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Efforts to Improve Mathematical Communication Skills in Mathematics Learning in Indonesia

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ABSTRACT

This research aims to identify various models/methods/strategies and media that are effective in improving mathematical communication. This study uses the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method with four stages, namely identification, scanning, eligibility, and inclusion. Harzing's Publish or Perish (PoP) is used to search for required research references. The research results found 30 publications regarding efforts to improve mathematical communication skills in schools and universities. Middle school level and geometry materials are most often used by researchers in efforts to improve mathematical communication. The results of this research can be a reference for teachers to choose the right model/method/strategy and media to improve mathematical communication skills in pupils and students.

ABSTRAK

Penelitian ini bertujuan untuk mengidentifikasi berbagai model/metode/strategi dan media yang efektif dalam meningkatkan komunikasi matematika. Studi ini menggunakan metode PRISMA (*Preferred Reporting Items for Systematic reviews and Meta-Analyses*) dengan empat tahapan, yaitu *identification*, *scanning*, *eligibility*, *dan inclusion*. Harzing's Publish or Perish (PoP) digunakan untuk menelusuri referensi penelitian yang dibutuhkan. Hasil penelitian menemukan 30 publikasi tentang upaya peningkatan kemampuan komunikasi matematika di sekolah dan perguruan tinggi. Jenjang SMP dan materi geometri paling sering digunakan peneliti dalam upaya meningkatkan komunikasi matematika. Hasil penelitian ini dapat menjadi rujukan bagi pengajar untuk memilih model/metode/strategi dan media yang tepat dalam upaya meningkatkan kemampuan komunikasi matematika pada siswa dan mahasiswa.

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INTRODUCTION

Mathematics learning in the 21st century is expected to equip students with higher order thinking skills (HOTS), which include critical thinking skills, creative thinking, problem solving and collaboration (Trilling & Fadel, 2009). 21st century skills must be mastered by learners (Pratiwi et al, 2019) in order to be able to compete in this era, therefore the world of education must be able to answer learning challenges that can develop learners to master 21st century skills. This is in line with the 21st century skills framework which makes mastery of problem solving skills, critical thinking, communication, and the use of ICT as important skills that every individual must have (Voogt & Roblin, 2012).

One of the important issues in mathematics learning in the 21st century is the need to develop critical mathematical thinking skills and mathematical problem-solving abilities. The aim of mathematics education in Indonesia, namely to develop students who have the ability to think logically, analytically, systematically, critically, creatively, collaboratively and have good communication skills (Yuliani, 2022). This is in line with the goals of mathematics learning according to the National Council of Teachers of Mathematics namely developing students to have problem solving, reasoning and proof, connection, communication and representation abilities (NCTM, 2000).

One of the basic abilities that must be possessed in the 21st century is communication skills. Communication is an important part of mathematics and mathematics learning (National Council of Teachers of Mathematics, 2000). Communication skills are very important when someone is going to convey their thoughts and ideas either verbally or in writing. Communication skills in mathematics are known as mathematical communication skills. Mathematical communication skills are skills for expressing and sharing ideas about mathematics (Chasanah et al., 2020). Communication skills can also be defined as the ability to convey mathematical ideas and the ability to understand and accept other people's mathematical ideas carefully, analytically, critically and evaluatively (Syukri et al., 2020). Mathematical communication is a way of sharing ideas, clarifying understanding, and communicating ideas through reflection, revision, and modification (Darto, 2021).

Based on this understanding, it can be concluded that mathematical communication is the ability to convey mathematical thoughts or solutions in solving a problem.

Mathematical communication can use symbols, notation and mathematical language in spoken, written or visual form so that understanding mathematical symbols can be an effort to make mathematical communication easier (Pierce & Begg, 2017). Many learners understand mathematics as memorizing symbols so they have difficulty communicating mathematics as a narrative (Pierce & Begg, 2017). Teachers need to develop various efforts to increase effective mathematical communication among students.

To increase effective mathematical communication, teachers can use various techniques such as creating a comfortable learning environment, collaborative learning, modeling, stimulating students with various questions, gaining new experiences to build mathematical connections (Cooke & Buchholz, 2005). Mathematical communication can be influenced by gender and learning styles (Kamid et al., 2020; Qirom et al., 2023), therefore it is important for teachers to use various strategies in learning and use various models, methods and media that are relevant to the type of learning. learner.

