

A Systematic Literature Review on Mathematical Communication: The Research Literature 2019-2024

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Abstract

Mathematical communication skills are an important aspect of mathematics learning, as they enable students to express ideas, understand concepts, and solve problems effectively. This study aims to systematically review research findings related to mathematical communication skills published between 2019 and 2024. The review process was conducted based on the PRISMA protocol by selecting 22 articles from the Scopus, Science Direct, and ERIC databases that met the inclusion and exclusion criteria. The results of the study indicate that technology-based instructional approaches and collaborative learning models such as ACODESA, Team-Assisted Individualization (TAI), Realistic Mathematics Education (RME), and GeoGebra have a significant impact on enhancing students' mathematical communication skills. Research trends over the past five years reveal a growing interest in the integration of digital tools and metacognitive strategies in developing mathematical communication. These findings underscore the importance of implementing innovative interventions tailored to students' characteristics in order to optimize communication processes within mathematics learning environments.

Keywords: mathematical communication, systematic literature review, mathematics education

1. Introduction

Mathematics is a subject taught at school that helps students develop critical thinking and argumentation skills [7], and can help people solve challenges in everyday life [10]. Mathematics also teaches students how to communicate effectively, concisely, and clearly, and gives them the skills to present information in a variety of ways [36]. In formal education, mathematics is one of the subjects that can develop students' way of thinking. The basic abilities in mathematics that students must have are classified into five types, namely: (1) recognizing, understanding and applying concepts, procedures, principles, and mathematics, (2) solving mathematical problems, (3) reasoning mathematically, (4) connecting mathematically, and (5) communicating mathematically [11].

One of the important parts of mathematical skills that students must have is mathematical communication skills. When learning mathematics, students must be able to communicate effectively. Communication is the process by which a person sends carefully selected information so that the receiver can understand the significance of the information [19], and enables students to share ideas or opinions and clarify understanding [32].

Mathematical communication ability is the ability of students to convey mathematical ideas both orally and in writing [13]. According to [5] said that if students' mathematical communication skills are good, this can stimulate students' ability to develop ideas and knowledge in finding mathematical concepts that are being studied. When students

communicate their thoughts to others in oral or written form it will help improve understanding, make connections, and develop language to express mathematical ideas [16]. Acquiring and sharing information, developing and refining ideas, and building concepts and strategies are fundamental functions of mathematical communication [8].

Mathematical communication is an important part of learning mathematics [34], important in mathematics that students should have to share and gain knowledge from literature, teachers, and peers [22]. The importance of mathematical communication is to monitor several mathematical communication standards. First, students can organize and formulate ideas using a variety of representations. Second, they can present their thinking (point of view) coherently and clearly to peers and teachers. The third way, students can solve math problems for their peers is by examining, evaluating, thinking, and even solving math problems for other students. Finally, students can use their mathematical abilities to express ideas accurately [37].

In general, students' mathematical communication skills are still relatively low, this is indicated by the number of students who still have difficulty working on problems in the form of pictures, graphs, and others [9]. Based on observation [15] that in mathematical communication skills, some students still have difficulty in expressing problems into mathematical ideas and difficulty in expressing a problem in the form of images or mathematical models. This makes most students choose to look at their friends' work rather than asking directly to the teacher, because students still feel that they are not sure of their abilities.

Given the importance of this issue, the purpose of this systematic review is to synthesize findings from empirical research in order to present a broader description of mathematical communication ability and its related issues for future advancement. The systematic process involves several steps: (1) collecting empirical studies that meet inclusion criteria, (2) examining both qualitative and quantitative data, and (3) synthesizing all relevant information from previous studies to describe the current status of research and report the effect sizes of approaches used. Ultimately, this study aims to identify emerging trends and theoretical frameworks in research on mathematical communication.

In order to achieve these aims, the study is guided by the following research questions:

- RQ 1: What are the effect sizes of various approaches used in mathematical communication ability research published in the last five years?
- RQ 2: What research trends on mathematical communication ability have emerged in the last five years?
- RQ 3: What theoretical frameworks have been applied in mathematical communication research published in the last five years?

2. Methodology

The research method used in this research is the Systematic Literature Review (SLR) method. This SLR identifies, selects, and critically assesses various studies to answer the research questions posed. The process of selecting articles to be reviewed is guided by guidelines that have been established for conducting systematic reviews in Educational Research [41] and the framework for systematic reviews and meta-analyses (PRISMA) [25]. There are various steps involved in a particular study, such as formulating a research question, searching for journal articles, setting inclusion and exclusion criteria, selecting articles, presenting data, processing data, and drawing conclusions. This study uses tools and materials that must be analyzed for their advantages and specifications. For quantitative research, it is necessary to explain the presence of researchers, subjects, informants, as well as data collection methods and data validity analysis.

2.1 Phase 1: Formulating research questions and building a conceptual design framework

This review aims to (1) analyze the effect size of various approaches used in mathematical communication ability research published in the last 5 years, (2) identify research trends on mathematical communication ability in the last 5 years, and (3) the theoretical framework on mathematical communication used in the last 5 years of publication.

2.2 Phase 2: Generate a set of selected criteria

The development of selection criteria for this study was based on PICO [30], which consists of three essential elements: population or problem, interest, and context. Based on this concept, we have included three main aspects in this review, namely school students and prospective teachers (population), mathematical communication ability (interest), and mathematics education (context).

2.3 Phase 3: Establish inclusion and exclusion criteria

We found two important keywords based on the research questions: mathematical communication skills and mathematics. In addition, we looked back at the previous keywords and asked for expert advice to complete the keywords. Several keywords related to the open search were examined through this procedure, including mathematical communication ability in students and mathematics education. Considering the maturity of the research field, this review limited the screening procedure to publications published in the last five years, i.e. from 2019 to 2024.

