
The Enhancement of Students Mathematical Communication Ability Through RME-Textbook

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Informasi Artikel

Article History:

Received November 10th, 2020

Revised Desember 21st, 2020

Accepted January 02nd, 2021

Keywords:

Realistic Mathematics Education; textbook; mathematical communication

ABSTRACT

This study was a research and development used ADDIE model aimed to produce mathematics textbook for 8th-grade students by applying five principles of the Realistic Mathematics Education (RME) approach, included: phenomenological exploration, bridging by vertical instruments, self-reliance with students own constructions and productions, interactivity, and intertwining. The subject in this study involved 30 students' junior high school in Yogyakarta. The qualities of the developed textbook refer to three criteria, namely validity, practicality, and effectiveness. Supporting instruments used to examine three criteria for the quality of the textbook were validation sheets, assessment sheets for teachers and students, and students' mathematical communication ability test. The textbook meets the criteria of validity, practicality, and effectiveness if at least "good" from the results of validator assessments, the results analysis from teachers and student assessments, and at least 75% of the students' mathematical communication ability test results. Based on the results of this study, the developed textbook has met the criteria of validity (very good), practicality (very good by the teacher and good by students), and effectiveness (good for 86.67%). Therefore, developing textbooks is suitable to use as an alternative to enhance the students' mathematical communication ability.

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INTRODUCTION

Communication is an indispensable ability in various fields of human life as a social being. In mathematics learning, communication has a major role for teachers and students to exchange and build knowledge in both spoken and written symbols. Through communication, students can organize, reflect on, and clarify ideas, relationships, mathematical thinking, and mathematical arguments. There are several goals for students to communicate during mathematics learning, including presenting or justifying solutions and expressing arguments or asking questions, to different audiences such as teachers, students, groups of students, or the whole class (Vale & Barbosa, 2017). Without communication ability, mathematics will be difficult to delivered from teacher to students, and conversely, the teacher will be difficult to know the level of students' mathematical knowledge.

NTCM (2000) emphasizes that it is important for students to have communication ability because the delivery of mathematical ideas is often carried out in the form of symbols,

oral, or written communication. The same thing with the importance of providing students' mathematical communication ability is also stated in Regulation of Education Ministry and Culture Number 21 Year 2016 about Standard of Content. Through this regulation, it is stated that national education starting from primary to secondary levels, one aims to produce students with communication ability. In particular, this is also expressed through one of the competencies required in mathematics for 8th to 9th grade that students can to communicate mathematical ideas.

Students who have mathematical communication ability will be able to give the reasons clearly for a mathematical concept both orally and in writing. This is supported by Lomibao, Luna, & Namoco (2016) that define that mathematical communication ability in mathematics is the ability of students to explain and justify through the expression of ideas, description, and discussion of mathematical concepts coherently and clearly using specific procedures and processes, both orally and in writing. Similarly, communication mathematics ability according to Lestari & Yudhanegara (2017) is the ability of students to deliver mathematical ideas, both orally, and in writing and the ability to understand and accept other students' mathematical ideas carefully, analytically, critically, and evaluatively to sharpen the understanding.

Even though it is one of the demands as well as an important thing that students need to have in learning mathematics, their communication abilities are still low. The results of PISA (Programme for International Student Assessment) in 2015, in which communication ability is one of the measurement indicators showed that Indonesia is ranked 62 of 70 participants with an average score is 386. This score is still below the international average which is 490 (OECD, 2016).

In order to improve the quality of learning, the government and curriculum developers make various efforts such as updating the curriculum and providing supporting tools. One of the supporting tools which is quite influential in the success of learning is a textbook. Textbooks are also an investment and to affect students powerfully and directly because they involve school activities in them. Textbooks provide a framework about what to teach, how it can be taught, and the order of a concept that can be taught by the teacher to students (Reys, Reys, & Chavez, 2004; Nicol & Crespo, 2006). Besides a good resource for building learning opportunities, textbooks are also good indicators of measuring students' math learning opportunities. This is because textbooks are a reflection of the school curriculum (Yang, Tseng, & Wang, 2017).

Textbooks as one of the teaching materials used in Indonesia also still have many weaknesses. Wijaya, van den Heuvel-Panhuizen, & Doorman (2015) have analyzed three mathematics textbooks for junior high school in Indonesia, two of them are for 8th grade students. Based on the results of this study, 85% of the questions in the textbook provided the information needed to solve these questions. This showed that textbooks do not facilitate students in constructing their abilities.

