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THE DEVELOPMENT OF JUNIOR HIGH SCHOOL MATHEMATICS LEARNING TOOLS USING REALISTIC MATHEMATICS EDUCATION APPROACH TO RELATIONS AND FUNCTIONS MATERIAL

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Abstract

This study aims to produce learning tools using Realistic Mathematics Education approach to relations and functions material. This type of research used the Plomp development model, which consists of three phases, namely the initial investigation phase, the development or prototyping phase, and the assessment phase. The research subjects were grade VIII students of SMPN 2 Takengon. The instruments of research are expert validation sheets, practicality assessment sheets, and effectiveness assessment sheets. The resulting tools include lesson plan, student books, teacher books, and student worksheets. The average assessment of the four aspects of the lesson plan was 3.89 with valid criteria. The average assessment of the three aspects of the teacher's book was 3.98 with valid criteria. The average assessment of three aspects of the student book was 3.97 with valid criteria. The average assessment of two aspects on the student worksheets was 3.75 with valid criteria. Learning implementation 96.86% and carried out well. The teacher's response showed that, on average, 82% of the lesson plan assessment aspects are responded positively by the teacher. The response of student books was obtained by 83.2% of students who gave positive responses to student books and 82.6% of students who gave positive responses to student worksheets. The students' learning outcomes obtained a classical average value of 74.2. The results of validation and testing of learning tools show that the tools meet the criteria of learning tools developed, referring to valid, practical, and effective.

Keywords: Development, Learning Tools, Realistic Mathematics Education (RME) Approach

PENGEMBANGAN PERANGKAT PEMBELAJARAN MATEMATIKA SMP MENGGUNAKAN PENDEKATAN REALISTIC MATHEMATICS EDUCATION PADA MATERI RELASI DAN FUNGSI

Abstrak

Penelitian ini bertujuan untuk menghasilkan perangkat pembelajaran menggunakan pendekatan Realistic Mathematics Education pada materi relasi dan fungsi. Jenis penelitian ini menggunakan model pengembangan Plomp yang terdiri dari tiga fase

yaitu fase investigasi awal, fase pengembangan atau pembuatan prototype dan fase penilaian. Subjek penelitian adalah siswa kelas VIII SMPN 2 Takengon. Instrumen penelitian berupa lembar validasi para ahli, lembar penilaian kepraktisan dan lembar penilaian keefektifan. Perangkat yang dihasilkan meliputi RPP, buku siswa, buku guru, dan LKS. Rata-rata penilaian pada empat aspek pada RPP adalah 3,89 dengan kriteria valid. Rata-rata penilaian tiga aspek pada buku guru adalah 3,98 dengan kriteria valid. Rata-rata penilaian tiga aspek pada buku siswa adalah 3,97 dengan kriteria valid. Rata-rata penilaian dua aspek pada LKS adalah 3,75 dengan kriteria valid. Keterlaksanaan pembelajaran 96,86% dan terlaksana dengan baik. Respons guru diperoleh bahwa rata-rata 82% aspek penilaian RPP direspons positif oleh guru. Respons peserta didik pada buku siswa diperoleh 83,2% peserta didik yang memberikan respons positif terhadap buku siswa dan 82,6% peserta didik yang memberikan respons positif terhadap LKS. Hasil belajar peserta didik diperoleh nilai rata-rata klasikal 74,2. Hasil validasi dan uji coba perangkat pembelajaran menunjukkan perangkat memenuhi kriteria perangkat pembelajaran yang dikembangkan mengacu yaitu valid, praktis, dan efektif.

Kata Kunci: Pengembangan, Perangkat Pembelajaran, Pendekatan Realistic Mathematics Education (RME)

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INTRODUCTION

Mathematics is one of the subjects that must be taken by students at primary school, junior high school, and senior high school. Mathematics is recognized as a very useful field of study because it is applied to other subjects (Inglis & Attridge, 2016). Learning mathematics can develop and hone general skills, such as logical thinking, the ability to analyze problems based on assumptions, and an awareness of how underlying assumptions can influence analytical conclusions or think (Inglis & Attridge, 2016). However, many students consider mathematics to be a difficult subject to understand. Common stereotypes about math are difficult and boring (Hall & Suurtamm, 2020). Students who find it difficult to understand mathematics consider mathematics to be a worrying specter.