Table 1. Search Strings Used in Finding Articles From the Database

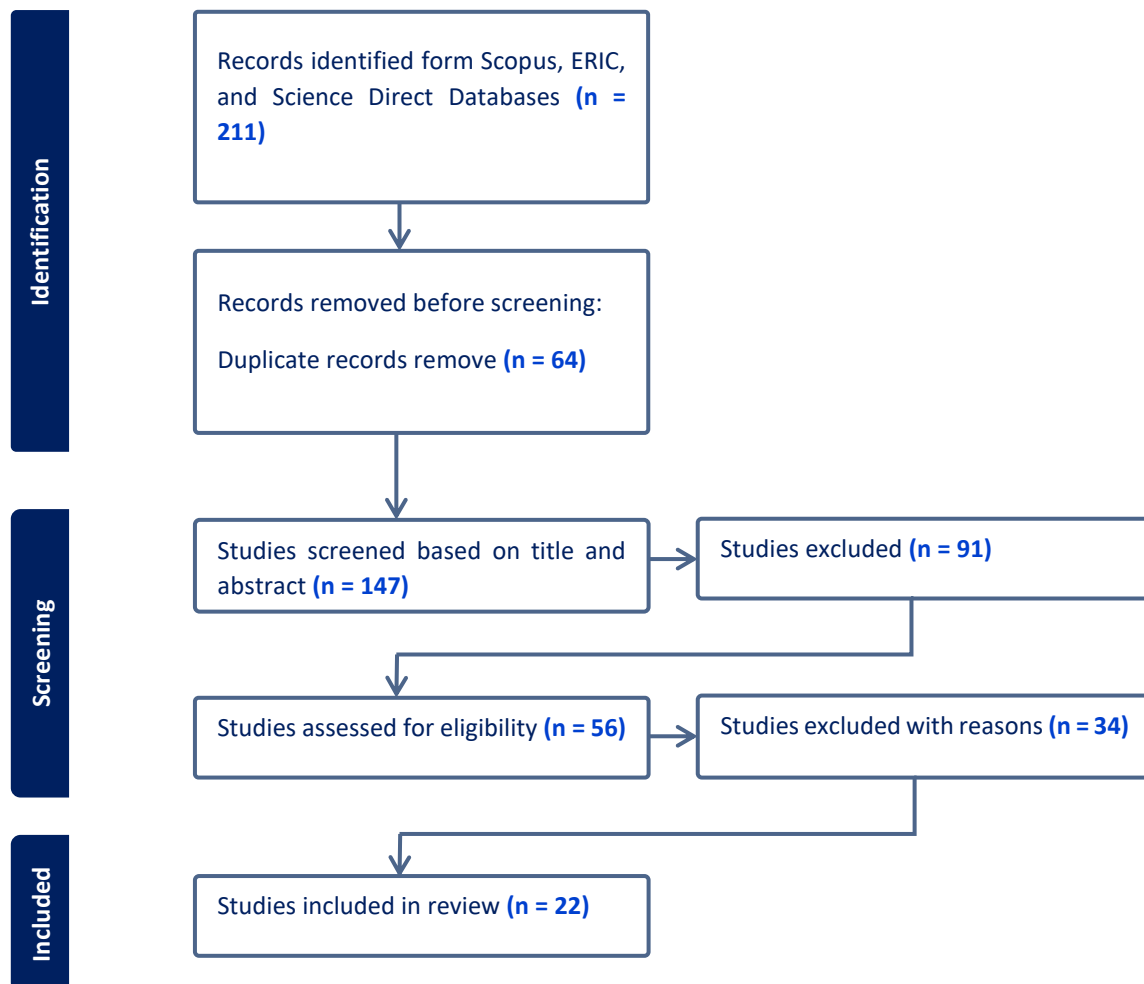
Database	String
Scopus	("mathematical communication") AND ("mathematics"))
Science direct	("mathematical communication") AND ("mathematics"))
ERIC	mathematical communication

Table 2. Inclusion and Exclusion Criteria

Inclusion	Exclusion
Contains the keyword "mathematical communication"	Does not contain the keyword "mathematical communication"
Articles published from 2019 to 2024	Articles published outside the specified timeframe
Sourced from a scopus indexed journal	Sourced from journal conference
There is quantitative data and/or qualitative data on mathematical communication skills	Consists of less than 4 pages
Math education	No math education
English	Not in English

2.4 Phase 4: Choose a study based on a set of criteria

The studies in this review were found through a process of identification, screening and eligibility, and through a verification process to ensure that they met the selection criteria. The article selection process followed the procedure outlined by PRISMA , as shown in Figure 1.

**Figure 1.** Protocol Systematic Review

2.5 Phase 5: Quality assessment

In the critical appraisal process, three factors are considered: research design, research methods, and relevance of the research to the topic of the review [6]. Articles are only considered for review if they relate to at least one of the categories.

2.6 Phase 6: Coding research

In stage 6 of the review, a coding scheme was used to assess all articles found through discussion based on the research topic. The extracted data contained information such as author, journal, participants, country, knowledge domain, intervention, focus, and effect size. We attempted to detect patterns in the data obtained from all studies examined in the process. Graphs were created to illustrate key facts from the 22 articles based on the country where the study was conducted, study design, year of publication, and age group of students/participants.

2.7 Phase 7: Data synthesis

The articles were analyzed using Mendeley, NVivo, and VOSviewer software. After the systematic review protocol (Figure 1) was conducted, 22 article titles were obtained from three data sources, namely Science direct (2), Scopus (14), and ERIC (6). The data analysis process began by categorizing the data from the 22 article titles based on the type of research (quantitative and qualitative), country of research, and research subjects (school students and prospective teachers). The effect size was analyzed and summarized in the quantitative research type to describe the effect of mathematical communication ability on the research results. Meanwhile, qualitative research and mixed qualitative-quantitative research are classified separately. The data presented in bibliometrics were analyzed using VOSviewer software. Data that has been entered in (.ris) format was analyzed using VOSviewer software to see the trend of research over the past 5 years with mathematical communication ability. The analysis starts from the relationship between keywords, and groups of keywords that are directly related to research trends in each year.