Then the results of the study revealed that only 45% of the questions based on context required routine mathematical procedures. This indicated that mathematics textbooks in Indonesia only emphasize procedural abilities and do not provide opportunities for students to do mathematization or modeling activities that are part of the mathematical communication process. The results of the analysis in the study also stated that only 2% of the reflection assignments contained in the textbook. This reflection is not only to reflect and gain insight into mathematics but also to communicate arguments. This showed that there are not many mathematics textbooks in Indonesia that facilitate students' mathematical communication abilities.

Regulation of National Education Ministry Number 16 Year 2007 about Academic Qualification Standards and Teacher Competencies stated that one of the core pedagogical competencies that teachers must have is being able to develop a curriculum related to the subject being taught. This means that mathematics teachers also have to develop teaching materials in the form of textbooks as a school curriculum's reflection. Even though textbooks according to the curriculum are abundant, it does not mean that teachers do not need to develop them. Here are some reasons teachers need to develop teaching materials. The first is as a guide for students. So many teaching materials can confuse students so that teachers need to make teaching materials that become guidelines for students. The second is according to student characteristics. Teaching materials developed by the government or others are often not suitable for students for several reasons so that teachers need to make teaching materials that can be adapted to target characteristics, such as social environment, cultural and geographic, basic abilities, level of student development, interests, family background, etc. The third is the book developed can solve the difficulties experienced by students in learning (Depdiknas, 2008).

However, based on the results of the pre-research, 86% of 8th-grade mathematics teachers in Yogyakarta used the 2013 curriculum mathematics textbook provided by the government as a reference and guide in learning, while the rest use certain publishers. The students also followed the use of the book as a guide in the learning process. This shows that the teacher's lack of competence and creativity in developing their learning textbooks oriented to mathematical abilities.

The importance of students having mathematical communication abilities, it is necessary to develop textbooks that can facilitate the improvement of these abilities. One possible approach is Realistic Mathematics Education (RME). RME is an approach in mathematics learning that is based on real-world contexts or what students can imagine. This approach emphasizes student activities to find and build their mathematical concepts, while the teacher only acts as a facilitator in learning. Gravemeijer (2010) defines that RME is a domain-specific teaching theory which guidelines students in constructing or reinventing mathematical concepts. Mathematical concepts are obtained through interactive teaching between teachers and students, between students, which is centered on a particular problem. The difference between the realistic approach and other approaches was also emphasized by Johar (2010) that it lies in the learning trajectory of the teacher's design that describes mathematics is not as a ready-made, but as acted-out. It means that mathematics learning with this approach starts with real problems, then students find informal solutions to real problems in the form of models or pictures or sketches or patterns, and finally, students achieve higher mathematical abilities.

Various real-world problems or what students can imagine as a starting point in learning using RME are converted into a mathematical system. This change in concrete mathematics towards formal level knowledge cannot be separated from the process of mathematization. Treffers (1987) distinguishes mathematization into two types, namely horizontal mathematization and vertical mathematization. In horizontal mathematization, students express mathematical tools to help organize and solve problems that exist in real-life situations. Meanwhile in vertical mathematization is a process of various reorganize and operations within the mathematical system itself.

Progressive mathematization in RME, both vertical and horizontal mathematization are based on five teaching principles, namely phenomenological exploration, bridging by vertical instruments, self-reliance: pupils' own constructions and productions, interactivity, and intertwining (Treffers, 1987). The characteristics of the textbooks that were developed contain RME teaching principles in the form of giving problems that can be discussed

interactively, which certainly can facilitate students' mathematical communication skills. This is supported by Van de Walle, Karp, & Bay-Williams (2013) that revealed that an environment of active discussion that encourages students to interact and explore in class can practice their mathematical communication abilities by exchanging and strengthening ideas.

METHOD

This development research aimed to produce mathematics textbook for junior high school students of 8th-grade even semester with the Realistic Mathematics Education (RME) approach oriented to mathematical communication ability which quality was based on criteria Nieveen (1999) namely valid, practical, and effective. Quantitative data on these three criteria were converted into qualitative based Widoyoko (2017) which can be seen in Table 1. The book developed was said to be valid, practical, and effective in sequence if: the results of the validator's assessment are at least in the good category, the results of teacher and student assessments are at least in the good category, and the results of the students' mathematical communication abilities test at least 75% are in the good category. The quality of the developed book was obtained by using test and non-test in several instruments, namely validation sheets, assessment sheets for teachers and students, and mathematical communication ability test questions.

