

Continuous Education : Journal of Science and Research
Volume 7 Issue 3 November 2026
Journal Homepage:
https://pusdikra-publishing.com/index.php/josr

Systematic Literature Review: Mathematical Representation Ability of Junior High School Students Based on Learning Materials

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ARTICLE INFO
Article history:
Received
25 September 2026
Revised
10 October 2026
Accepted
01 November 2026

ABSTRACT

Mathematical representation ability is an important component of mathematics learning because students need to express, interpret, and connect mathematical ideas in different forms when understanding concepts and solving problems. At the junior high school level, representation is commonly examined through visual, symbolic, and verbal forms. Previous studies have examined this ability from different perspectives, including learning models, learning styles, and types of representation. However, the distribution of studies according to the mathematics learning materials investigated has not been clearly mapped. This study aims to systematically review research on the mathematical representation ability of junior high school students based on the mathematics learning materials studied. The study used a Systematic Literature Review approach by searching Google Scholar Indonesian keyword "kemampuan representasi matematis siswa SMP" and limiting the publication period to 2016–2026. Relevant articles were identified, selected, recorded in Microsoft Excel, grouped according to learning material, and analyzed descriptively to determine the distribution of research. The review identified 36 articles covering 18 mathematics learning materials. SPLDV was the most frequently studied material with six articles, followed by statistics with four articles, while relations and functions and circles each had three articles. Several materials were represented by only one article. These findings indicate that research on mathematical representation ability at the junior high school level has covered diverse materials, but the distribution remains uneven. The mapping provides a basis for identifying materials that have received relatively limited research attention and for planning further studies.

Key Word *Mathematical Representation Ability, Learning Materials, Junior High School Students, Systematic Literature Review.*

How to cite https://pusdikra-publishing.com/index.php/josr

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INTRODUCTION

Mathematics is an important subject in education because learning mathematics involves more than obtaining numerical answers. Students are expected to understand concepts, solve problems, communicate ideas, and

organize mathematical information. These processes require students to express mathematical ideas in forms that can be interpreted and connected. Mathematical representation ability is therefore an important component of mathematics learning because representation allows students to express mathematical situations, relationships, and procedures through visual, symbolic, and verbal forms. The three forms are frequently used in studies of students' mathematical representation abilities (Maulana et al., 2025).

At the junior high school level, students encounter mathematics learning materials with different conceptual characteristics. Some materials emphasize symbolic relationships and algebraic expressions, while others require students to interpret tables, diagrams, graphs, geometric figures, or contextual situations. Consequently, the representation demanded from students may vary according to the material being learned. A student may be required to translate a contextual problem into an equation in one material, construct a graph or diagram in another, and explain a mathematical procedure using written language in another. The material studied is therefore a relevant dimension for understanding how mathematical representation ability has been investigated.

Previous literature reviews indicate that mathematical representation ability has been examined from several perspectives. Azizi et al. (2025) for example, reviewed mathematical representation ability in relation to mathematics learning models and reported that Problem Based Learning appeared prominently in the studies they analyzed. Inayah et al. (2024) reviewed Indonesian students' mathematical representation ability according to learning styles. Maulana et al. (2025). examined studies of mathematical representation ability more generally by considering visual, symbolic, and verbal representations. Sholehah et al. (2023) also reviewed research on students' mathematical representation ability. These studies demonstrate that representation has been reviewed according to different analytical dimensions.

Although those reviews provide important information, a review that specifically maps the research distribution according to mathematics learning materials at the junior high school level is still useful. The material dimension is important because the structure and characteristics of a mathematical topic influence the representations that students may use. For example, studies on algebraic material can involve symbolic expressions, whereas geometry and statistics can provide opportunities for visual representations through figures, tables, diagrams, or graphs. Therefore, mapping the materials that have been studied can show where research has been concentrated and where relatively limited evidence is available.

The present study addresses this gap by focusing on junior high school students and classifying the selected studies according to the mathematics learning material investigated. The review does not seek to rank materials in terms of difficulty or student ability. Instead, it maps the distribution of research and discusses the characteristics of the materials that provide contexts for studying mathematical representation. This distinction is important because a larger number of studies on a material does not automatically indicate that students have higher or lower representation ability in that material. It indicates only that the material has received more research attention within the dataset used in this review.

The purpose of this study is therefore to systematically identify mathematics learning materials that have been investigated in research on the mathematical representation ability of junior high school students and to describe the distribution of studies across those materials. More specifically, the study addresses two questions: (1) What mathematics learning materials have been studied in research on junior high school students' mathematical representation ability during 2016–2026? and (2) How is the distribution of research across those materials represented in the selected literature? The results are expected to provide a research map that can support teachers and researchers in identifying areas that have received relatively limited attention and in planning future investigations.