3. Results and Discussion

3.1. Effect Size of Various Approaches Used in Research on Mathematical Communication Skills over the Last 5 Years (2019-2024)

After completing all stages of the protocol, 22 articles were obtained using three research approaches: quantitative, qualitative, and mixed (qualitative and quantitative). The collected quantitative research was analyzed quantitatively using effect size [4]. There were 22 articles processed and classified into three research approaches: quantitative (10 titles), qualitative (6 titles), RnD (3 titles), and mixed (3 titles). The quantitative group (table 3) was conducted in several countries, including Indonesia (10) and Vietnam (3).

Table 3. Effect Size Calculation of Quantitative Data

No.	Author, year	Journal	Participant	Country	Domain Knowledge	Intervention	Effect Size
1	(Tong et al., 2021)	Heliyon	87 elementary school students	Vietnam	Ellipse topics	ACODESA	0,63 (Medium)
2	(Tinungki et al., 2022)	Education Sciences	92 prospective teachers	Indonesia	Linear Programming	Team-Assisted Individualization (TAI) cooperative learning model	1,12 (Large)
3	(Kusumah et al., 2020)	International Journal of Instruction	82 senior high school students	Indonesia	Geometri 3D	GeoGebra	0,34 (Small)
4	(Uyen et al., 2021)	European Journal of Educational Research	40 junior high school students	Vietnam	Congruent triangles	Realistic Mathematics Education (RME)	0,13 (Small)
5	(Ahdhianto et al., 2020)	European Journal of Educational Research	204 elementary school students	Indonesia	Time, Distance, Speed, Discharge, and Comparison.	Metacognitive-Based Contextual Learning Model	0,11 (Small)
6	(Nguyen et al., 2024)	Heliyon	79 elementary school students	Vietnam	Fractional Numbers	Model 5E	0,21 (Small)
7	(Tinungki et al., 2024)	Cogent Education	72 prospective teachers	Indonesia	Operations Research	Team-Assisted Individualization (TAI) cooperative learning model	0,68 (Medium)
8	(Mujiasih et al., 2021)	International Journal of Learning, Teaching and	35 prospective teachers	Indonesia	Geometri	GeoGebra-assisted EPIC-R	-0,19 (Small)

No.	Author, year	Journal	Participant	Country	Domain Knowledge	Intervention	Effect Size
9	(Kurniawan, 2021)	Educational Research International Journal of Instruction	187 junior high school students	Indonesia	SPLDV	PINTER Mathematics Learning Models	0,72 (Medium)
10	(Prabawanto, 2019)	Infinity Journal	118 prospective teachers	Indonesia	Aljabar	Metacognitive scaffolding	0,16 (Small)
11	(Palinussa et al., 2021)	International Journal of Evaluation and Research in Education	130 junior high school	Indonesia	Geometri	Realistic mathematics education (RME) pendekatan dalam konteks pedesaan	0,32 (Small)

The participants of these studies were divided into four groups: elementary school students (3 titles), junior high school students (3 titles), high school (1 title) and prospective teachers (4 titles). As shown in Table 4, the effect sizes of the 11 quantitative research titles were classified as small, medium and large. The strength of the relationship between the variables studied is measured by the effect size. The advantages of calculating the effect size are threefold: (1) it can estimate a sample size sufficient to detect statistically significant results in future research studies, (2) it can assess the practical significance of research studies, and (3) it can synthesize findings across studies more accurately (e.g., conduct a meta-analysis) [14].

Table 4. Type of Effect Size Grouping by Intervention

Small Effect	Medium Effect	Large Effect
ACODESA ¹⁾	PINTER Mathematics Learning Models ²⁾	Team-Assisted Individualization (TAI) cooperative learning model ⁴⁾
GeoGebra ³⁾	Team-Assisted Individualization (TAI) cooperative learning model ⁴⁾	
Metacognitive-Based Contextual Learning Model ¹⁾		
Metacognitive scaffolding ¹⁾		
Realistic mathematics education (RME) ²⁾		
Realistic mathematics education (RME) pendekatan dalam konteks pedesaan ²⁾		
Model 5E ¹⁾		
EPIC-R berbantuan GeoGebra ³⁾		

Description:

¹⁾ = Elementary school, ²⁾ = Junior high school, ³⁾ = High school, and ⁴⁾ = Prospective teachers

Table 5 Shows The Studies Collected Using Qualitative (6 Titles), Rnd (3 Titles) And Mixed (3 Titles) Approaches. These Studies Were Conducted In Several Countries, Including Indonesia (8), Australia (1), Denmark (1), Usa (1), And Vietnam (1). RnD (3 titles) and mixed (3 titles) approaches. These studies were conducted in several countries, including Indonesia (8), Australia (1), Denmark (1), USA (1), and Vietnam (1).