Research on various efforts to improve mathematical communication has been widely carried out, but there is still little literature that collects various media in efforts to improve mathematical abilities among pupils and students in Indonesia. This research seeks to complement existing research by identifying various methods used by researchers in an effort to improve mathematical communication among learners. This research seeks to identify and compile various effective efforts to improve mathematical communication skills. It is hoped that from this research teachers and lecturers can apply appropriate methods/models/strategies/approaches/media in an effort to develop mathematical communication among students and students in Indonesia.

METHOD

This study uses the systematic literature review (SLR) method, which is a rigorous and robust approach to identifying, assessing, and synthesizing findings from primary research studies (Chapman et al., 2023). This study used the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) method (Moher et al., 2009). The technique for presenting data distribution based on main keywords is using the VoSviewer application. The next stages of research using the PRISMA method are explained in more detail as follows.

Identification

Identification is carried out through literature search. Literature searches are carried out online via the Harzing's Publish or Perish (PoP) application. The selected publication time range is articles published in the last 5 years, 2012-2023. Harzing's Publish or Perish (PoP) was chosen to speed up the discovery of suitable references. Semantic Scholar was chosen in the PoP application for data networking because it has complete data-based data and free access. Google Scholar based data is not used as a reference in this research considering that the data produced is not specific to the search target and produces too much output so it takes time to identify (Peter et al., 2019).

To make it easier to search for literature, specific keywords are used, namely: "mathematical communication", and "mathematical ability". These keywords are used to obtain specific publication data for research purposes.

Scanning

This scanning stage is carried out by reading the title and abstract of the research to obtain the main content of the article. The article scanning process is assisted by the https://typeset.io/ application to speed up finding the main idea and main content of the article.

Eligibility

The eligibility stage is carried out by selecting based on specified criteria, namely the year of publication between 2013-2023 in order to obtain publications that are more up to date, published online, in English or Indonesian, there are methods and testing the effectiveness of the methods used, the data comes from

journals international, ISSN national journals, international and national proceedings. Books, chapter books, and scientific works in the form of papers are not included in the criteria because they do not have research methods and effectiveness testing.

The criteria set aim to ensure that the journals analyzed have a new range of publications so that they are still relevant. English and Indonesian language journals were chosen because they are based on the research context in Indonesia. To simplify the analysis, the journal review focuses on the title, abstract, keywords, methods, and research results and conclusions.

Inclusion

At this stage the journal is read in full to find out the entire contents and is focused on determining the method and effectiveness of using the method in an effort to improve mathematical communication skills. The following is a flowchart of analysis literature using the PRISMA method.