Table 1. Conversion of quantitative data into qualitative

Interval scores	Categories
$X > \bar{X}_i + 1,8 \times sb_i$	Very good
$\bar{X}_i + 0,6 \times sb_i < X \leq \bar{X}_i + 1,8 \times sb_i$	Good
$\bar{X}_i - 0,6 \times sb_i < X \leq \bar{X}_i + 0,6 \times sb_i$	Medium
$\bar{X}_i - 1,8 \times sb_i < X \leq \bar{X}_i - 0,6 \times sb_i$	Low
$X \leq \bar{X}_i - 1,8 \times sb_i$	Very low

Information:

\bar{X}_i = ideal average = $\frac{1}{2}$ (ideal maximum score + ideal minimum score)

sb_i = ideal standar deviation = $\frac{1}{4}$ (ideal maximum score - ideal minimum score)

X = empirical score

Maximal score = number of items x maximal score

Minimum score = number of items x minimum score

The textbook produced in this development research used the ADDIE (Analyze, Design, Develop, Implement, and Evaluate) model through five sequential stages, namely analysis, design, development, implementation, and evaluation (Branch, 2009). At the analysis stage, the researcher conducted an analysis of the needs, students, the material developed in the book. At the design stage, various preparations were made to design textbooks with other supporting instruments both technically and substantially. At the development stage, a validation and revision process was carried out based on the results of the assessment and input from three experts to the draft of the textbook. At the implementation stage, a field trial was conducted to see the practicality and effectiveness of the textbooks that had been developed involving a mathematics teacher and 30 students from a 8th grade junior high school in Yogyakarta at even semester of the school year 2017/2018. Finally, in the evaluation stage, an analysis of practicality and effectiveness was carried out as well as the final revision of the input given by the teacher and students to the developed textbook.

RESULTS AND DISCUSSION

The qualities of the developed textbook that are valid, practical, and effective are obtained from the development stage to the evaluation stage. At the development stage, the draft of the textbook was validated by three experts. The results of this expert's assessment stated that developed textbook was valid and suitable to use in the learning class. In detail, the average score from the experts to the assessment components of the textbook developed can be considered in Table 2. Based on the table, developed textbook was in the very good validity category for all assessment components, namely the content (material and suitability with mathematical communication ability), RME approach, presentment, language, and graphics.

Table 2. Validity of the textbook

Assessment Components	Average scores	Categories
Content	4,51	Very good
RME approach	4,33	Very good
Presentment	4,67	Very good
Language	4,33	Very good
Graphic	4,75	Very good

Furthermore, at the end of the implementation stage involved 30 students of 8th grade, data was obtained to see the practicality and effectiveness of the developed textbook. Practicality data obtained from the results of teacher and student assessments toward the book. Meanwhile, the effectiveness data was obtained from the results of students' mathematical communication ability test. These two data are then analyzed at the evaluation stage.

Based on the results of the analysis at the evaluation stage which can be considered in Table 3, the visual aspects and the ease of use of the teacher's assessment were in the very good category with an overall average score of 4.50. Meanwhile, student assessments were in the good category with an average overall score of 3.79. The results of the assessment of both met the minimum being in the good category, so that the developed textbook met the practical criteria.

Tabel 3. Practicality of the textbook

Aspects of the assessment	Teacher Assessment		Student Assessment	
	Average scores	Categories	Average scores	Categories
Visual	4,67	Very good	3,96	Good
Ease of use	4,33	Very good	3,61	Good
Overall average	4,50	Very good	3,79	Good

Meeting of practical criteria from the ease of use's aspect related to the systematics of presentation; the language used; understanding of the images, graphs, tables, and illustrations presented; understanding instructions, procurement of tools or materials, and implementation of activities in books. Meanwhile, the meeting of practical criteria from display's aspect is related to the suitability size, thickness, and weight of the book; clarity of type and size; clarity of images, graphics, or tables of appearance in the developed textbook. Overall, the visual of the book consists of two components, namely the main and additional components that can be considered in figure 1. The main components consist of a cover, book identity, preface, table of contents, instructions for using the book, introduction to the topic, concept maps, section activities, problem example, section exercises, summary, chapter evaluation exercises, glossary, and references. Meanwhile, additional components consist of 'Do you know?' which contains encyclopedias related to the material being studied, 'Tekomnet' which contains how to use computer applications and site providers

regarding the material being studied, 'Glimpse of figure' which contains stories or history of figures related to the material, and 'Play while learning' contains games that are as well as train understanding of the material that students have learned. The provision of this additional component is intended so that students can add insight into the material being studied in the textbook.