Table 5. List of Qualitative Research on Mathematical Communication

No.	Author, year	Journal	Participant	Country
1	(Cartwright, 2020)	Journal of Mathematical Behavior	63 junior high school students	Australia
2	(Rosita et al., 2019)	Infinity Journal	47 junior high school students	Indonesia
3	(Pantaleon et al., 2023)	Bolema - Mathematics Education Bulletin	48 prospective teachers	Indonesia
4	(Bach et al., 2024)	ZDM – Mathematics Education	5 junior high school students	Denmark
5	(Pourdavood et al., 2020)	Athens Journal of Education	34 elementary school students	USA
6	(Muhtarom et al., 2021)	Infinity Journal	3 prospective teachers	Indonesia
7	(Kamid et al., 2020).	International Journal of Evaluation and Research in Education	125 senior high school students	Indonesia
8	(Nguyen et al., 2024)	Heliyon	79 junior high school students	Vietnam
9	(Wardono et al., 2020)	International Journal of Instruction	80 junior high school students	Indonesia
10	(Setiyani et al., 2020)	Journal on Mathematics Education	40 junior high school students	Indonesia
11	(Hidayat & Aripin, 2023)	Infinity Journal	49 junior high school students	Indonesia

No.	Author, year	Journal	Participant	Country
12	(Wahyudi et al., 2019)	Infinity Journal	10 elementary school students	Indonesia

3.2. Trends in Mathematical Communication Skills Research in the Last 5 Years-Publications

The research trends of the past five years were obtained from bibliometric data processed using VOSviewer as shown in Figure 2. The same color indicates the same cluster, and the size of the circle indicates the popularity of keywords. The larger the circle size, the more popular the topic is discussed in 22 articles. The connecting lines between the circles indicate the direct relationship between the keywords.

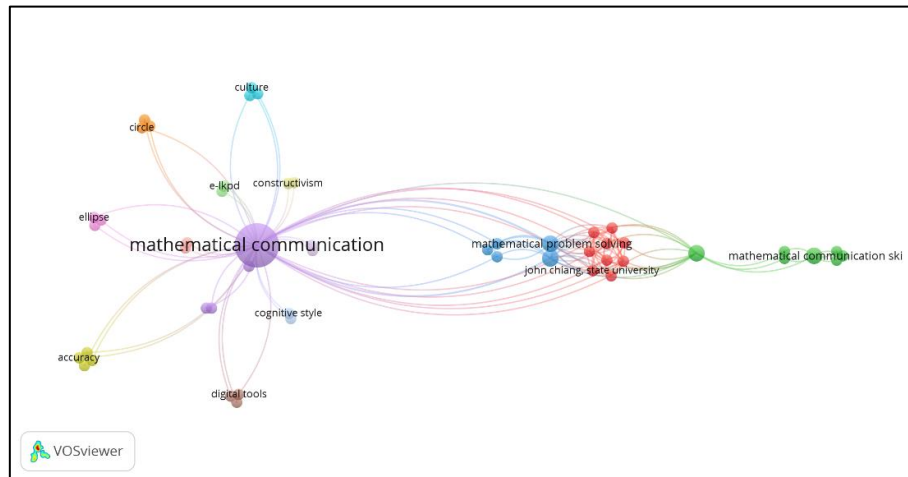


Figure 2. Keyword Network Visualization from the 22 Reviewed Articles Categories of Frequently Occurring Keywords or Variables and Their Relationships

Observation of the most frequently studied topics in a period of time can reveal the trend of research on geometric thinking in the last 5 years. Comparisons are also made to see the trend of research on geometric thinking over time, so that the stages of development can be known. This is reflected in the topics that have emerged over time and the most popular topics. As shown in Table 5, there are 5 groups of keywords that show the proximity of keywords in the processed articles. The keywords discuss geometry materials, interventions in geometry, cognitive aspects, affective aspects, and other aspects that may be related.

Table 6. Hierarchical Grouping of Keywords

Cluster	Daftar Kata Kunci
Cluster 1	Assessment & testing, higher education, john chiang, state university of new york, usa, non-parametric statistics, statistics & probability, teaching & learning, teaching & learning education, team assisted individualization, theories of learning
Cluster 2	Congruent triangles, contextual based learning, mathematical communication skills, mathematics education, metacognition, problem solving skills, the teaching process
Cluster 3	Cooperative learning model, mathematical problem solving, operation research, self-proficiency, team assisted individualization (TAI)
Cluster 4	Accuracy, clarity, coherence, math anxiety
Cluster 5	Concept attainment model, mathematical communication, metacognitive approach, prior mathematical knowing
Cluster 6	Culture, reasoning skill, rural context
Cluster 7	Circle, didactical design research, learning obstacle
Cluster 8	Digital tools, dynamic geometry, mathematical representation
Cluster 9	Ellipses, skill, students attitude
Cluster 10	Ability, adversity quotient
Cluster 11	E-LKPD, scientific approach
Cluster 12	Cognitive style, gender
Cluster 13	Constructivism, media
Cluster 14	Problem based students, self-efficacy

The circle size of each keyword (Figure 2) indicates the popularity of the 22 processed research titles. The larger the circle size indicates the greater use of that keyword in research. This indicates that the variable has previously been researched extensively. The direct relationship between the keyword 'geometric thinking' and other keywords is presented in Figure 3.

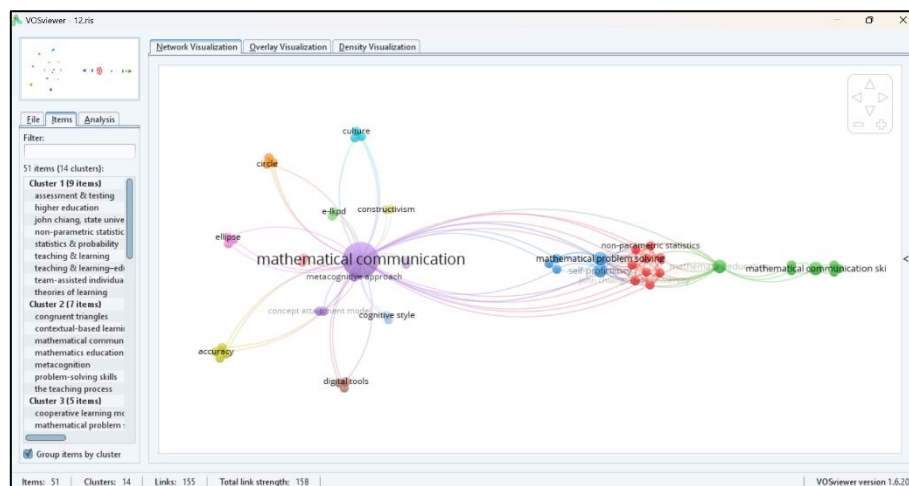


Figure 3. The Relationship Between the Keyword ‘Mathematical Communication Skills’ and Other Keywords

