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Teaching Materials based on Reciprocal Teaching to Improve Mathematical Communication Skills

Nunung Azizah; Budi Usodo; Dewi Retno Sari Saputro

Department of Mathematics Education, Universitas Sebelas Maret, Indonesia

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Abstract

The most significant concern in teaching mathematical concepts is developing and improving mathematical communication skills. However, the reality reveals that communication skills possessed by students are still relatively low. This causes students' difficulty in understanding the material, solving problems, and conveying mathematical ideas both in oral or written form. Furthermore, students' teaching material is not adequate to support the expected learning goals. It creates students' difficulty in understanding the materials and it doesn't integrate mathematical communication skills. This study aims to develop teaching materials in the form of mathematics module based on reciprocal teaching to improve students' mathematical communication skills. This is a research development that employs Four-D model. Subjects of the study are the teachers and the seventh grade Junior High School. In collecting the data, the researchers employ observation, interviews, questionnaires, and mathematical communication skills test. The results show that teaching material in the form of module that is assessed by experts has reached excellent criteria in terms of material and media. The module is also practically used by students and teachers in the learning process. It means, module based on reciprocal teaching can improve students' mathematical communication skills.

Keywords: *Teaching Materials; Communication Skills; Reciprocal Teaching; Module*

Introduction

In the last two decades, educators around the world prepare students to face challenges in the 21st century (Teo, 2019). Education has an important role to develop quality and superior students. The quality of education starts by improving the quality of learning, namely arranging proper learning objectives. Learning objectives have to consider the 21st century skills to meet students' need in a globalized world. Students must master and possess information and communication skills, calculation skills, problem-solving, intrapersonal skills, and self-direction. In several countries, educators have explicitly agreed that communication skills as a competence required for scientific literacy in the 21st century (Chung, Yoo, Kim, Lee & Zeidler, 2016). The skills that should be mastered by students in the 21st century are creative thinking, problem-solving and collaboration, innovation, and communication skills (Armiati, Donny & Noperta, 2018). The soft skills required by students are communication skills (Ikram, 2018). Mathematical communication skills are one of the needed core skills to face the disruption era 4.0 (Ismail

& Made, 2018). The most significant concern in teaching mathematical concepts is developing and improving mathematical communication skills.

Mathematical communication skill is one of the basic abilities in mathematics and is very crucial for students (Euphony, Chang, Hercy & Chan, 2016). Mathematical communication set to enable students to articulate ideas, thoughts, and feelings using verbal and visual representations, and to convey complex ideas efficiently and effectively (Burleson, 2010; Timothy & Holladay, 2013). Communication can create an understanding (Paridjo & Walluya, 2017). If students have a good understanding, it means that they have good communication skills (Kostos & Shin, 2010). Students must be able to convey their ideas with others both in written and oral form. Mathematical communication skill is employed to produce creations and solutions to an explanation (Kaya & Aydin, 2016). It is also developed to create students' mathematical understanding.

Communication skills are expected to be mastered by students. However, in the fact, students experience difficulties in mathematical communication (Perwitasari & Surya, 2017). Besides, communication opportunities between students and other students, or students and teachers have not been fully available in the learning process. Even though various models of learning have been implemented, the reality reveals that all learning processes are teacher-centered (Videu & Oliveria, 2017). Another fact is students' mathematical communication skills are not as good as possible. For example, 1) Students cannot restate concepts and understanding with requirements; 2) Students still find difficulties in classifying objects according to specific features of the concept on the problem; 3) Students do not identify the amount of sufficient data to solve problems; it may occur because their learning activities are still inefficient (Zakiah & Asy, 2018). This case supports that students' mathematical communication skills must be developed and improved to achieve effective learning goals.

According to the above case, the teacher needs to create a more interesting learning system to make students can easily learn to achieve learning objectives. The learning model based on problem is more effectively applied in the learning process to improve mathematical communication skills. At the secondary school level, learning design is required to improve mathematical communication skills (Sundayana, Herman, Dahlan & Prahmana, 2017). Currently, the most significant thing for teachers is designing learning so that active learning can be created and can improve mathematical communication skills. In this case, the use of learning models itself is not adequate to improve students' mathematical communication skills.

Mathematics learning in the classroom setting must be well-prepared. The way to improve mathematical communication skills is the teachers should choose a proper learning model and it should be supported by appropriate teaching materials to the learning process and students' needs. The teacher must prepare learning devices well so that they can facilitate students in using their thinking skills (Maulana & Suparman, 2018). The success of students in learning is influenced by several factors, including the availability of teaching materials such as learning media, textbooks, worksheets, and modules as sources of reading and additional information. One form of teaching material that can be developed is a module. Modules are one form of teaching material that have a whole and systematic way, which contains a set of planned learning experiences and they are designed to help students in mastering specific learning goals (Hikayat, Suparman, Hairun & Suharna, 2020).