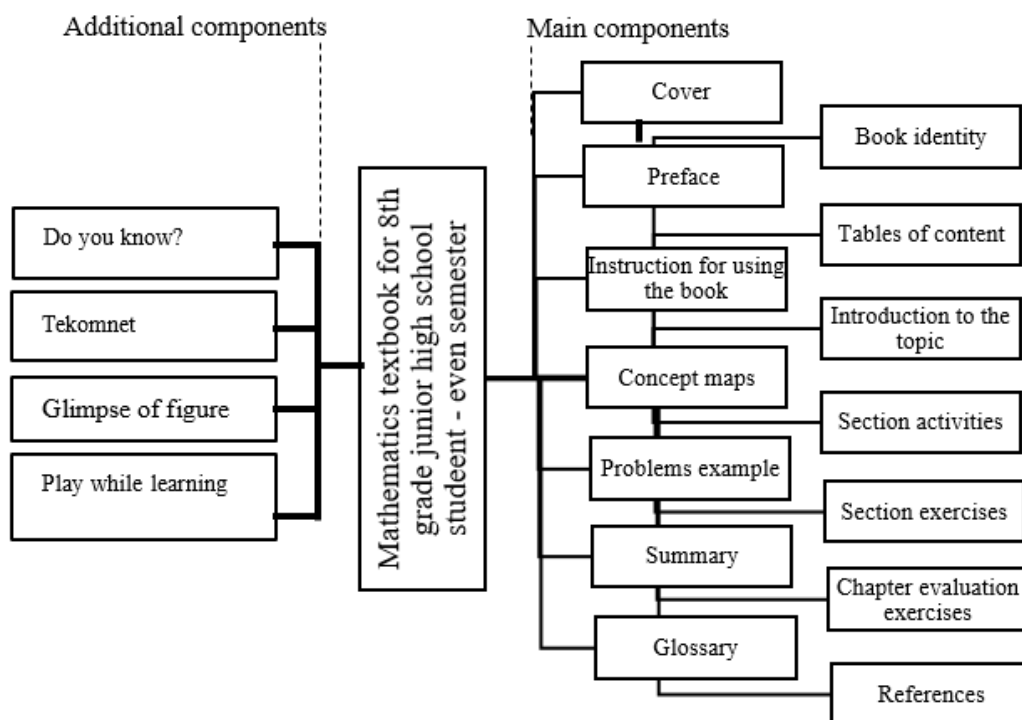


Figure 1. Components of textbook

Then, at the evaluation stage, a result's analysis of students' mathematical communication ability test was also carried out to see the effectiveness of the developed textbook. The results of the analysis that can be seen in Table 4 showed that the average score of students' mathematical communication ability was good with an average score of 78.13. There were no students who were in the low and very low category but only in the upper-medium category. In the medium category, there were only 4 students with a percentage of 13.33%. The rest, 10 students were in a good category and 16 students were in a very good category with the respective percentages of 33.33% and 53.33%. As for the number of students who were at least good were 26 students with a percentage of 86.67% > 75%. Thus, the developed textbook is effective in terms of students' mathematical communication ability.

Table 4. Students' Mathematical Communication Ability

Categories	Number of students	Percentage	Average value
Very Good	16	53,33 %	78,13 (Good)
Good	10	33,33 %	
Medium	4	13,33 %	
Low	0	0 %	
Very low	0	0 %	

Mathematical communication ability as well as indicators were also facilitated after using the developed textbook. By observing Table 5, there were four indicators of

mathematical communication that can be achieved after using this book. The textbook has facilitated the four indicators in the best order, namely express a mathematical idea visually, express mathematical ideas from a visual representation, express the mathematical idea of a problem, and express reason of a mathematical idea put forward.

Table 5. Achievement Indicators of Students' Mathematical Communication Ability

Indicators	Average scores	Categories
Express the mathematical idea of a problem	3,12	Good
Express reason of a mathematical idea put forward	2,72	Good
Express a mathematical idea visually	3,42	Very good
Express mathematical ideas from a visual representation	3,25	Very good

Besides practice questions in accordance with the indicators of students' mathematical communication ability available in the book, the material provided also applies the principles of RME teaching. The principle of interactivity which is applied through learning 'activities' (see figure 2a) in book facilitates active discussion of students in the learning process to intertwine and express ideas or strategies along with reasons. This discussion activity begins with applying the principles of phenomenological exploration by giving students real or imagined problems. Space for students to write down the results of the discussion is also available which an application of the principle of bridging by vertical instruments and also self-reliance: pupils' own constructions and productions. Indirectly, this space also provides opportunities for students to express ideas both written and visual along with reasons. Meanwhile providing space for users, the book also presents not only limited writing and or formulas for the material being studied, but also various visual representations (see figure 2b).