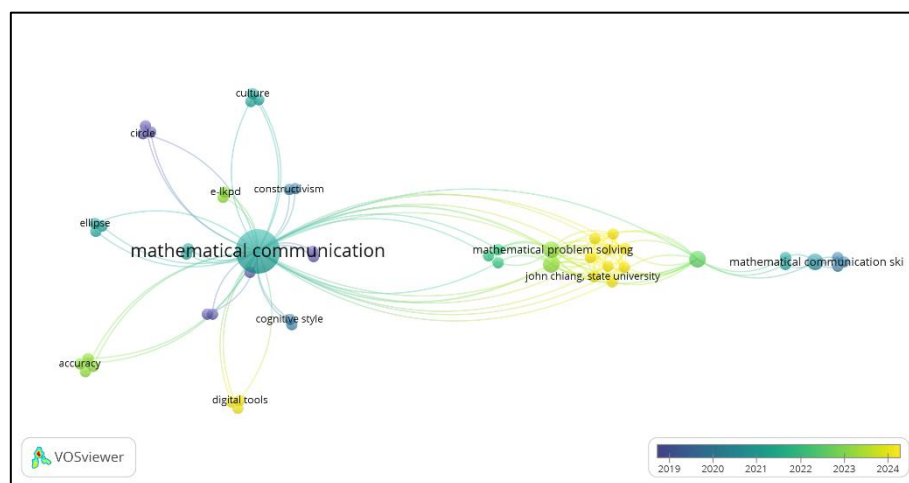


Figure 4. Publication Trends From 2019 to 2024

Trends, as shown in Figure 4, are indicated by color, with lighter marks indicating more recent publications. Most of the recent publications, denoted in yellow, show that the trends include the keywords digital tools, non-parametric statistics, mathematical problem solving, and teaching & learning. For researchers, information on topic novelty is important to show the current state of research being conducted in line with the times.

3.3. Theoretical Frameworks on Mathematical Communication Used in the Last 5 Years Publications

The predetermined articles were coded and analyzed in terms of theories, models, or geometric thinking frameworks. A total of 22 articles were classified based on definition, participants, intervention type, and research knowledge domain. An overview of the theories, models or frameworks of mathematical communication was obtained from the 22 articles and is presented in Figure 5. As illustrated in Figure 5, there are several main topics addressed in the theoretical frameworks of the 22 mathematical communication articles.

3.4. Discussion

Effect Size shows the effect of one variable on another and is influenced by the number of samples used. An interesting thing was found in the summary table (Table 3). Where a 'very large' effect on mathematical communication skills was obtained in the study that applied the Team-Assisted Individualization (TAI) cooperative learning model. The TAI cooperative learning model combines individual and group learning, making the material easier to understand, increasing students' enthusiasm, and creating a conducive learning atmosphere. However, its implementation requires quite long steps, so it takes more time. This can cause high-ability students to feel bored because they have to adjust with friends who take longer to understand the concept [36].

The next section is about the participants, which consist of elementary school students (5 studies), junior high school students (10 studies), senior high school students (2 studies), and pre-service teachers (5 studies). In primary school students, class teachers communicated with students about rules, roles and expectations. For example, teachers communicated with students about how to talk about math, how to listen to each other's ideas and perspectives, and how to challenge each other's solutions during problem-solving activities. This is in line with research [28], Verbal

communication between students has various benefits, such as encouraging reflection and critical thinking, helping teachers assess student understanding, as well as being a basis for teachers to improve and adjust their teaching methods. In junior high school, students need to develop logical thinking, modeling, problem solving, and mathematical communication skills, which include the effective use of mathematical language (symbols, diagrams, graphs) in explaining, questioning, and proving solutions. Similarly, pre-service teachers' research to realize students' good mathematical communication skills is provided by teachers, trained or prepared since becoming prospective teachers [20].

Various forms of intervention in research and knowledge domains are the focus of research on junior high school students. For example, RME [38] or This means that math should be close to the child and relevant to the child's daily situation, especially the student's life [26]. By using RME, students are more active in the classroom in communicating to solve mathematical problems when compared to students who learn conventionally where the teacher is the center of mathematics learning and students' mathematical emotions are individualized [26]. Both studies were conducted on junior high school students, in line with Piaget's learning theory which states that the basic principles of one's knowledge will change and adapt to the surrounding reality.

Some metacognitive-based approaches have also been reported to be effective in stimulating more reflective and structured mathematical communication. Context-based learning models such as metacognitive-based contextual learning approach [1] and metacognitive-scaffolding [29] encourages students to think about their own thinking, which in turn improves the ability to convey mathematical ideas in writing. This ability is in line with the statement [24] that good communication skills can stimulate students in developing ideas and finding mathematical concepts that are being learned.

Bibliometric trends also show that current research trends are also starting to involve affective dimensions in the study of mathematical communication skills. Several studies highlighted the influence of self-efficacy, math anxiety, and students' attitudes towards mathematics in shaping their courage and communication skills ([12]; [16]; [20]). This shows that mathematical communication is not just a cognitive ability, but is also strongly influenced by students' psychological conditions. Therefore, holistic learning interventions that combine cognitive and affective strategies are important to create a supportive learning atmosphere and empower students to express their mathematical ideas.