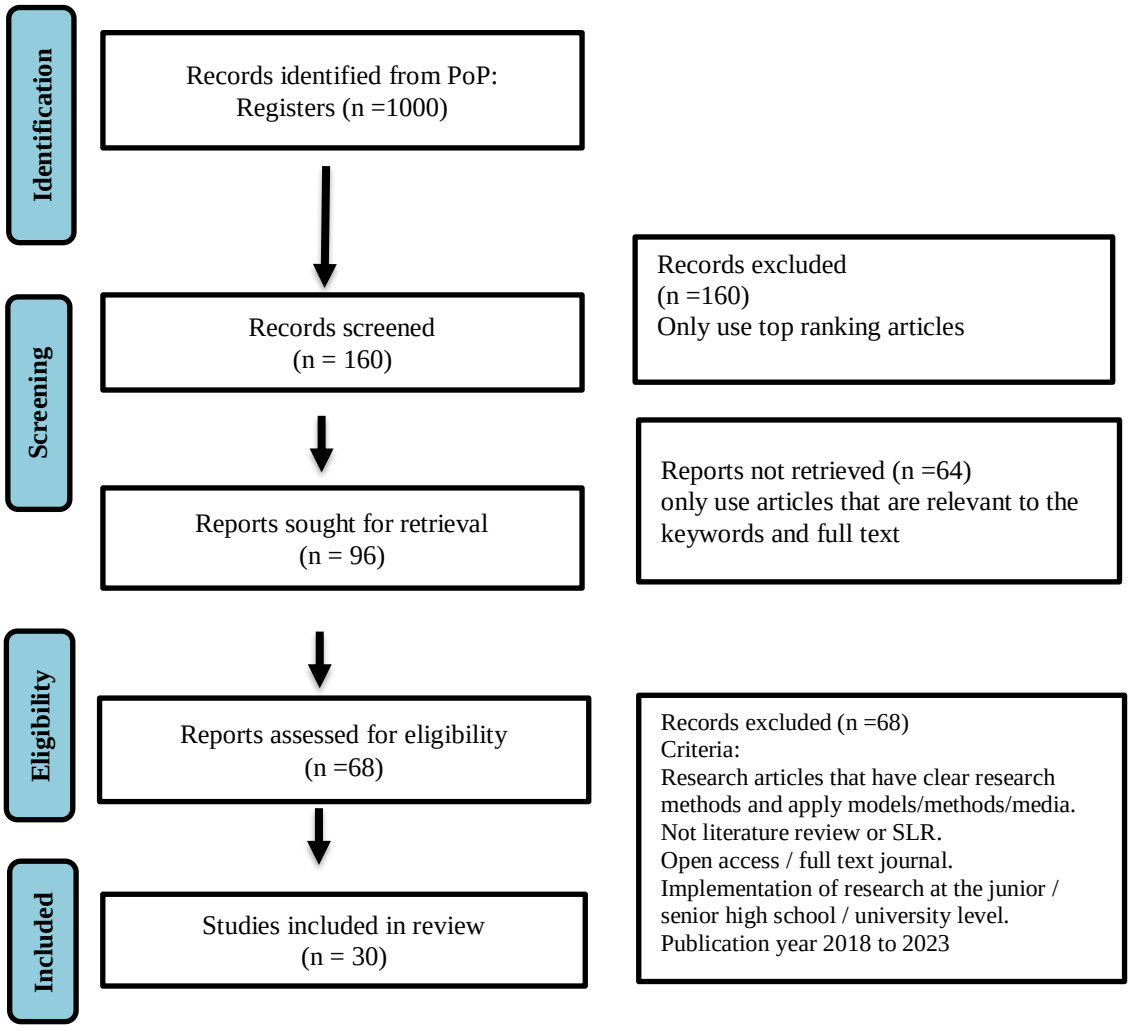

Figure 1. Systematic review flow diagram using the PRISMA method

Based on Figure 1, it can be explained that the SLR stage begins with the identification stage through searching journals with the PoP application and obtaining 1000 article titles according to the keywords used. After reducing duplication and suitability of articles, 160 top articles were selected. At the stage of scanning the contents of the journal, there were 160 articles whose abstracts were read with the help of the application https://typeset.io/ and 96 journals were obtained that met the specified criteria. There were 68 journals that passed the scanning stage and were then read in full using fast reading techniques and 30 eligible journals were obtained for analysis.

RESULTS AND DISCUSSION

To determine trends in research topics in an effort to improve mathematical communication, research theme mapping was carried out using VOSviewer. Mapping using VOSviewer can find keywords used in mathematics communication research so that from the mapping you can see various efforts to improve mathematics communication through the application of various strategies, models, methods or media that are widely used by researchers in Indonesia.