Activity 1.1

Purpose : Prove the Pythagorean Theorem

Tools/materials : Millimeter block paper, scissor, and stationery

Activity steps:

- 1) Sit in groups of 3-4 peoples.
- 2) Provide the necessary tools / materials.
- 3) Draw three squares on millimeter block paper as shown in **Figure 1.1** with the length of each squares: $a = 3$ units, $b = 4$ units, and $c = 5$ units.

(a)



Common Tangents to Circles

1. Common External Tangents

Have you ever paid attention to bicycle and motorcycle components and the function of each component? What components work to continue the rotating power so that the rear wheels move? What mathematical concepts work on the chain and gear of a bicycle or motorcycle?



Source: <https://www.hargaalatolahraga.com>; <https://www.otorider.net>

(b)

Figure 2. Application of RME in the Book

The application of RME principles which can improve students' mathematical communication ability is also supported by several previous studies. Asmida (2011) and Zaini & Marsigit (2014) revealed that RME is better than conventional learning in terms of communication abilities. In that line, Habsah (2017) in her research developed a 7th grade mathematics textbook with the RME approach involved 30 students in the experimental class and 29 students in the control class. The results of this study indicated that 86.67% of students have good communication abilities after using the developed textbook. This showed that the 7th grade mathematics textbook with the RME approach is more effective than the school electronic book from the government to improve mathematical communication ability.

Then Trisnawati, Pratiwi, & Waziana (2018) through classroom action research also revealed the same thing. The results showed that the application of RME characteristics could improve students' mathematical communication ability in the pretest, cycle I and cycle II. This is also confirmed by Anggraini & Fuzan (2018) that their research showed that students' mathematical communication ability with the RME approach is higher than conventional approaches in mathematics learning.

CONCLUSION

Mathematics textbook of 8th grade junior high schools students even semester developed by applying RME principles oriented to students' mathematical communication ability has met the criteria of being validity, practicality, and effectiveness. The application of RME principles include phenomenological exploration, bridging by vertical instruments, self-reliance: pupils' own constructions and productions, interactivity, and intertwining. Thus, the developed textbook is suitable to use in mathematics learning as an alternative to improve students' mathematical communication ability.

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Peningkatan Kemampuan Komunikasi Matematis Siswa melalui Buku Teks PMR

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Penelitian ini merupakan penelitian pengembangan menggunakan model ADDIE untuk menghasilkan buku teks matematika siswa kelas VIII dengan menerapkan prinsip pendekatan Pendidikan Matematika Realistik (PMR) berupa eksplorasi fenomenologi, menjembatani dengan instrumen vertikal, konstruksi dan produksi siswa, interaktivitas, dan keterkaitan yang berorientasi pada kemampuan komunikasi matematis siswa. Subjek dalam penelitian ini melibatkan 30 siswa kelas VIII Sekolah Menengah Pertama Negeri di Yogyakarta. Kualitas dari buku teks yang dikembangkan mengacu pada tiga kriteria yaitu kevalidan, kepraktisan, dan keefektifan. Instrumen pendukung yang digunakan untuk menguji ketiga kriteria kualitas buku teks adalah lembar validasi, lembar penilaian untuk guru dan siswa, dan soal tes kemampuan komunikasi matematis siswa. Buku teks yang dikembangkan dikatakan masing-masing memenuhi kriteria kevalidan, kepraktisan, dan keefektifan jika minimal 'baik' dari hasil penilaian validator, hasil penilaian guru dan siswa, dan paling sedikit 75% hasil tes kemampuan komunikasi matematis siswa. Berdasarkan hasil penelitian ini, buku teks yang dikembangkan telah memenuhi kriteria kevalidan (sangat baik), kepraktisan (sangat baik oleh guru dan baik oleh siswa), dan keefektifan (baik sebesar 86,67%). Dengan demikian, buku teks yang dikembangkan telah layak digunakan sebagai salah satu alternatif untuk meningkatkan kemampuan komunikasi matematis siswa.

Kata Kunci: Pendidikan Matematika Realistik; buku teks; komunikasi matematis

Diterima 10 November 2020

Direvisi 21 Desember 2020

Disetujui 02 Januari 2020