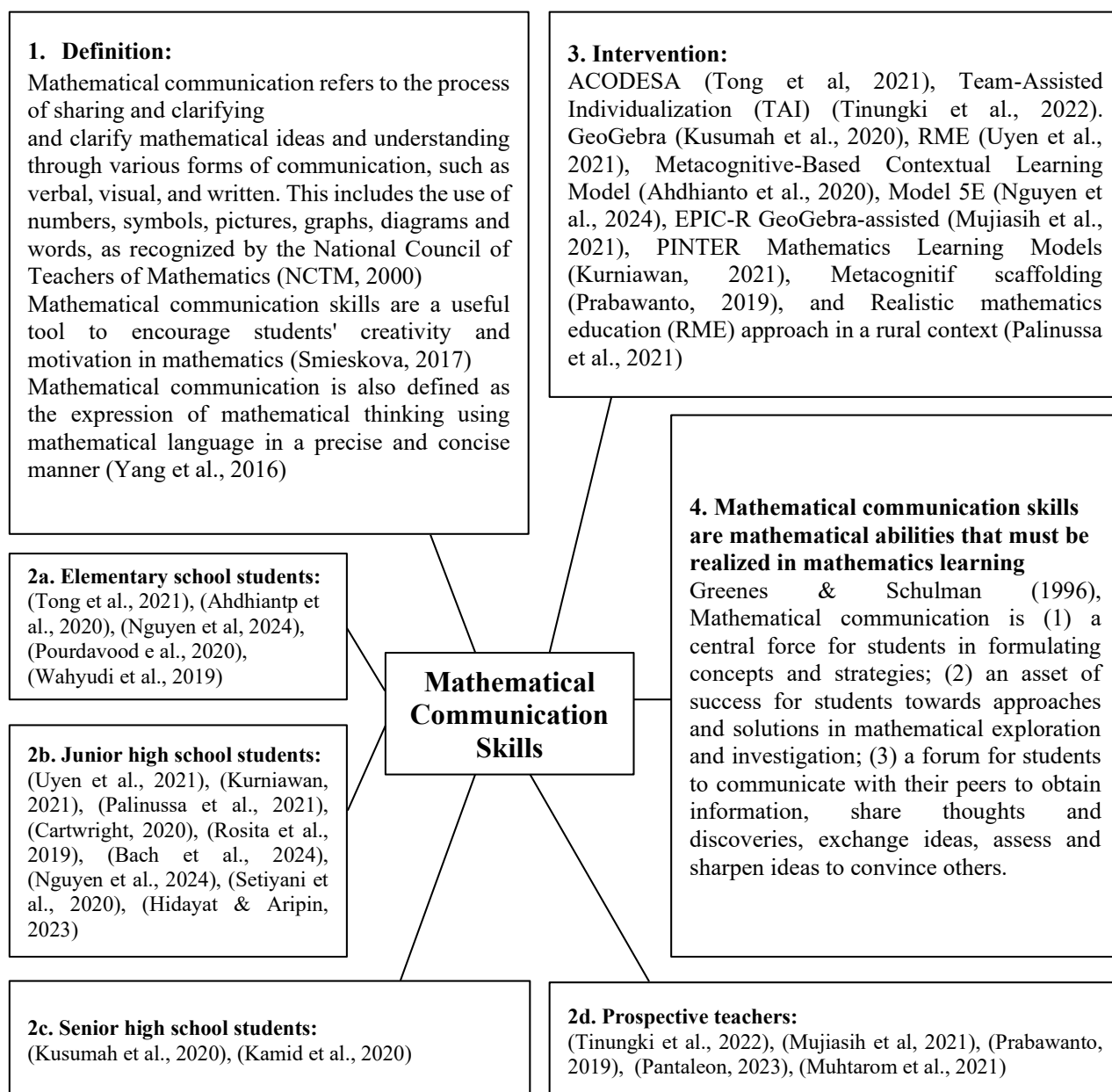


Figure 5. Theoretical Framework on Mathematical Communication Skills

4. Conclusion

This systematic review concludes that students' mathematical communication skills have improved significantly in the last five years through the implementation of various innovative learning approaches. Collaborative learning models, technology-based, and contextual-metacognitive approaches have proven effective in improving students' ability to communicate ideas, understand concepts, and solve mathematical problems. Research trends also show the increasing use of digital tools and the integration of affective aspects as part of efforts to strengthen mathematical communication. Therefore, mathematics teachers and educators are advised to integrate learning models that are adaptive to students' needs, use varied media, and create a learning atmosphere that supports open communication. Further research can be directed at exploring approaches that combine technology, local culture, and character strengthening to form intact, critical, and reflective mathematical communication.