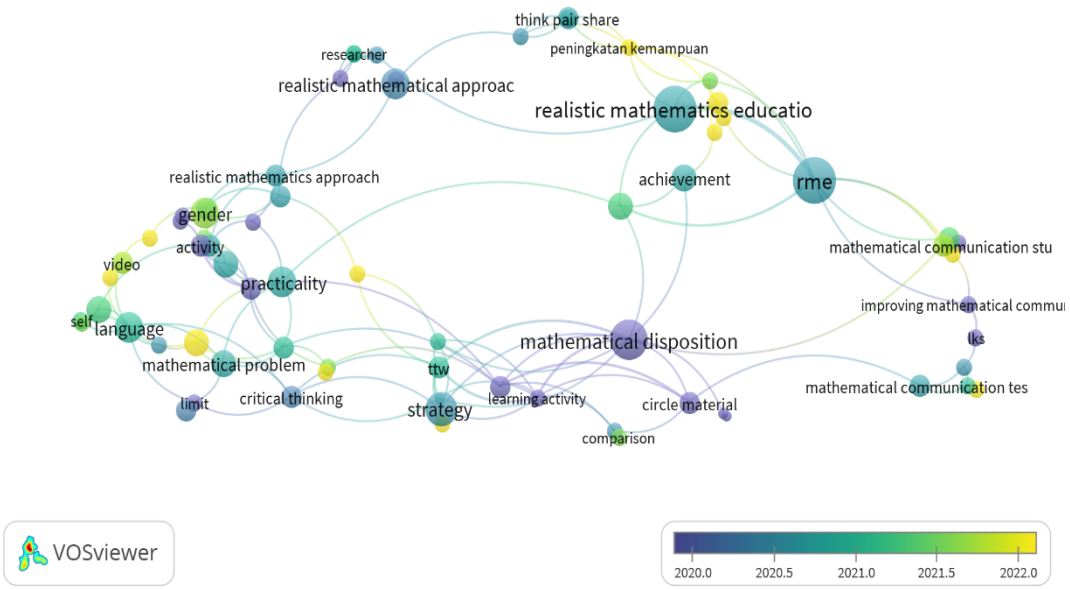

Figure 2. VOSviewer output results

Based on Figure 2, it is known that the keywords "realistic mathematics", "RME" are the words that appear most frequently in connection with efforts to improve mathematical communication. Several other methods such as cooperative learning, Think Pair Share (TPS), and the use of video media are also keywords that appear in mapping using VOSviewer, this indicates that these models and media are also often used in mathematics learning with a focus on improving mathematical communication skills. The following is the trend of articles analyzed based on the year of publication.

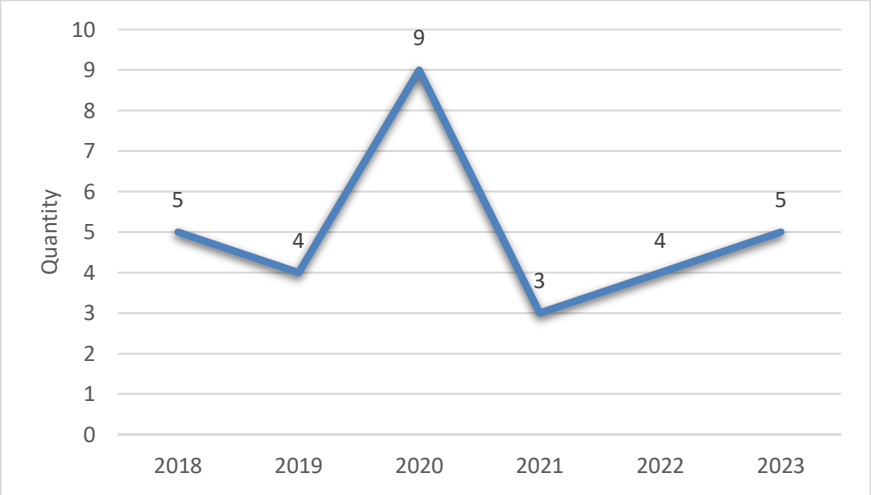

Figure 3. Trend of Mathematics Communication Research Articles Based on Publication Year

Based on Figure 3, it is known that the most articles published in 2020 were analyzed in this research. In that year, many research publications were published regarding mathematical communication, especially those related to aspects of mathematical communication within the limitations caused by the Covid-19 pandemic. The least number of article publications in 2021 were analyzed in this study. This may be due to the decline in research trends that year. Furthermore, an overview of research trends in improving mathematical communication based on research levels is presented in Figure 4.

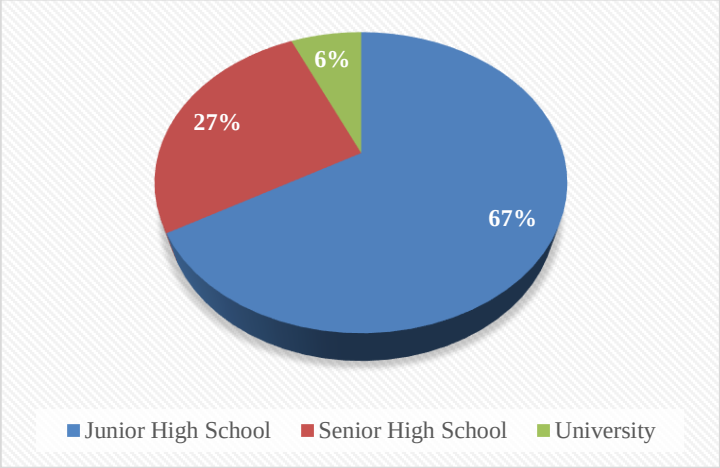

Figure 4. Trends in Mathematics Communication Research Based on Level of Education

Referring to Figure 4, it can be seen that the trend of mathematics communication research is mostly carried out at the junior high school level, namely 67%. This trend is related to efforts to improve communication among junior high school students who will develop better in the concrete operational transition phase to the formal operational phase so that it is more unique to examine.