RESEARCH METHOD

This study employed a Systematic Literature Review (SLR) approach to identify and synthesize research articles concerning the mathematical representation ability of junior high school students based on mathematics learning materials. A literature review is appropriate for this purpose because the study focuses on identifying, collecting, organizing, and analyzing previously published research rather than collecting primary data from students (Chong et al., 2022). The review procedure in this study consisted of article searching, preliminary selection, recording of article information, grouping by learning material, and descriptive synthesis.

The literature search was conducted through Google Scholar using the Indonesian keyword "kemampuan representasi matematis siswa SMP". The publication period was limited to 2016–2026 to define the scope of the literature search and to capture relevant studies published within the selected period.The retrieved records were subsequently screened based on the predetermined inclusion criteria to identify articles relevant to the research focus.

The inclusion criteria used in the selection were: (1) the publication fell within the 2016–2026 period; (2) the study discussed mathematical representation ability; (3) the participants or context concerned junior high school students or an equivalent junior high school level where the study was retained in the original dataset; and (4) the mathematics learning material investigated could be identified. Articles that did not meet these criteria or did not correspond to the research focus were excluded from the dataset. Because the original search and selection were conducted through Google Scholar, the review should be understood as a database-specific literature mapping rather than an exhaustive search of every academic database.

Information from the selected articles was recorded in Microsoft Excel. The extracted information included the author or authors, publication year, article title where available in the working records, and mathematics learning material. The records were then organized according to learning material. This organization allowed the researchers to count the number of selected articles associated with each material and to identify materials with relatively more or fewer studies in the dataset. The procedure also made it possible to check the total number of included articles against the material-level counts.

The data were analyzed descriptively. First, the selected articles were grouped according to mathematics learning material. Second, the number of articles in each group was counted. Third, the distribution was interpreted by comparing the number of studies across materials. Finally, the pattern was discussed in relation to the characteristics of mathematical representation and the findings reported in selected previous studies. The analysis therefore emphasizes research distribution rather than a quantitative effect size or a statistical meta-analysis. No attempt was made to calculate a pooled effect because the selected studies differed in design, participants, materials, and research purposes.

The scope of the method should also be considered when interpreting the findings. The search was limited to Google Scholar and one primary Indonesian keyword, and the review focused on the information available in the selected articles. Consequently, the results describe the pattern represented in the selected 36 articles and should not be interpreted as a complete census of every study on mathematical representation ability published during 2016–2026. This limitation is important when using the findings to plan subsequent research.

RESULT AND DISCUSSION

The literature search using the keyword “kemampuan representasi matematis siswa SMP” through Google Scholar within the 2016–2026

publication period initially produced approximately 16,000 search results. These results represented the initial search output and were not directly treated as the review dataset. The retrieved records were screened based on the inclusion criteria described in the Research Method, including publication period, relevance to mathematical representation ability, junior high school context, and identification of the mathematics learning material. Articles that did not meet the criteria were excluded. Following this screening process, 36 articles met the criteria and were retained as the data sources for the review.

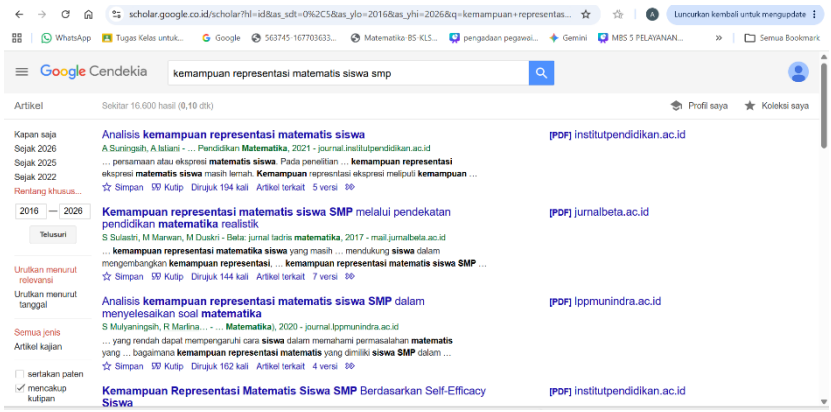


Figure 1.
Google Scholar Search Results for the Keyword "kemampuan representasi matematis siswa SMP"

The 36 selected articles were subsequently recorded in Microsoft Excel and classified according to the mathematics learning material investigated. The classification produced 18 learning-material categories, allowing the distribution of research to be identified across different mathematics topics.