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References

- [1] Ahdhianto, E., Marsigit, Haryanto, & Santi, N. N. (2020). The Effect of Metacognitive-Based Contextual Learning Model on Fifth-Grade Students' Problem-Solving and Mathematical Communication Skills. *European Journal of Educational Research*, 9(2), 753 – 764. <https://doi.org/10.12973/eu-jer.9.2.753>
- [2] Bach, C. C., Bergqvist, E., & Jankvist, U. T. (2024). Students' Dynamic Communication While Transforming Mathematical Representations in A Dynamic Geometry Environment. *ZDM - Mathematics Education*, 56(4), 543–557. <https://doi.org/10.1007/s11858-024-01575-x>
- [3] Cartwright, K. (2020). Analyzing Students' Communication and Representation of Mathematical Fluency During Group Tasks. *Journal of Mathematical Behavior*, 60(August), 100821. <https://doi.org/10.1016/j.jmathb.2020.100821>
- [4] Cohen, L., Manion, L., & Keith Morriison. (2007). *Research Methods in Education*. In Routledge Taylor & Franscis Group. <https://doi.org/https://doi.org/10.4324/9780203029053>
- [5] Dewi, R. S., Sundayana, R., & Nuraeni, R. (2020). Perbedaan Peningkatan Kemampuan Komunikasi Matematis dan Self-Confidence antara Siswa yang Mendapatkan DL dan PBL. *Mosharafa: Jurnal Pendidikan Matematika*, 9(3), 463–474. <https://doi.org/10.31980/mosharafa.v9i3.830>
- [6] Gough, D. (2007). Weight of Evidence: A Framework for The Appraisal of The Quality and Relevance of Evidence. *Research Papers in Education*, 22(2), 213–228. <https://doi.org/https://doi.org/10.1080/02671520701296189>
- [7] Gravemeijer, K., Stephan, M., Julie, C., Lin, F. L., & Ohtani, M. (2017). What Mathematics Education May Prepare Students for The Society of The Future? *International Journal of Science and Mathematics Education*, 15. <https://doi.org/10.1007/s10763-017-9814-6s>
- [8] Greenes, C., & Schulman, L. (1996). *Communication Processes in Mathematical Explorations and Investigations* (In P. C. E). NCTM.
- [9] Hakiki, S. N., & Sundayana, R. (2022). Kemampuan Komunikasi Matematis pada Materi Kubus dan Balok Berdasarkan Kemandirian Belajar Siswa [Mathematical Communication Ability on Cube and Block Materials Based on Student Learning Independence]. *Plusminus*, 2(1), 101–110. <https://doi.org/10.31980/plusminus.v2i1.1088>
- [10] Hendri Prayogi, A. (2019). Desain Bahan Ajar Bangun Datar Segiempat Berbasis Kemampuan Komunikasi Matematis pada Siswa SMP melalui Model Discovery Learning [Design of Quadrilateral Learning Materials Based on Students' Mathematical Communication Ability through the Discovery Learning Model]. *Jurnal LEMMA*, 5(2). <https://doi.org/10.22202/jl.2019.v5i2.3259>
- [11] Hendriana, H., Rohaeti, E. E., & Sumarmo, U. (2021). *Hard Skills dan Soft Skills Matematika Siswa*. PT Refika Aditama.
- [12] Hidayat, W., & Aripin, U. (2023). How to Develop an E-LKPD With a Scientific Approach to Achieving Students' Mathematical Communication Abilities? In *Infinity Journal* (Vol. 12, Issue 1, pp. 85–100). <https://doi.org/10.22460/infinity.v12i1.p85-100>
- [13] Hodiyo, H. (2017). Kemampuan Komunikasi Matematis dalam Pembelajaran Matematika [Mathematical Communication Skills in Mathematics Learning]. *AdMathEdu : Jurnal Ilmiah Pendidikan Matematika, Ilmu Matematika Dan Matematika Terapan*, 7(1), 9. <https://doi.org/10.12928/admathedu.v7i1.7397>
- [14] Ilie, M. D., Maricuțoiu, L. P., Iancu, D. E., Smarandache, I. G., Mladenovici, V., Stoia, D. C. M., & Toth, S. A. (2020). Reviewing the research on instructional development programs for academics . Trying to tell a different story : A meta-analysis. *Educational Research Review*, 30, 100331. <https://doi.org/10.1016/j.edurev.2020.100331>
- [15] Ishlah, N., Syamsuadi, A., & Ernawati. (2023). Deskripsi Kemampuan Komunikasi Matematis Materi Statistika Ditinjau dari Self-Confidence Siswa Kelas VIII SMP Muhammadiyah Limbung [Description of Mathematical Communication Ability of Statistics Material in View of Self-Confidence of Students of Class VIII SMP Muhammadiyah Limbung]. *Jurnal Penalaran Dan Riset Matematika*, 2(1), 1–19. <https://doi.org/10.62388/prisma.v2i1.224>
- [16] Kamid, Rusdi, M., Fitaloka, O., Basuki, F. R., & Anwar, K. (2020). Mathematical Communication Skills Based on Cognitive Styles and Gender. *International Journal of Evaluation and Research in Education*, 9(4), 847–856. <https://doi.org/10.11591/ijere.v9i4.20497>
- [17] Kurniawan, H. (2021). The PINTER Learning Model to Enhance Higher Order Thinking and Communication Skill in Algebra. *International Journal of Instruction*, 14(3), 359–374. <https://doi.org/10.29333/iji.2021.14321a>
- [18] Kusumah, Y. S., Kustiawati, D., & Herman, T. (2020). The Effect of Geogebra in Three-Dimensional Geometry Learning on Students' Mathematical Communication Ability. *International Journal of Instruction*, 13(2), 895 – 908. <https://doi.org/10.29333/iji.2020.13260a>
- [19] Maulana, D. R., & Sritresna, T. (2021). Kemampuan Komunikasi Matematis Ditinjau dari Gender Siswa [Mathematical Communication Ability Based on Student Gender]. *FARABI: Jurnal Matematika Dan Pendidikan Matematika*, 4(1). <https://doi.org/https://doi.org/10.47662/farabi.v4i1.79>
- [20] Muhtarom, Pratiwi, A. D., & Murtianto, Y. H. (2021). Profile of Prospective Teachers' Mathematical Communication Ability Reviewed from Adversity Quotient. *Infinity Journal*, 10(1), 93–108. <https://doi.org/10.22460/infinity.v10i1.p93-108>
- [21] Mujiasih, M., Waluya, B., Kartono, K., & Mariani, S. (2021). The Students' Mathematics Communication Skill Performance After Geogebra-Assisted EPIC-R Learning Implementation. *International Journal of Learning, Teaching and Educational Research*, 20(10), 256 – 273. <https://doi.org/10.26803/ijlter.20.10.14>
- [22] Musdi, E., Syaputra, H., Arnellis, & Harisman, Y. (2024). Students' Mathematics Communication Behavior: Assessment Tools and Their Application. *Journal on Mathematics Education*. <http://doi.org/10.22342/jme.v15i1.pp317-338>
- [23] Nguyen, T. T., Nguyen, N. D., Trinh, T. P. T., Tong, D. H., Uyen, B. P., & Han, N. N. (2024). Vietnamese Sixth Graders' Mathematical Communication Competency Developed by Teaching Fraction Topics Using The 5E Model. *Heliyon*, 10(20), e39440. <https://doi.org/10.1016/j.heliyon.2024.e39440>

