ICMSE (2023): 67-73
International Conference on Mathematics, Science, and Education
QRCBN 62-6861-0508-697
https://proceeding.unnes.ac.id/icmse

Improving Mathematical Representation Ability With Problem Based Learning Models: A Systematic Literature Review

Marthinus Yohanes Ruamba[1,a)] Yohanes Leonardus Sukestiyarno[2,b)], Rochmad[3,c)]
Tri Sri Noor Asih[4,d)], Arief Agoestanto[5,e)]

Author Affiliations
[1,2,3,4,5]*Semarang State University, Sekaran Campus, Gunungpati Semarang, Central Java, Indonesia, 50229*

Author Emails
[a)]Corresponding author: *marthinusruamba94@students.unnes.ac.id*
[b)] *sukestiyarno@mail.unnes.ac.id*
[c)] *rochmad@mail.unnes.ac.id*
[d)] *Inung.mat@mail.unnes.ac.id*
[e)]*arief.mat@mail.unnes.ac.id*

Abstract. One of the important problems in learning mathematics is representation ability. Mathematical representation includes three basic abilities, namely visual representation, verbal representation and representation of mathematical equations or expressions. The Problem Based Learning (PBL) approach is effective in facilitating a deeper understanding of concepts and the development of mathematical problem solving skills. The research method uses a literature review method based on the PRISMA diagram with the following process sequence: Background and Purpose, Research Question, Searching for the literature, Selection Criteria, Practical ScreenQuality Checklist and Procedures, Data Extraction Strategy, and Data Synthesis Strategy. The results of journal research in the last 6 years, namely 2017 - 2023, resulted in 8 articles relating to efforts to improve mathematical representation skills using a problem based learning (PBL) approach. In-depth review related to this research article, it can be concluded that the problem based learning approach is the right approach to teach mathematical representation at various levels of education, this can be seen from the fulfillment of each indicator of mathematical representation, individual learning outcomes are more than KKM and gain value (n -gain) is in the medium category and has experienced a significant increase.

Keywords. Mathematical representation; problem based learning; systematic literature review

INTRODUCTION

One significant aspect in the context of mathematics learning is representational abilities, as revealed by research conducted by[1]. The importance of mathematical representation abilities can be seen from the standards of representation abilities that have been set by[2]. Indicators of mathematical representation include visual representation, representation of equations or expressions and verbal representation[3]. Visual representation is an individual's ability to transform mathematical problems into diagrams, symbols, tables, graphs and other visual forms. Verbal representation is an individual's ability to convert mathematical problems into words. Equation representation is an individual's ability to convert mathematical problems into the form of equations or mathematical expressions.

Problem low Mathematical representation ability is a significant issue in mathematics education. Students' low ability to describe, model and communicate mathematical problems correctly can hinder the learning process and understanding of mathematical concepts. This can result in difficulty in solving problems, communicating mathematical ideas, and applying concepts in real situations. Some factors that may contribute to low mathematical representation abilities include inadequate teaching methods, inadequate curriculum, and students' lack of confidence in speaking or writing about mathematics.

The Problem Based Learning (PBL) approach in mathematics learning has been proven to be effective in facilitating a deeper understanding of concepts and development of students' problem solving skills"[4]. PBL helps

students better internalize mathematical concepts, promotes critical thinking, and strengthens problem-solving abilities[5]. PBL can produce a deeper understanding of mathematical concepts and facilitate real-world oriented problem solving[6]. PBL not only improves mathematical understanding, but also develops students' critical thinking skills and communication abilities[7].

The importance of the problem based learning (PBL) approach in teaching mathematical representations is due to[2]PBL is one approach that can help students develop these abilities by giving them opportunities to think critically, model problems, and communicate their understanding visually, symbolically, and verbally. This research was carried out to review an article in a certain field, which is very important in order to develop research in related fields in the future[8]. This research focuses on efforts to find research articles related to mathematical representation and problem based learning (PBL) approaches in mathematics education in the period 2017 to 2023. In studyThis is done by analyzing the distribution of research results in various regions, analyzing topics or research focus points on mathematical representations.

The question of this research is how many published research results relate to mathematical representation with PBL in 2017 – 2023?; What variables are the main focus of research on improving mathematical representation abilities using the PBL model from 2017 – 2023? The purpose of preparing this article is to provide an overview of mathematical representations discussed in mathematics education research related to problem based learning models.