One research study stated that teachers must have a meaningful learning concept, meaningful assignments relevant to students' lives so that mathematics is not boring for students (Khoshaim, 2020). The mathematics

teacher's role was to provide meaningful mathematics teaching, not only teaching mathematics based on rules of concepts and procedures (Aytekin & Sahiner, 2020). Teaching mathematics was oriented to basic principles and techniques and its application in certain contexts (Gil-Domenech & Berbegal-Mirabent, 2020). Because of this, meaningful mathematics teaching is an important virtue that mathematics teachers must apply.

Based on researchers' observations at SMPN 2 Takengon, mathematics learning at the school is still teacher-centered. Teachers still used the lecture method in the learning process, and students only listen to and record explanations from the teacher. When the teacher asked a question, only one and two students answered. The other students just kept quiet. From these observations, the researcher observed that student activities became passive during the learning process. Passive students will position themselves as objects that only wait and receive information from educators or teachers (Wibowo, 2020). In addition, researchers also found mismatches in applying learning methods to lesson plans and conditions in the field. The method to be used in the learning process outlined in the lesson plan is the discussion and question and answer method, but the teacher does not apply it. The teacher only uses the lecture method.

The learning approach that focuses on meaningful learning is Realistic Mathematics Education (RME). A group of mathematicians has developed RME since 1971 at Utrecht University in the Netherlands. Indonesia has adopted RME since 1994, which was originally chaired by Professor Sembiring from the Bandung Institute of Technology (Zulkardi, Putri, & Wijaya, 2020). In Indonesia, RME is better known as Indonesian Realistic Mathematics Education (PMRI). The main objective of the RME approach is to apply real-world problems in the mathematics learning process so that learning activities are inspiring and meaningful for all students (Zulkardi, Putri, & Wijaya, 2020). Learning mathematics that is inspiring and meaningful for students will help students deal with everyday problems. RME principle emphasizes that the students actively participate in the learning process, dominating the learning activities and student learning activities close to the students' real-life problems (Ndiung, 2020). The learning tools developed in this study refer to the RME stage; situation, model of, model for, and formal model. RME-based learning tools in this study are expected to build students' creative thinking and solve mathematical problems through problems found in everyday life.

The RME approach applied in schools is recognized as one way of providing the best and most detailed elaboration of a problem-based approach (Hadi, 2002). RME also focuses on skills when doing mathematics, which leads students to solve their problems by utilizing informal knowledge from student life (Gee, Fauzan, & Atmazaki, 2018). One study that focused on RME states that student progress when creating mathematical ideas. They are able to develop methods in their way (Rasmussen & King, 2000). Research conducted on students in secondary schools in South Africa stated that RME successfully enhanced their comprehension (Barnes, 2004). The RME approach emphasizes that teachers are actively involved in designing and developing learning materials or tools, implementing strategies that allow students to be more active thinkers in the class, and developing context and teaching materials that are closely related to the school environment and student interests (Sembiring, Hadi, & Dolk, 2008). Thus, the development of learning tools using the RME approach is expected to motivate and develop students' interest in learning mathematics. The study results stated that the learning materials for mathematics using the RME approach met the effective criteria to improve students' problem solving abilities (Putri, Hasratuddin, & Syahputra, 2019). Other studies also suggested that learning tools were developed using RME approach valid criteria, practical and effective, to increase students' independence and problem solving skills (Hasibuan, Saragih, & Amry, 2018). The development of learning tools that are arranged must be in accordance with the curriculum, using realistic and contextual problems to help and motivate students. Good learning tools are expected to accommodate the students' mathematics learning process which has been considered difficult by students. In addition, structured and systematic learning tools will facilitate mathematics teachers in the learning process (Amin, 2014).

The materials chosen in this study are relations and functions. Relationship and function material is a mathematical material that really needs to be considered because it is the basis of introducing calculus. The calculus discussion will be discussed more about the limit functions, quadratic functions, trigonometric functions, and others. Junior high school students must understand the concept of relations and functions because in senior high school will be explained further material about the function and the types of other functions. The material on relations and functions can also help students solve daily life problems because it is close to real life, such as "the relationship of."