- [24] Noor, H. J., Masrukan, M., & Dewi, N. R. (2024). Analysis of Students' Mathematical Communication Skills in Review of Self-Efficacy in The Project-Based Learning Model Using Project Assessment. *AlphaMath: Journal of Mathematics Education*. <https://doi.org/10.30595/alphamath.v10i1.20624>
- [25] Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hrobjartsson, Loder, E. W., Mayo-Wilson, E., McDonald, S., & Moher, D. (2021). The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *Systematic Reviews*, 10. <https://doi.org/10.1186/s13643-021-01626-4>
- [26] Palinussa, A. L., Molle, J. S., & Gaspersz, M. (2021). Realistic Mathematics Education: Mathematical Reasoning and Communication Skills in Rural Contexts. *International Journal of Evaluation and Research in Education*, 10(2), 522–534. <https://doi.org/10.11591/ijere.v10i2.20640>
- [27] Pantaleon, K. V., Juniati, D., & Lukito, A. (2023). Female Student Mathematical Communication Ability in The Proving Process: a Review Based on Math Anxiety. *Bolema - Mathematics Education Bulletin*, 37(77), 1299 – 1316. <https://doi.org/10.1590/1980-4415v37n77a18>
- [28] Pourdavood, R., McCarthy, K., & McCafferty, T. (2020). The Impact of Mental Computation on Children's Mathematical Communication, Problem Solving, Reasoning, and Algebraic Thinking. *Athens Journal of Education*. <https://eric.ed.gov/?id=EJ1256896>
- [29] Prabawanto, S. (2019). Enhancement of Students' Mathematical Communication Under Metacognitive Scaffolding Approach. *Infinity Journal*, 8(2), 117–128. <https://doi.org/10.22460/infinity.v8i2.p117-128>
- [30] Richardson, W. S., Wilson, M. C., Nishikawa, J., & Hayward, R. S. A. (1995). The Well-Built Clinical Question: A Key to Evidence-Based Decisions. *ACP Journal Club*, 123, A12–A13.
- [31] Rosita, C. D., Nopriana, T., & Silvia, I. (2019). Design of Learning Materials on Circle Based on Mathematical Communication. *Infinity Journal*, 8(1), 87–98. <https://doi.org/10.22460/infinity.v8i1.p87-98>
- [32] Septiana, Kusmayati, & Fitriana. (2018). Mathematical Communication Skill of Senior High School Students Based on Their Personality Types. *Journal of Physics: Conference Series*. <https://bit.ly/45zxY5d>
- [33] Setiyani, Putri, D. P., Ferdianto, F., & Fauji, S. H. (2020). Designing a Digital Teaching Module Based on Mathematical Communication in Relation and Function. *Journal on Mathematics Education*, 11(2), 223–236. <https://doi.org/10.22342/jme.11.2.7320.223-236>
- [34] Siregar, N. F. (2018). Komunikasi Matematis dalam Pembelajaran Matematika. *Logaritma: Jurnal Ilmu-Ilmu Pendidikan Dan Sains*, 6(2), 74–84. <https://bit.ly/45Azt2X>
- [35] Tinungki, G. M., Hartono, P. G., Nurwahyu, B., Islamiyati, A., Robiyanto, R., Hartono, A. B., & Raya, M. Y. (2024). Exploring The Team-Assisted Individualization Cooperative Learning to Enhance Mathematical Problem Solving, Communication and Self-Proficiency in Teaching Non-Parametric Statistics. *Cogent Education*, 11(1), 2381333. <https://doi.org/10.1080/2331186X.2024.2381333>
- [36] Tinungki, G. M., Nurwahyu, B., & Hartono, A. B. (2022). Team-Assisted Individualization Type of The Cooperative Learning Model for Improving Mathematical Problem Solving, Communication, and Self-Proficiency: Evidence from Operations Research Teaching. In *Education Sciences*. [mdpi.com. https://bit.ly/4oCKfyv](https://bit.ly/4oCKfyv)
- [37] Tong, D. H., Uyen, B. P., & Quoc, N. V. A. (2021). The Improvement of 10th Students' Mathematical Communication Skills Through Learning Ellipse Topics. *Heliyon*, 7(11), e08282. <https://doi.org/10.1016/j.heliyon.2021.e08282>
- [38] Uyen, B. P., Tong, D. H., & Tram, N. T. B. (2021). Developing Mathematical Communication Skills for Students in Grade 8 in Teaching Congruent Triangle Topics. *European Journal of Educational Research*, 10(3), 1287–1302. <https://doi.org/10.12973/eu-jer.10.3.1287>
- [39] Wahyudi, Ambarwati, M., & Indarini, E. (2019). Development of Web Game Learning Materials for Primary School Students. *Infinity Journal*, 8(2), 199–208. <https://doi.org/10.22460/infinity.v8i2.p199-208>
- [40] Wardono, Rochmad, Uswatun, K., & Mariani, S. (2020). Comparison Between Generative Learning and Discovery Learning in Improving Written Mathematical Communication Ability. *International Journal of Instruction*, 13(3), 729–744. <https://doi.org/10.29333/iji.2020.13349a>
- [41] Zawacki-Richter, O., Kerres, M., Bedenlier, S., Bond, M., & Buntins, K. (2020). *Systematic Reviews in Educational Research: Methodology, Perspectives and Application*. Springer. Springer Fachmedien Wiesbaden. <https://doi.org/10.1007/978-3-658-27602-7>