METHOD

This research is a Systematic Literature Review using the Preferred Reporting Items for Systematic Reviews and Meta-analyses or PRISMA method. The procedure for this systematic review consists of several steps, namely 1) preparing Background and Purpose, 2) Research Questions, 3) Searching for the literature 4) Selection Criteria 5) Practical Screen 6) Quality Checklist and Procedures 6) Data Extraction Strategy, 7) Data Synthesis Strategy. Article searches were carried out using Harzing's Publish or Perish by limiting the search scope to several existing searches such as Crossref, Google Scholar, and Scopus.As for The data in this research was searched using words or combinations of words that are relevant to this research, namely mathematical representation ability, problem based learning, and . Publication times were taken from journals published in the last twenty years, namely 2017 - 2023. Screening was carried out to select articles, namely articles published in the last 6 years (2017 - 2023), English and Indonesian language journals, articles published in reputable national and international journals. . Inclusion criteria are articles related to mathematical representation skills and problem based learning. The articles found are then selected based on abstract information taking into account the inclusion criteria which will be used as literature in the literature review. The essence taken from this research is the research title, name of the researcher, year of publication, research location, research methods, and significant research results. The data analysis carried out was by conducting an in-depth study to obtain more in-depth information so as to obtain the right information to answer the objectives of this research.

RESULTS AND DISCUSSION

Results The process of searching for journals in national and international journal databases with reference to the inclusion criteria is as follows describe the findings of relevant research articles and refer to review articles using the PRISMA method.

Search articles with the help of Harzing's Publish or Perish software, 18 articles were found with existing search Google Scholar, 1909 articles with existing search crossref, and 1 article with existing search Scopus which corresponded to the words and combinations of keywords that had been determined, then the articles were shared to Obtain articles that truly comply with the predetermined inclusion criteria. The following is a systematic review procedure as in Figure 1 below.

QRCBN 62-6861-0508-697
https://proceeding.unnes.ac.id/icmse

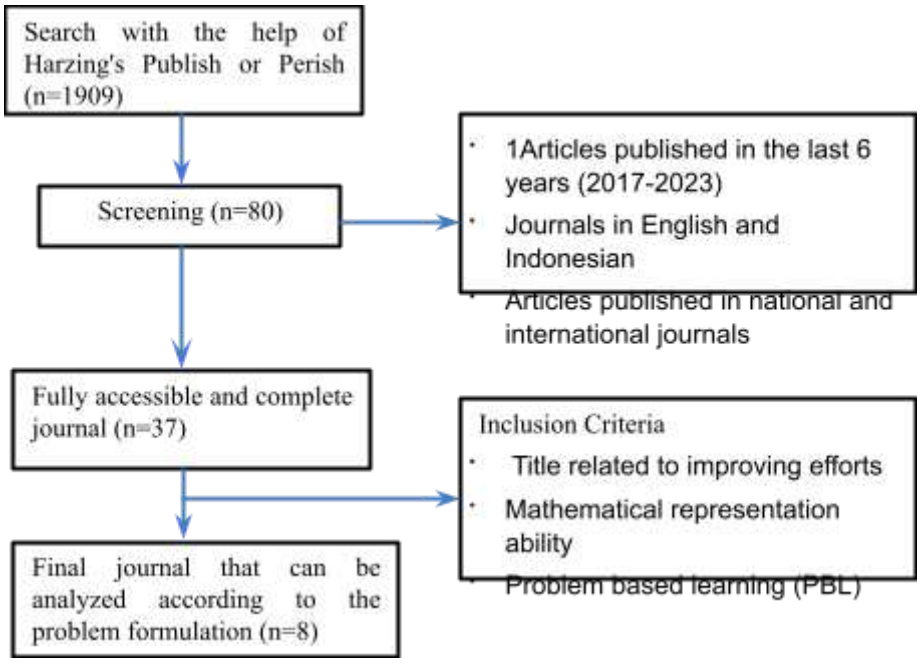

Figure 1. PRISMA diagram: Stages of systematic review

Based on stages as in Figure 1, 8 journals were produced that correspond to the research title which is considered to represent the title of the literature used by the author. The search results for these articles are then presented in Table 1 below.