The development of quality learning device can produce a good learning model development (Fauzi & Waluya, 2018). In addition to creating good learning and helping students, good learning tools help teachers deliver indicators that must be understood by students interestingly so that it is more effective and efficient (Destino & Bharata, 2019). Based on the description above, it is necessary to develop a learning device using RME approach. Learning tools that will be developed include lesson plans, worksheets, student books, and teacher books. This study aims to develop learning tools using an RME approach to relations and functions material and describe the quality of the learning device from validity, practicality, and effectiveness. This research will produce learning tools on the relation and function material of class VIII SMP based on the RME approach.

METHODS

This research is development research using the Plomp development model. The Plomp model is seen as more flexible than other models, such as the Four-D model, because each step contains development activities that can be adjusted according to the research characteristics (Rochmad, 2012). Four-D model, which includes four stages; define, design, develop, and disseminate. The definition stage includes five phases: (1) front-end analysis, (2) learner analysis, (3) task analysis, (4) concept analysis, and (5) specific instructional objectives. The design stage includes four phases: (1) constructing a criterion-referenced test, (2) media selection, (3) format selection, and (4) initial design. The development stage includes two phases: (1) expert appraisal, and (2) developmental testing. The dissemination stage includes three phases: (1) validating testing, (2) packaging, and (3) diffusion and adoption. In comparison, the Plomp development model consists of an initial investigation phase, a development or prototyping phase, and an assessment phase (Plomp & Nieveen, 2013). The investigation phase carried out curriculum analysis, concept analysis, and analysis of student characteristics. In the development phase or prototype, an RME-based mathematics learning device was designed. The assessment phase carried out limited testing at SMPN 2 Takengon, Central Aceh Regency.

Quality learning tools must include criteria that refer to validity, practicality, effectiveness (Nieveen, 1999). In this study, the validity to be assessed was the validity of learning tools, namely the validity of the lesson plans, the validity of teacher books, student books, and student worksheets.

The development phase of evaluation did by the two experts and practitioners in each of the learning tools. This study's validator was a mathematics education lecturer at IAIN Takengon with the initials ER and AU. The quantitative data from the validation results were analyzed by determining the average score of the validator's assessment (*Ii*) on each indicator and then determining the validity score (*Vs*) by calculating the average *Ii* on all assessment indicators.

The validity criteria used are based on the following validity score criteria.

Table 1. Criteria for the Validity Score

Interval *Vs*	**Criteria**
$4 < Vs. \leq 5$	Highly Valid
$3 < Vs. \leq 4$	Valid
$2 < Vs. \leq 3$	Less Valid
$1 \leq Vs. \leq 2$	Invalid

(Mauliana, Ikhsan, & Subianto, 2018)

Learning tools are declared valid if at least be in a valid category. The practicality of the tool is seen from the feasibility of learning, teacher responses, and students at the trial stage. The effectiveness of the tool is seen from the learning outcomes achieved by students after participating in learning with the tools developed.

RESULTS AND DISCUSSION

Based on the stages of the Plomp development model, the first phase is the initial investigation. The analysis at this stage includes a needs analysis, the curriculum, concepts, and characteristics of students. In this phase, conducted a needs analysis to assess the needs in the development of learning tools. The curriculum analysis stage was a review of the 2013 curriculum in mathematics class VIII SMP odd semesters, which consisted of number patterns, Cartesian coordinates, relations and functions, straight line equations, and a two-variable linear equation system. Further curriculum analysis will serve as a guideline in developing learning tools using the RME approach. Concept analysis aims to determine the content and material needed in developing learning tools to achieve competency achievement indicators. In this research, the main concepts were relations and functions. Analysis of students' character in this study based on the results of observations and interviews resulted that

mathematics learning at the school is also teacher-centered. Teachers also used the lecture method in the learning process, and students only listen to and record explanations from the teacher. When the teacher asked a question, the other students only stayed silent, responding to just one and two students. From the results of these findings, the researcher noticed that student behaviors were passive during the learning process. In applying learning methods to lesson plans and situations in the field, researchers have also identified mismatches. As illustrated in the lesson plan, the approach to be used in the learning process is the discussion method and question and answer, but the truth is that the teacher does not use this method. The teacher uses only the lecture method.

In the development or prototyping phase, the Realistic Mathematics Education (RME) based learning device prototype is designed. Learning tools developed include lesson plans, worksheets, student books, and teacher books. At this stage also tests the validity of the learning tools are developed.

Phase assessment performed limited testing on 25 students of class VIII SMPN 2 Takengon. At this stage, the practicality test and effectiveness test were carried out.