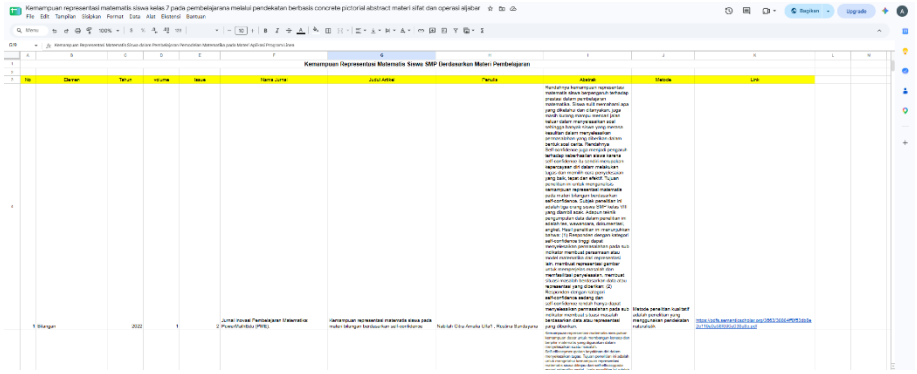


Figure 2.
Classification of Selected Articles Based on Mathematics Learning Materials

The distribution is presented in Table 1. SPLDV accounts for the largest number of selected studies, with six articles. Statistics follows with four articles. Relations and functions and circles each account for three articles. Numbers,

rectangles, similarity and congruence, flat-sided solids, triangles and squares, and data presentation each account for two articles. Social arithmetic, comparison and fractions, sets, PSLV, three-dimensional figures, plane figures, cubes and blocks, and transformations each appear once in the selected dataset. The distribution confirms that the 36 articles are not evenly distributed across the 18 materials.

The concentration of research on SPLDV can be considered in relation to the representational demands of the topic. SPLDV can require students to translate a contextual situation into equations, manipulate symbolic expressions, and interpret graphical representations. The mathematical object can therefore be expressed through more than one representation. Studies in the dataset illustrate this multidimensional character. Firdaus (2022), for example, examined students' mathematical representation ability on SPLDV using visual, mathematical-expression, and written-text indicators. Harahap and Rakhmawati (2020) also examined SPLDV through visual, expression, and verbal representation and reported that some students experienced difficulty in connecting these forms. These findings help explain why SPLDV can provide a productive context for representation research, although the frequency of research in this review should not be interpreted as evidence that SPLDV is inherently more difficult than other materials.

Statistics is the second most frequently represented material in the dataset. The characteristics of statistics naturally involve the organization and interpretation of information through tables, diagrams, graphs, and numerical measures. These forms create opportunities to examine whether students can move between visual, symbolic, and verbal representations. Silviani et al. (2021), for example, examined verbal, visual, and symbolic representation on statistics material and reported differences in students' mastery of these indicators. Yulinawati and Nuraeni (2021) investigated mathematical representation ability in statistics in relation to self-confidence, using tests, interviews, and questionnaires. The presence of several studies in this material indicates continued interest in representation within contexts that involve data organization and interpretation.

Relations and functions were represented by three studies in the selected dataset. The material provides several forms of representation, including rules, equations, tables, diagrams, and graphs. Herlina et al. (2017) examined representation ability in function material and considered visual, verbal, and symbolic forms. Hartono et al. (2019) also investigated representation in function material using an open-ended approach. These studies show that functions can be examined through transitions among different representations

rather than through symbolic manipulation alone. The material therefore offers a context for investigating students' ability to interpret and coordinate representations.

Circle material was also represented by three studies. Geometry materials generally provide direct opportunities for visual representation because students work with figures, properties, measurements, and spatial relationships. Wijaya (2018) investigated mathematical representation in solving circle problems, while the study by Simbolon and Munandar examined representation ability on circle material using visual, mathematical-expression, and written-text indicators. The selected studies indicate that geometry can make the visual dimension of representation particularly visible. At the same time, solving geometric problems can require students to connect figures with symbolic calculations and written explanations.

The materials represented by two studies include numbers, rectangles, similarity and congruence, flat-sided solids, triangles and squares, and data presentation. These materials show that representation research is not confined to algebraic topics. In number material, for example, students may need to express numerical relationships and connect representations of quantities. Ulfa and Sundayana (2022) examined mathematical representation ability on number material in relation to self-confidence, while Putri and Munandar investigated representation in problems involving integers and fractions. In geometry, Nurpadilah et al. (2018) examined representation ability on rectangular material and reported differences among visual, symbolic, and verbal representation across student ability levels. The presence of more than one study in these categories suggests recurring research interest, although the evidence base is smaller than for SPLDV and statistics.