Table 1. Mathematics Communication Articles Based on Citations

Author's	Title	Citation
Triana et al., 2019	Students' Mathematical Communication Ability through the Brain-Based Learning Approach using Autograph	91
Trisnawati et al., 2018	The effect of realistic mathematics education on student's mathematical communication ability	59
Palinussa et al., 2021	Realistic mathematics education: Mathematical reasoning and communication skills in rural contexts	37
Paroqi et al., 2020	The Implementation of Realistic Mathematics Education Approach to Improve Students' Mathematical Communication Ability in Statistics Course.	28
Paroqi et al., 2020	Education Videos on The Linear Program Material as Observed in Vocational High School Students'mathematical Communication	21

Table 1 shows the selected articles based on the number of citations. The highest number of citations is in the article written by Triana et al. (2019) with 91 quotes as of 27 December 2023. The themes related to Brain-Based learning raised in this research are rarely studied and are unique, so they are often used as references by other authors. The following are trends in the study of teaching materials used in relation to mathematical communication in schools and universities.

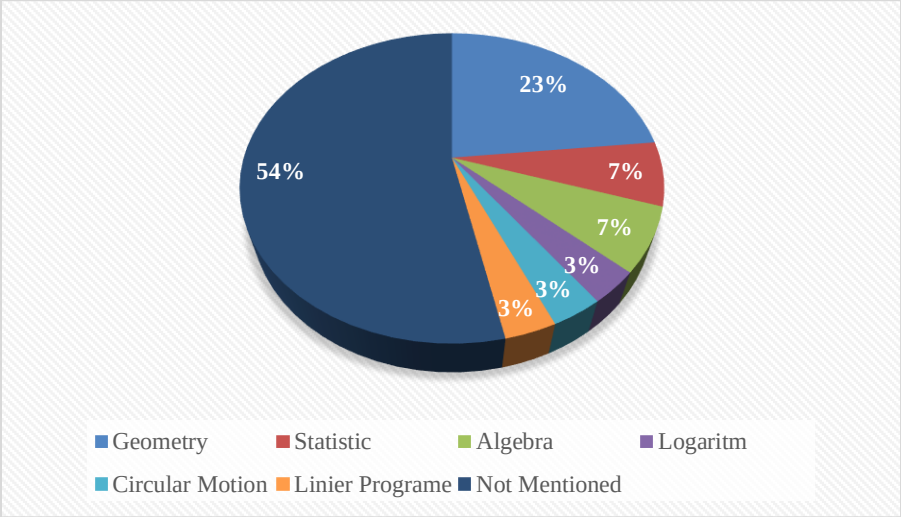

Figure 5. Distribution of Research Trends Based on Teaching Materials

Figure 5 shows the distribution of SLR research trends based on the teaching materials used in the research. Geometry, statistics and algebra materials are most often used by researchers to describe mathematical communication skills. As many as 54% of the studies did not specifically mention the teaching material used in the research so that the reference used was the highest percentage that specifically mentioned the teaching material, namely geometry material with a percentage of 23%.

Table 2. SLR Research Results

Model/Method/Media	Level	Reference	Result
Realistic Mathematical Education (RME)	Senior High School	(Trisnawati et al., 2018)	Effective
	Junior High School	(Palinussa et al., 2021)	Effective
	Junior High School	(Harahap & Sari, 2022)	Effective
	Junior High School	(Septriyana et al., 2018)	Effective
	Junior High School	(Fitrianti et al., 2018)	Effective
	Junior High School	(Dasini, 2022)	Effective
	Junior High School	(Paroqi et al., 2020)	Effective
Media ICT & E-learning	Senior High School	(Syukri et al., 2020)	Effective
	Senior High School	(Dewi & Kuswanto, 2020)	Effective
	Junior High School	(Kurniawati & Azka, 2022)	Effective
	University	(Hutajulu, 2022)	Effective
	Junior High School	(Tambunan & Syahputra, 2023)	Effective
	Junior High School	(Rahmawati et al., 2020)	Effective
	Senior High School	(Zakiah et al., 2018)	Effective
Cooperative Learning	Junior High School	(Sarah et al., 2021)	Effective
	Junior High School	(Mulia et al., 2021)	Effective
	Junior High School	(Firdaus, 2019)	Effective
	Junior High School	(Hendrayati et al., 2019)	Effective
	Senior High School	(Imron, 2019)	Effective
	Junior High School	(Hasanah, 2020)	Effective