Table 1. Article Tracking Results

Name of Journal	Tracking Results
Journal of Mathematical Didactics	1
Pasundan Journal of Mathematics Education	1
Suska Journal of Mathematics Education	1
Al Qalasadi Mathematics Education Scientific Journal	1
Square: Journal of Mathematics and Mathematics Education	1
Intermathzo (Journal of Mathematics Education and Learning)	1
Journal of School Mathematics Learning Research	1
Integral (Mathematics Education Research Journal)	1
Number of articles	8

Based on the results of analysis of research articles that focus on improving representation abilities with us eproblem based learning model approach, in general the number of studies always appears every year. This can be seen in Table 2. From 2017 to 2023 there are always articles on this topic published.

Table 2. Distribution of the number of dt research publications from 2017 – 2023

Year	Tracking Results
2017	1
2018	1
2019	5
2021	0
2023	1
Number of articles	8

In Figure 1, research on mathematical representation abilities with the PBL model in 2017 - 2023, there are 8articlepublished by several national and international journals. The article is spread across several journals in English and Indonesian. Apart from that, it was found that an average of 1 to 2 articles per year were published from 2017 to 2023. Based on the grouping results in table 1 and table 2 above, these articles are presented in the table below, grouped based on the author's name, article title, research level, research methods and main findings from the research, as in table 3 below.

Table 3. Study of 9 articles from reviews of national and international journals

Author, Year	Title	Level	Method	Key Findings
Pratiwi, et al (2023)	*Vocational School Students' Mathematical Representation Ability with Problem Based Learning Model*	Vocational High School (SMK)	Quantitative with a pretest-posttest design	Learning outcomes have increased and are above the KKM (KKM 75), the proportion of complete learning is above 75%, the average learning outcomes with PBL are better than those in the control class, and students' mathematical representation abilities using the PBL model are at a moderate gain score.
Herdiana. Y, et al (2019)	*Mathematical Representation Ability and Self Confidence of Middle School Students Through the Application of the Problem Based Learning (PBL) Model*	Junior high school	Qualitative	Learning with the PBL model can help foster the development of mathematical representation abilities. Even though students have not been able to fulfill all the indicators measured, the majority of students have been able to fulfill all the indicators of mathematical representation, namely (1) presenting data or information from a problem in the representation of pictures, diagrams, graphs or tables, (2) solving problems involving expressions. mathematical. Only one indicator of mathematical representation ability is not met, namely writing down the steps to solve mathematical problems.
Jenita, G. et al. (2019)	*Efforts to Improve Mathematical Representation Skills Through the Application of the Problem Based Learning (PBL) Model for Class X MIA 1 Students at SMAN 4 Bekasi*	Senior High School	Classroom action research	The research results show that learning mathematics using the PBL model can improve students' mathematical representation abilities. This is shown by an increase in the average of mathematical representation ability tests and an increase in the percentage of students who reach the minimum completeness criteria (KKM) in each cycle.
Astria, Kiki (2018)	*Increasing Problem Solving and Mathematical Representation Skills Using Problem Based Learning*	Vocational School	Mixed methods	Learning using Problem Based Learning can improve students' mathematical representation abilities in mathematics learning; Increasing students' mathematical representation abilities using Problem Based Learning is better than the control class (not PBL). Learning using Problem Based Learning can foster students' attitudes.
Chakim, Lukman (2019).	*Effectiveness of the Problem Based Learning (PBL) Model with Think-Talk-Write (TTW) Strategy to Improve Mathematical Representation Ability*	Junior high school	Experimental method	The mathematical representation ability of students taught using the problem based learning model with the think-talk-write (TTW) strategy is higher than the average mathematical representation ability of students taught using the conventional learning model.
Fitri, Nurul. et al, (2017)	*Improving Mathematical Representation Skills through the Application of the Problem Based Learning Model*	Senior High School	Quantitative research	Improve the mathematical representation of students who applied learning model of problem based learning is better than an increase in the ability of the mathematical representation of students who received conventional learning, and there is no interaction between the learning model and grouping of students to increase the ability of mathematical representation.
Susani, M. et al (2019)	*Improving Mathematical Representation Ability Through Problem-Based Learning Models in Middle School/MTs Students*	*Junior high school*	Experimental method	The results of the research show that (1) the application of the PBL model can improve mathematical representation abilities with an average N-Gain value of 0.43 which is classified as "medium", and based on the paired sample t test it is obtained that tcount > ttable or 21.11 > 1.71 so that the mathematical representation ability increased significantly (2) Based on the independent t-test, obtained tcount > ttable or 7.00 > 1.675The mathematical representation of students taught by the PBL model is better than the mathematical representation abilities of students taught using conventional learning.