Data presentation also has a clear connection with representation because students must translate information among tables, diagrams, graphs, and written descriptions. Pasehah and Firmansyah (2019) analyzed mathematical representation on data-presentation material using qualitative methods, tests, and interviews. Their study focused on visual representation in transferring information among diagrams, graphs, and tables and on written-text representation. This type of material illustrates how the representation construct is closely related to the ability to transform information from one form into another.

Several materials were represented by only one article in the selected dataset. These were social arithmetic, comparison and fractions, sets, PSLV, three-dimensional figures, plane figures, cubes and blocks, and transformations. The smaller number of studies does not indicate that students

have weaker or stronger representation ability in these materials. Rather, it indicates that fewer studies meeting the selection criteria were identified for these categories in the present search. This distinction is important because a literature review should separate the frequency of research from conclusions about students' mathematical performance.

Social arithmetic, for example, connects mathematical relationships with contextual situations. Nurbayan and Basuki (2022) examined students' mathematical representation ability in social arithmetic from the perspective of self-efficacy. The study used tests, interviews, and questionnaires, showing that the representation construct can be examined together with affective or learner-related variables. Comparison and fractions were represented by Marina et al. (2025), while number-related representation was also found in (Ulfa and Sundayana (2022). These studies indicate that number and contextual arithmetic materials can provide opportunities to examine how students interpret quantities and express relationships mathematically.

Sets and linear equations in one variable were also represented by single studies. Sari and Sutirna (2022) investigated mathematical representation ability in set material through verbal, visual, and symbolic indicators. Their study illustrates that even a topic such as sets can be examined through multiple representation forms. The presence of PSLV as a single-material category similarly indicates that representation research extends to algebraic topics beyond SPLDV. Together, these categories show that the research landscape is broad even though the frequency of studies differs substantially among materials.

Geometry-related categories with one or two studies also deserve attention. The review includes three-dimensional figures, plane figures, cubes and blocks, triangles and squares, rectangles, circles, similarity and congruence, and flat-sided solids. Hapsari et al. (2019) investigated representation ability on flat-sided three-dimensional figures and analyzed visual, mathematical-expression, and written-text indicators. Abdurahman et al. (2023) examined representation in similarity and congruence using visual, verbal, and symbolic forms. These studies reinforce the point that geometric materials provide contexts in which students may need to coordinate drawings, mathematical expressions, and written explanations.

Transformation material appears once in the dataset. Cahyaningrum et al. (2023) specifically characterized visual and symbolic mathematical representation in transformation material. The study demonstrates the relevance of representation to a topic in which a geometric object and its symbolic description can be connected. The limited number of studies in the

present dataset suggests that transformation is a potential area for additional investigation, but it would be inappropriate to infer from one article that the material is under-researched in the entire international literature.

Overall, the distribution in Table 1 reveals two important patterns. First, mathematical representation ability has been studied across algebra, numbers, geometry, statistics, and data-related materials. This breadth confirms that representation is not restricted to a particular mathematical domain. Second, the frequency of research is uneven. Six studies were identified for SPLDV, four for statistics, three each for relations and functions and circles, while eight material categories had only one study each. The pattern suggests that future reviews and empirical research may benefit from paying attention to materials that appear less frequently in the present evidence base.

The findings also complement previous literature reviews. Azizi et al. (2025) organized research according to learning models, Inayah et al. (2024) according to learning styles, and Maulana et al. (2025) according to forms of representation. The present review adds a material-based dimension to these perspectives. Rather than asking which learning model is most common or which student characteristic is associated with representation, this study asks where, in terms of mathematics content, representation ability has been investigated. The three dimensions can be considered complementary: learning model describes the learning context, learning style or learner characteristics describe student-related variation, representation form describes the mode of mathematical expression, and learning material describes the mathematical content in which the representation is used.

This material-based perspective has implications for future mathematics education research. Researchers can use the distribution as an initial map when selecting topics for empirical studies, particularly when they wish to examine representation in materials that appear less frequently in the selected literature. Teachers can also consider the representational demands of each material when designing tasks. For example, tasks can require students not only to produce a symbolic answer but also to construct a visual representation and explain the reasoning in words. Such an approach is consistent with the broader view of mathematical representation as the ability to use and connect multiple forms rather than treating each representation as an isolated skill.