1. The validity of Learning Tools

Analysis of the learning tool's validity aims to determine the extent to which the learning device developed lesson plan and worksheets valid criteria based on expert judgment using the validation sheet (Marlinda & Wijaya, 2018). In the development phase of evaluation by the two experts and practitioners in each learning tool. The quantitative assessments of the two experts were averaged to determine the validity score (*Vs*). The *Vs* score is categorized according to Table 1, and several revisions were made based on the qualitative assessment of the validator for each of the learning tools described next.

The Validity of Lesson Plan

The aspects assessed in validating the lesson plan are curriculum, material, language, and time allocation. The average assessment of four aspects of the lesson plan is 3.89 with valid criteria.

Table 2. The Results of Expert Assessments on the Validity Aspects of the Lesson Plan

No.	Aspects	*Ii*	Criteria
1	Curriculum	4	Valid
2	Material	3.9	Valid
3	Language	3.66	Valid
4	Time Allocation	4	Valid
	Vs	3.89	Valid

Although the lesson plan assessment criteria are valid, the validator provides suggestions for improvement. The validator suggests that because learning uses the Realistic Mathematics Education (RME) learning approach, the lesson plan needs to bring up an activity level design based on the RME principle. The activity levels referred to include: 1) situation; 2) model of; 3) model for; 4) formal knowledge.

Table 3. The Results of the Revision of Lesson Plan

Revision	Validators' Suggestions
The RME stage is emphasized in phase 2: the presentation of the material (STAD model) in the RPP includes 1. Situation; 2. Model of; 3. Model for; 4. Formal knowledge.	It is necessary to emphasize each stage of the RME approach in the lesson plan's learning phase.

Based on the validator's suggestion, the following are examples of improvements to the first meeting lesson plan shown in table 4.

Table 4. The Revised Results of the Validators for Improving the Lesson Plan

Phase 2: Presenting the Material		
Learning Objectives	**Mental Activity**	**Time Allocation**
Through this activity, students connect members to the two sets (real context) given and construct	Connect the members on the left with the members on the right with arrows (→). Write down the name of the relationship you made in sentence	15

sentences about the relationships formed. (Situation)	form (Tuliskan apa nama hubungan yang kalian buat dalam bentuk kalimat)

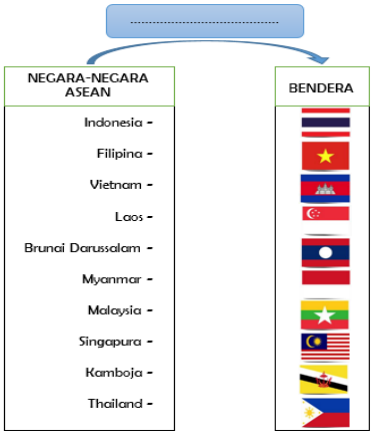


Figure 1. Diagram 1

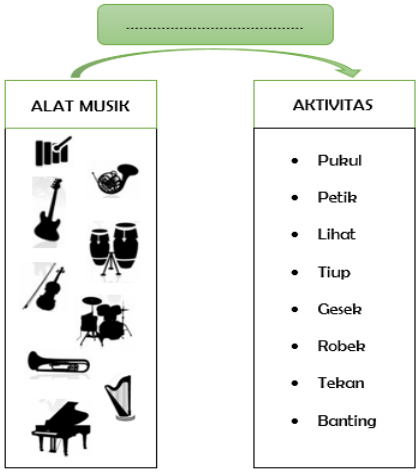
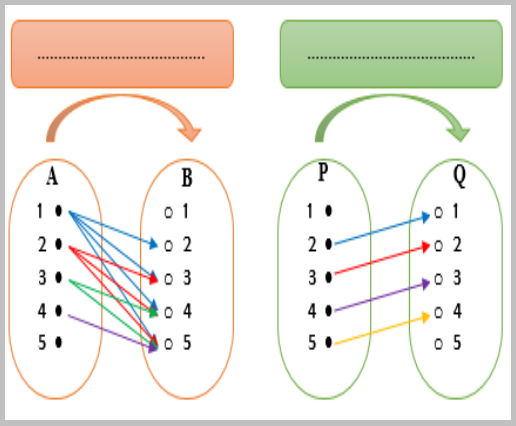
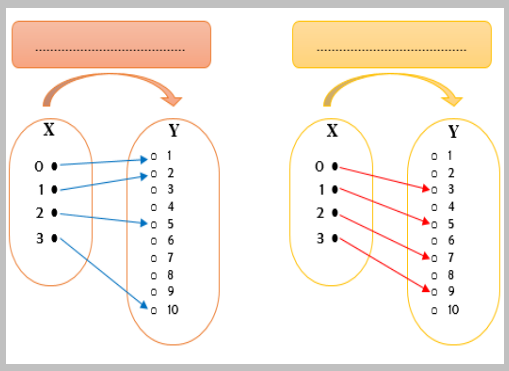