QRCBN 62-6861-0508-697
https://proceeding.unnes.ac.id/icmse

Kamilah, SR et al (2019)	*Application of the Problem Based Learning (PBL) Learning Model with the Assistance of Geogebra to Improve Vocational School Students' Mathematical Representation Ability*	*Senior High School*	Quasi experiment	From the research results, it was found that 1) there was an increase in the mathematical representation abilities of students who used Problem Based Learning with the help of Geogebra in their learning; and 2) increasing the mathematical representation abilities of students who receive Problem Based Learning with the help of Geogebra better than conventional learning.

Based ontable 3 above, the focus of research from researchers who study efforts to improve mathematical representation abilities using the Problem Based Learning (PBL) model is presented in figure 2 below.

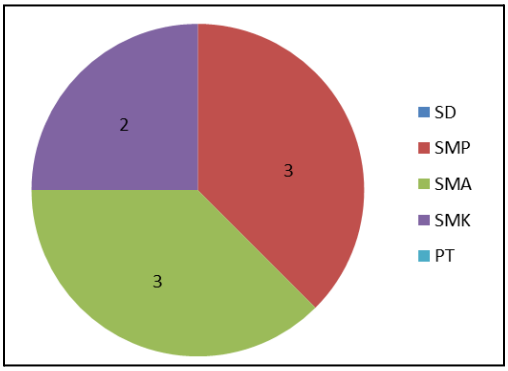

Figure 2. Distribution of Research Focus Locations

Figure 2. Shows that the distribution of focus of research locations on improving mathematical representation skills with the PBL model at the junior high school level is 3 studies, at the high school level is 3 studies, and at the vocational school level is 2 studies, while at the elementary and tertiary levels there is no related research. Furthermore, the research method most often used to examine improving mathematical representation abilities using the Problem Based Learning (PBL) model is presented in Figure 3 below.

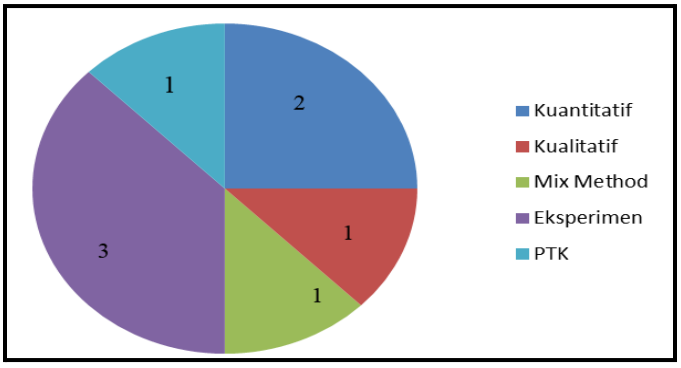

Figure 3. Research methods used

Figure 3. Shows that the research method used to examine efforts to improve mathematical representation abilities using the Problem Based Learning (PBL) model is a qualitative methodas much1 research, 2 quantitative methods, 1 mixed method, 3 experimental methods and 3 experimental methods.

The research results as shown in table 3 show that the results of several studies carried out as an effort to improve mathematical representation abilities using the problem based learning (PBL) learning model show that this model is very appropriate to use for teaching representation. Research result[9];[10];[11];[12]revealed that by using PBL in teaching mathematical representations, learning outcomes were above 75% of the KKM in each learning cycle. Besides that[9];[13]By using PBL, mathematical representation abilities continue to increase significantly, as indicated by the gain (n-gain) value being at a moderate score, namely 0.43. Meanwhile, the PBL model is used with the help of Geogebra[14]and think-talk-write (TTW) strategy[15]succeeded in increasing mathematical representation abilities compared to other learning models. More carry on [16]in his research stated that using the PBL model can foster mathematical representation abilities and individuals can fulfill all indicators of mathematical representation abilities, namely presenting problems in visual form (pictures, graphs, tables), presenting problems in the form of mathematical expressions or equations and verbal representation.

Learning with Problem Based Learning (PBL) is the right model to use teach mathematical representation abilities because the PBL model can improve mathematical concept abilities and mathematical representation abilities. This is because the PBL model is associated with increasing problem solving abilities, mathematical modeling, and a deeper understanding of concepts in a mathematical context[4]. Besides that[17]revealed that the PBL model can help students develop better mathematical representations by providing tasks that require real problem solving and mathematical modeling. This shows that PBL can stimulate the development of deeper conceptual understanding and mathematical representation.