However, the results should be interpreted within the limitations of the review. The search was conducted using Google Scholar and a single primary keyword. The initial search output was approximately 16,000 records, but the final dataset consisted of 36 articles after selection. The review therefore represents the evidence captured by the chosen search strategy and criteria. In

addition, the present analysis emphasizes the number and distribution of studies by material. It does not calculate effect sizes or statistically compare students' representation performance across materials. Differences among study designs, participants, instruments, and research objectives also mean that the number of articles should not be treated as a measure of the effectiveness of learning a particular material. Future reviews can strengthen the evidence base by using multiple databases, a broader search string, a transparent screening flow, and a more detailed extraction of representation indicators and study outcomes.

Table 1.
Distribution of Articles Based on Learning Materials

Learning Materials	Author (Year)	Number of Articles
Numbers	(Putri & Munandar, 2019; Ulfa & Sundayana, 2022)	2
Social Arithmetic	(Nurbayan & Basuki, 2022)	1
Comparison and Fractions	(Marina et al., 2025)	1
Relationships and Functions	Herlina et al. (2017); Iffa et al. (2022) (Hartono et al., 2019)	3
Sets	(Sari & Sutirna, 2022)	1
SPLDV	Sinaga et al. (2021); Handayani et al. (2025); Khairuniisa et al. (2020); Sugihartini et al. (2025) (Firdaus, 2022; Harahap & Rakhmawati, 2020)	6
PSLV	Nisa et al. (2024)	1
Rectangles	Khoerunnisa & Maryati (2022); (Nurpadilah et al., 2018)	2
Similarity and Congruence	Marliani & Puspitasari (2022); (Abdurahman et al., 2023)	2
Three-dimensional Figures	Ramadan & Ain (2021)	1
Plane Figures	Sutriyono & Hanifa (2018)	1
Circles	Johar & Maidah (2019); (Simbolon & Munandar, 2020; Wijaya, 2018)	3

Flat-sided Solids	Rahmatika & Widodo (2018) (Hapsari et al., 2019)	2
Cubes and Blocks	(Simanjuntak et al., 2024)	1
Triangles and Squares	Sari & Nurjaman (2019) (Yustika & Roesdiana, 2020)	2
Transformations	(Cahyaningrum et al., 2023)	1
Statistics	Ristiani & Maryati (2022); Nasution et al. (2023) (Silviani et al., 2021; Yulinawati & Nuraeni, 2021)	4
Data Presentation	(Pasehah & Firmansyah, 2019) Mukti et al. (2024)	2

The distribution in Table 1 also provides a practical basis for interpreting the scope of the present review. The table should be read as a map of the selected literature rather than as a direct measure of the importance, difficulty, or quality of a mathematics topic. A topic appearing once may have substantial educational importance but limited representation in the particular search dataset. Conversely, a topic appearing six times may simply have attracted more research attention during the period and under the search strategy used in this review. This distinction prevents the frequency count from being overinterpreted.

From the perspective of research design, the selected studies also illustrate methodological diversity. The literature includes qualitative descriptive studies, case studies, quantitative descriptive studies, and studies examining representation together with learner variables such as self-confidence or self-efficacy. For example, Harahap and Rakhmawati (2020) used tests, documentation, and interviews, while Nurbayan and Basuki (2022) combined tests, interviews, and questionnaires. Such variation means that a future systematic review can move beyond material frequency and code methodological characteristics, representation indicators, participant characteristics, and findings in a more detailed evidence matrix.

Therefore, the main contribution of the present review is the material-based mapping of research on junior high school students' mathematical representation ability. The mapping shows the breadth of topics already investigated and the uneven distribution of research attention. It can serve as an initial reference for subsequent reviews or empirical studies, particularly those

intending to examine representation in materials that have appeared less frequently in the selected literature.

CONCLUSION

The Systematic Literature Review identified 36 articles concerning the mathematical representation ability of junior high school students across 18 mathematics learning materials during the 2016–2026 publication period. The distribution was uneven: SPLDV was represented by six articles, statistics by four, relations and functions and circles by three each, while several materials were represented by only one article. The findings show that mathematical representation has been investigated across algebraic, numerical, geometric, statistical, and data-related content. The material-based mapping complements previous reviews that have focused on learning models, learning styles, or representation forms by providing a content-oriented view of the research landscape. The results should be interpreted as a map of the selected literature rather than as a ranking of mathematics materials or a direct measure of students' ability. The review is limited by its reliance on Google Scholar, one primary search keyword, and a descriptive analysis of 36 selected articles. Future research can extend the search to multiple databases and use a more detailed coding framework to compare representation indicators, research methods, student characteristics, and findings across materials. The present mapping nevertheless provides a useful starting point for identifying materials that have received relatively limited research attention and for formulating further studies of mathematical representation ability.

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