M. (2022). Kemampuan Numerasi Siswa Melalui Implementasi Bahan Ajar Matematika Berbasis Problem Based Learning. *Indiktika : Jurnal Inovasi Pendidikan Matematika*, 4(2), 49–61. <https://doi.org/10.31851/indiktika.v4i2.7903>
- Navela, R. A., Kristanto, Y. D., & Partini. (2023). Upaya Meningkatkan Pemahaman Konsep Dan Self Regulated Learning Peserta Didik Melalui Pbl Dipadukan Dengan Nht. *Jurnal Pendidikan Matematika Mat-Edukasia*, 8(1), 9–18.
- Noorhidayati, Nisa, K., & Hardiansyah. (2018). Penerapan Kombinasi Model Pembelajaran PBL dan NHT untuk Meningkatkan Aktivitas dan Hasil Belajar Siswa pada Konsep Fungsi. *QUANTUM: Jurnal Inovasi Pendidikan Sains*, IX(2), 144–149.
- Novikasari, I. (2017). Uji Validitas Instrumen. *Seminar Nasional Riset Inovatif 2017*, 1(1), 530–535.
- Nugroho, H., Ishartono, N., Agustiani, R., & Fitriani, N. (2024). Integrating Adobe Flash Professional CS6 into ethnomathematics-based learning media to improve students' understanding of math. *The 7th Progressive and Fun Education International Conference*, 1–20. <https://doi.org/10.1063/5.0183038>
- Nurlaily, V. A., Soegiyanto, H., & Usodo, B. (2019). Elementary school teacher's obstacles in the implementation of problem-based learning model in mathematics learning. *Journal on Mathematics Education*, 10(2), 229–238. <https://doi.org/10.22342/jme.10.2.5386.229-238>
- OECD. (2023). *PISA 2022 Results (Volume I and II) - Country Notes: Indonesia*.
- Phungsuk, R., Viriyavejakul, C., & Ratanaolarn, T. (2017). Development of a problem-based learning model via a virtual learning environment. *Kasetsart Journal of Social Sciences*, 38(3), 297–306. <https://doi.org/10.1016/j.kjss.2017.01.001>
- Pusmendik. (2022). *Framework Asesmen Kompetensi Minimum (AKM)*. Badan Penelitian dan Pengembangan dan Perbukuan.
- Rahmawati, E., & Gusmania, Y. (2017). Pengaruh Model Pembelajaran Kooperatif Tipe Numbered Head Together (Nht) Terhadap Pemahaman Konsep Matematis Siswa Kelas

- Viii Smp Negeri 53 Batam. *PYTHAGORAS: Jurnal Program Studi Pendidikan Matematika*, 6(2), 151–160. <https://doi.org/10.33373/pythagoras.v6i2.942>
- Ramadhani, R., Farid, F., Lestari, F., & Machmud, A. (2020). Improvement of Creative Thinking Ability through Problem-Based Learning with Local Culture Based on Students' Gender and Prior Mathematics Ability. *Al-Jabar : Jurnal Pendidikan Matematika*, 11(1), 61–72. <https://doi.org/10.24042/ajpm.v11i1.4961>
- Risdiyanti, I., & Prahmana, R. C. I. (2021). Designing Learning Trajectory of Set Through the Indonesian Shadow Puppets and Mahabharata Stories. *Infinity Journal*, 10(2), 331–348. <https://doi.org/10.22460/infinity.v10i2.p331-348>
- Setyaningsih, N., & Utami, D. P. (2021). The implementation of the discovery model based on numbered head together reviewed from students' cognitive style in mathematics learning. *Journal of Physics: Conference Series*, 1722(1). <https://doi.org/10.1088/1742-6596/1722/1/012109>
- Ulya, H., Sugiman, Rosnawati, R., & Retnawati, H. (2024). Technology-based learning interventions on mathematical problem-solving: a meta-analysis of research in Indonesia. *International Journal of Evaluation and Research in Education*, 13(1), 292–301. <https://doi.org/10.11591/ijere.v13i1.26380>
- Wahyuni, D., & Septiati, E. (2024). Pengaruh Model PBL (Problem Based Learning) Terhadap Kemampuan Literasi Numerasi Peserta Didik SMP Melalui Soal Cerita. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, 8(2), 1579–1589. <https://doi.org/10.31004/cendekia.v8i2.2721>
- Wijaya, A., & Doorman, M. (2021). A Learning Trajectory for Probability: A Case of Game-Based Learning. *Journal on Mathematics Education*, 12(1), 1–16. <https://doi.org/10.22342/jme.12.1.12836.1-16>
- Zetriuslita, & Ariawan, R. (2021). Students' Mathematical Thinking Skill Viewed From Curiosity Through Problem-Based Learning Model on Integral Calculus. *Infinity Journal*, 10(1), 31–40. <https://doi.org/10.22460/infinity.v10i1.p31-40>