CONCLUSION

Based on research results after analyzing research articles regarding improving mathematical representation abilities through the Problem Based Learning (PBL) approach from 2017 to 2023, there has been an increase every year. This can be seen from the 8 articles spread across national and international journals that focus on junior high school, high school and vocational school levels. The research methods that are widely used are experimental and quantitative methods. Apart from that, research results show that PBL is effective in improving mathematical representation abilities, with learning outcomes exceeding 75% of the KKM and significant gain (n-gain) values. Combines the use of tools such as Geogebra and strategies think-talk-write strategy (TTW) in the PBL approach can improve mathematical representation abilities. Therefore PBL is an appropriate approach to teach mathematical representations with positive results in various studies.

.

ACKNOWLEDGMENTS

Thanks are expressed to the Faculty of Mathematics and Natural Sciences, Semarang State University, for being a forum for researchers to conduct this research.

REFERENCES

1. Idharwati, T., Rasiman & Utami, RE Analysis of the mathematical representation abilities of class VIII junior high school students in terms of field independent cognitive style.*Senatetic*40 (2019).
2. NTCM. Principles and Standards for School Mathematics.*Reston, VA NCTM.*(2000).
3. Barti, N., Conference, DU-I. & 2020, U. An Analysis of Mathematical Representation Skills in Solving Problems of Systems of Linear Equations in Two Variables.*proceedings.upi.edu*(2020).
4. Hmelo-Silver, CE Problem-Based Learning: What and How Do Students Learn?*Educ. Psychol. Rev.*16, 235–266 (2004).
5. Hwang, GJ, Hung, CM & Chen, NS Improving learning achievements, motivations and problem-solving skills through a peer assessment-based game development approach.*Educ. Technol. Res. Dev.*62, 129–145 (2014).
6. Walker, A. & Leary, H. A Problem Based Learning Meta Analysis: Differences Across Problem Types, Implementation Types, Disciplines, and Assessment Levels.*Interdiscip. J. Probl. Learn.*3, 3–24 (2009).
7. Barrows, HS Problem-based learning in medicine and beyond: A brief overview.*New Dir. Teach. Learn.*1996, 3–12 (1996).

8. Chang, Y., Schlenstedt, G., Flockerzi, V. & Beck, A. Properties of the intracellular transient receptor potential (TRP) channel in yeast, Yvc1.*FEBS Lett.*584, 2028–2032 (2010).
9. Pratiwi, NM, Indiati, I., Ariyanto, L. & Indriati, ND Vocational School Students' Mathematical Representation Ability using the Problem Based Learning Model.*Integr. J. Researcher. Educator. Matt.*5, 99–109 (2023).
10. Jenita, G., Sudaryati, S. & Ambarwati, L. Efforts to Improve Mathematical Representation Skills Through the Application of the Problem Based Learning (PBL) Model for Class X MIA 1 Students at SMAN 4 Bekasi.*J. Ris. Learning Mat. School.*1, 11–18 (2017).
11. Fitri, N., Munzir, S. & Duskri, M. Improving Mathematical Representation Skills through the Application of Problem Based Learning Models.*J. Didact. Matt.*4, 59–67 (2017).
12. Astria, K. Increasing Problem Solving Abilities and Mathematical Representations UsingProblem Based Learning. Fit. J. Math. Educ. J. Educator. Matt. 8, (2018).
13. Susanti, S., Duskri, M. & Rahmi, M. Improving Mathematical Representation Ability through the Problem-Based Learning Model in Middle School/MTs Students.*Suska J. Math. Educ.*5, 77 (2019).
14. Kamilah, SR, Budiwisata, P. & Gunawan, I. Application of problem-based learning (PBL) learning model with the help of GeoGebra to improve mathematical representation skills of vocational students.*J. Educator. and Mat Learning.*4, 70–77 (2019).
15. Chakim, L. Effectiveness of the Problem Based Learning (PBL) Model with Think-Talk-Write (TTW) Strategy to Improve Mathematical Representation Ability.*sq. J. Math. Math. Educ.*1, 91 (2019).
16. Herdiana, Y., Marwan, M. & Morina Zubainur, C. Mathematical Representation Ability and Self Confidence of Middle School Students Through the Application of the Problem Based Learning (Pbl) Model.*Al-Qalasadi J. Ilm. Educator. Matt.*3, 23–35 (2019).
17. Lesh, R. & Harel, G. Problem Solving, Modeling, and Local Conceptual Development.*Math. Think. Learn.*5, 157–189 (2003).