Model/Method/Media	Level	Reference	Result
Quantum Learning	Junior High School	(Utari et al., 2020)	Effective
	Junior High School	(Basuki et al., 2020)	Effective
Problem Based Learning	Senior High School	(Zakiri et al., 2018)	Effective
(PBL)	Junior High School	(Anam et al., 2020)	Effective
Generative Learning Model (GLM)	Junior High School	(Hulukati et al., 2023)	Effective
Case Base Learning (CBL)	University	(Suratno et al., 2023)	Effective
Brain-Based Learning (BBL)	Senior High School	(Triana et al., 2019)	Effective
Discovery Learning	Senior High School	(Firmansyah et al., 2023)	Effective
Inquiry	Junior High School	(Supiyanto et al., 2020)	Effective
Search, Solve, Create, and Share (SSCS)	Junior High School	(Putriana & Haqiqi, 2023)	Effective

Based on Table 2, it is known that Realistic Mathematical Education (RME) is the method most often used to improve mathematical communication skills. ICT & e-learning based media, cooperative models with various variations as well as various other methods such as quantum learning, PBL, generative learning models, CBL, BBL, discovery, inquiry, and SSCS. Apart from the models/methods listed in Table 2, there are still several other methods that are not listed because the articles cannot be accessed in full or do not meet the specified criteria.

Realistic Mathematical Education (RME) is most often chosen in efforts to improve mathematical communication skills. Research conducted by Harahap & Sari, (2022) found that the use of RME is more effective in improving mathematical communication skills due to several factors such as contextual, fun learning, more meaningful learning, discussion and collaboration, and providing context to the visual representation. This is in line with the results of research conducted by Darto, (2021) who found that the use of RME in mathematics learning in elementary schools increases problem solving by students, makes learning more contextual, trains critical thinking, and uses mathematical tools (symbols, tables, paragraphs) to resolve issues and discuss them.

RME is a learning approach that emphasizes the use of everyday context and environment in teaching mathematics so as to construct and communicate experiences (Trisnawati et al., 2018). The application of RME provides students with the opportunity to express mathematical models in simple language, explain mathematical ideas, situations and relationships both orally and in writing, as well as express mathematical situations or everyday events in mathematical models and solve them until finally a formal formula is obtained (Septriyana et al., 2018).

Efforts to improve communication skills can also be made through various effective media (Angela & Subekti, 2022). The use of various ICT learning media such as Augmented Reality (AR) and mobile learning can be an effective and fun solution for building mathematical communication skills (Dewi & Kuswanto, 2020; Allen, 2017; Marei & Altarawneh, 2023). Efforts to improve mathematical communication skills with the help of media include: ICT media, video, LMS, applications (Geogebra) and artificial intelligence in the form of Augmented Reality. The use of this media is effective in facilitating the development of mathematical communication skills, especially in students.

Cooperative learning models with various variations such as Think Pair Share (TPS), Team Game Tournament, Cooperative Script and others are also widely used in efforts to improve mathematical communication skills. The use of the cooperative model has been proven to be able to encourage teamwork, build communication and use effective mathematical language in problem solving. This will certainly encourage students' mathematical communication skills to be even better (Mulia et al., 2021; Sarah et al., 2021). The results of this research also found that all efforts made in the research (Table 2) showed effective results, meaning that all treatments used in the research could be chosen as alternative solutions to improve mathematical communication skills. The most recommended method/approach based on this research is RME because it has more suitable characteristics and is often used as a solution in improving mathematical communication skills.

CONCLUSION

Based on the research results, 30 articles were obtained that were relevant to the research objectives to be achieved, namely identifying various efforts to improve mathematical communication skills. The results of the analysis found Realistic Mathematics Education (RME) as a method/approach that is often implemented in an effort to improve mathematics communication among pupils and students. ICT & e-learning based media, cooperative models and various other models/methods/approaches such as quantum learning, PBL, generative learning models, CBL, BBL, discovery, inquiry, and SSCS as other alternatives that can be chosen to improve mathematical communication skills. This research also found that

efforts to improve mathematical communication skills were more closely examined at the junior high school level, with geometry teaching material being the most frequently chosen. The results of this research can be a reference for teachers and lecturers in implementing effective learning methods to improve mathematical communication among students. For the researchers in the future can be implemented in the school in the same grade. For example in Islamic school or vocational high school students.

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