Figure 2. Diagram 2

Through this activity, students are able to develop knowledge about relations in a mathematical context, in this case involving a set of numbers (Model of)	Define the relationship what you observe on the sets of the following numbers (Rumuskan hubungan apa yang kalian amati pada himpunan-himpunan bilangan berikut ini:)  Figure 3. Diagram 3  Figure 4. Diagram 4	15
Through this activity, the student is able to determine the Y members corresponding to the members of X based on a predetermined relationship (Model for)	Find the member of set Y (y) which is the equivalent of the member of set X (x) based on the relation X→Y that is determined as follows: (X and Y are sets of real numbers) (Tentukan anggota himpunan **Y** (y) yang merupakan padanan dari anggota himpunan **X** (x) berdasarkan relasi **X→Y** yang ditentukan berikut:) (**X** dan **Y** adalah himpunan pada bilangan Real)	15

	1. Relation: y one is less than three times x (Relasi: y satu lebih kecil dari tiga kali x) [$y = 3x - 1$] a) $x = -4 \rightarrow y = ...$ b) $x = -2 \rightarrow y = ...$ c) $x = 3 \rightarrow y = ...$ d) $x = 5 \rightarrow y = ...$ e) $x = 9 \rightarrow y = ...$ 2. Relation: y is the square of x minus 1 (Relasi: y merupakan kuadrat dari x dikurang 1) [$y = (x - 1)^2$] a) $x = -2 \rightarrow y = ...$ b) $x = -1 \rightarrow y = ...$ c) $x = 0 \rightarrow y = ...$ d) $x = 2 \rightarrow y = ...$ e) $x = 7 \rightarrow y = ...$	
Through this activity, students are able to formulate set relations in the form of formal mathematics (Formal knowledge)	If (x, y) expresses the equivalent of the member of the set X (x) to the member of the set Y (y) by a relation, express the relation X→Y in terms of the equation (Jika (x, y) menyatakan padanan anggota himpunan **X** (x) dengan anggota himpunan **Y** (y) oleh suatu relasi, nyatakan relasi X→Y dalam bentuk persamaan:) 1. X→Y : {(-3, 3), (-2, 2), (-1, 1), (0, 0), (1, -1), (2, -2), (3, -3)} y = ... 2. X→Y : {(0, -4), (1, 1), (2, 6), (3, 11), (4, 16), (5,21)} y = ... 3. X→Y : {(-2, 8), (-1, 5), (0, 2), (1, -1), (2, -4)} y = ... 4. X→Y : {(0, -1), (1, 0), (2, 3), (3, 8), (4, 15), (5, 24)} y = ...	15

The Validity of Teacher Books, Student Books, and Worksheets

The aspects assessed in validating the teacher's and student's books are structure, material, and language. The average rating for three aspects of the Teacher's Book is 3.98 with valid criteria.

Table 5. The Results of Validators' Assessments on the Validity Aspects of the Teacher's Book

No.	Aspects	*Ii*	Criteria
1	Teacher's books structure	4.16	Highly Valid
2	Material	4	Valid
3	Language	3.77	Valid
	Vs	3.98	Valid

The average assessment of three aspects of the Student Book is 3.97 with valid criteria.

Table 6. The Results of Validators' Assessments on the Validity Aspects of the Teacher's Book

No.	Aspects	*Ii*	Criteria
1	Student's books structure	4.25	Highly Valid
2	Material	4	Valid
3	Language	3.66	Valid
	Vs	3.97	Valid

The aspects assessed on the worksheets are content and language. The average assessment of two aspects on the worksheets is 3.75 with valid criteria.

Table 7. The Results of Validators' Assessments on the Validity Aspects of the Student's Worksheets

No.	Aspects	*Ii*	Criteria
1	Content	3.75	Valid
2	Language	3.75	Valid
	Vs	3.75	Valid

Overall, the acquired learning device with a valid category can be used after minor revisions. Qualitative assessments and revisions of teacher books, student books, and student worksheets include adjustments with revisions to

the lesson plans. The adjustment in question presents teaching materials with the RME activity level: 1) situation; 2) model of; 3) model for; 4) formal knowledge. Based on the validation results above, improvements were made and continued with the trial phase. The testing of the device was carried out in class VIII4 for four meetings.

2. Practical Learning Tools

The device's practicality is seen from the feasibility of learning, teacher and students' responses at the trial stage. Learning implementation is obtained from observing learning activities at four meetings. The learning used the RME approach using the STAD type cooperative learning model. The observations obtained at the first meeting of learning, 91.65% accomplished. The second meeting 100% done learning, the third meeting 100% successful, and the fourth meeting of the learning, 95.82% accomplished. Overall adherence to the learning gained 96.86% and is considered to have learned by using learning tools developed performing well.

The teacher's response to the lesson plan shows that, on average, 82% positive response assessment aspects of the lesson plan by two teachers.

Table 8. The Results of Teacher's Response to the Lesson Plan

No.	Aspects	Positive response
1	Formulation of learning objectives	84.00%
2	Content	80.00%
3	Language	82.00%
4	Time allocation	82.00%
	Average	82.00%

As for the response to the teacher's book, it was found that 81% of the assessment aspects were responded positively by two teachers.

Table 9. The Results of Teacher's Response to the Teacher's Book

No.	Aspects	Positive response
1	Teacher’s book structure	82.00%
2	Material writing organization	78.00%
3	Language	83.00%
	Average	81.00%

The response of students to student books was obtained 83.2% of students who gave positive responses to student books and 82.4% of students who gave positive responses to student worksheets.

Table 10. The Result of Students' Response to Student Books

No	Aspects and Indicator	Response	
		Positive	Negative
1	Material	84.0%	16.0%
2	Language	88.0%	12.0%
3	Picture	80.0%	20.0%
4	Notation	80.0%	20.0%
5	Display	84.0%	16.0%
	Rata-rata	83.2%	16.8%

Table 11. The Result of Students' Response to Student Worksheet

No	Aspects and Indicator	Response	
		Positive	Negative
1	Language	84.0%	16.0%
2	Picture	80.0%	20.0%
3	Notation	84.0%	16.0%
4	Display	80.0%	20.0%
5	Time allocation of activity	84.0%	16.0%
	Rata-rata	82.4%	17.6%

From the response data, it can be concluded that teachers' and students' responses to learning tools are positive. This shows that students are interested in and satisfied with student books and worksheets because it facilitates their understanding of learning. These results are also consistent with Nababan's research, which showed a positive response from students when learning using RME-based learning tools (Nababan, 2017). Therefore, learning activities are carried out well and get a positive response. The learning tool is considered to meet the criteria of practicality.

3. Effectiveness of Learning Tools

The effectiveness of the tool is seen from the learning outcomes achieved by students after participating in learning with the tools developed. The learning outcomes of students obtained a classical average value of 74.2. There are 12% of students who do not meet the minimum learning completeness, and the remaining 88% meet the minimum learning

completeness. From these results, the learning tool is considered effective. The success of teachers also influences the effectiveness of learning tools in teaching mathematics. The ability of mathematics teachers to manage learning activities, having knowledge and skills about mathematics and RME, and applying them in the learning process can make mathematics learning meaningful for students (Fauzi & Waluya, 2018). Other related research also showed that the development of learning tools using the RME approach meets the criteria for effectiveness. This is because RME-based learning refers to a constructivist philosophy that constructs knowledge from experience (Nababan, 2017). Students are invited to think exploratively rather than procedurally in the learning process using RME approach. Therefore, learning using RME is more effective than ordinary mathematics learning.

CONCLUSION

This research produces mathematics learning tools for junior high school on relation and function materials using the Realistic Mathematics Education (RME) approach. The development of learning tools with the RME approach adapts the Plomp model development procedure consist of three phases: the investigation phase, the prototype phase, and the assessment phase. The resulting tools include lesson plan, student book, teacher book, and worksheets based on the RME approach. The validation and testing of learning tools show that the tools meet the criteria of learning tools developed, referring to valid, practical, and effective. Realistic mathematics learning tools for other topics need to be designed so that realistic mathematics learning tools are deeper and more diverse.

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