The reciprocal teaching approach is teaching with a focus on building meaning in the process of interaction between students and teachers (Ostavar & Shahhosseini, 2011). The reciprocal teaching is a centered-learning where students change roles to become a teacher (Aderonke & Akinsola, 2013). In the learning, there are several activities to improve students' mathematical communication skills including questioning, generating, and summarizing activities. The use of reciprocal teaching learning can improve mathematical communication skills (Abdul & Utari, 2013). Teaching materials is currently developed by many researchers, including (Fitria Hairun & Ruhama, 2020; Amawa, Yerizon, Sari & Putra, 2019), an effort to improve students' abilities, the teachers need teaching materials to improve these abilities. The

results of the study (Setiawan & Suparman, 2019) reveal that the module with the reciprocal teaching approach has the characteristics of learning activities that help students to convey mathematical ideas and mathematical models. Based on these problems, preparing learning tools is required to create an effective and efficient learning process. So the learning objectives are well-achieved. The teaching material must be well-prepared. It can be developed in the form of a module with the selection of appropriate learning models.

Materials and Method

This is a research development because it produces a product (Borg & Gall, 1983). The main purpose of development research is not to formulate or test a theory but to develop effective products in the learning process. The product is a mathematics learning module based on reciprocal teaching to improve students' mathematical communication skills. The stages refer to the 4-D model, namely Define, Design, Development, and Dissemination (Thiagarajan, 1974). The subjects are the seventh grade Junior High School students. The objects of the research are students' mathematical communication skills, learning models, and teaching materials. In collecting the data, the researchers employ interviews and questionnaire in the form of questionnaires and tests of mathematical communication skills. The interview guidelines are semi-structured. Interviews are conducted with students and teachers to determine the conditions of the learning process, namely in terms of models or teaching materials used by students. The module assessment instrument is assessed by material and media experts to find out the validity of the mathematics module. The questionnaire is employed to dig responses of the students and teachers to find out the practicality of mathematical module in the learning process. The test is in the form of problem description that is given before and after using the module, which aims to find out whether there is an increase in students' mathematical communication skills.

Results

This research employs Four-D development model that includes four stages, namely Define, Design, Development, and Dissemination.

Define

Pada in this phase, there are three stages, namely preliminary research, teaching materials analysis, and literature review. The preliminary research is intended to collect data through interviews regarding the general conditions of the learning process. The interview aims at obtaining several problems faced by teachers and students in the learning process. The teacher believes that students have difficulty in understanding the material because the 2013 curriculum textbook covers a very wide range material. Students have difficulty in understanding story problems and making mathematical models. Some students are inactive in conveying ideas in writing or verbally and they find difficulties to express their opinions, especially in conveying mathematical ideas into written form and mathematical models. The statement is in line with indicators of students' mathematical communication skills. It is also consistent with the results of students' answer. According to students' opinion, the material in the book is difficult to understand; students find difficulties in understanding the story problem and convey ideas through writing or mathematical models.

Based on the interview results of students and teachers, there are obstacles in conveying mathematical ideas. This is in accordance with existing indicators on students' mathematical communication skills. The author gives a test to find out that students' mathematical communication skills are low. Initial ability tests include indicators of mathematical communication achievement such as

explaining ideas through writing, symbols and diagrams, expressing arguments in written form, drawing conclusions in the form of symbols and algebraic manipulation. The results of students' answer related to mathematical communication skills can be seen in the following Figure 1.

The Task
A teacher of VIIA records a favorite subject of 40 students; 26 students like science, 20 students like mathematics, and 7 students do not like science or mathematics. How many students who like both science and mathematics? Write down your answers correctly!

The Answer
So, the students who like both science and mathematics are:
40-7 = 37
So, students who like both of them are 37 students.

Figure 1. Preliminary Study Answer

Figure 1 shows that the student cannot use mathematical models and algebraic expressions correctly. This can be seen from the answer. He has difficulty in determining the number of students who love both. He tends to write answers directly. Based on the explanation, it can be concluded that the student has difficulty in communicating mathematical ideas so that his mathematical communication skills are low. Furthermore, the phase of teaching materials analysis aims to find out appropriate teaching materials to overcome obstacles during the learning process. Teaching material must be adjusted to the students' needs and facilities for independent learning to improve students' mathematical communication skills. The results of teaching material analysis explain that the existing textbook is written based on international standards PISA and TIMSS. Even though, it is known that students have various abilities. The tasks still focus on solving problem instead of improving students' mathematical communication skills. This is in contrary to the aim of learning mathematics in school.

In the literature review stage, the researchers examine and collect theories about modules, reciprocal teaching approach, mathematical communication skills, and learning material. Learning material refers to the 2013 curriculum and students must fulfill basic competencies. One of the basic competencies that must be achieved by students can be seen in table 1.

Table 1. Core Competence and Basic Competence

Core Competence	Basic Competence
Understanding knowledge (factual, conceptual, and procedural) based on curiosity about science, technology, art, culture related to phenomena and visible case.	Explain the ratio of two quantities (the units are the same and different) Distinguish direct proportion and inverse proportion values by using data tables, graphs, and equations.
Trying, processing, and presenting in the concrete domain (employing, explaining, composing, modifying, and making) and abstract domain (writing, reading, counting, drawing, and arranging) regarding to the school's materials and other sources in the same perspective/ theory.	Solve problems related to the ratio of two quantities (the units are the same and different) Solve problem related to direct proportion and inverse proportion values

Design

The design phase aims at designing learning tools. There are 2 stages at this phase, namely the preparation of theoretical products and the design of test instruments. Preparing theoretical products is applied by determining the writing rules and module framework. The prototype product consists of three parts, namely the beginning, the core, and the final part. In the test instrument stage, the researchers arrange a mathematical communication ability test in the form of a pretest and post-test which is implemented to test the effectiveness and efficacy of using mathematical module based on reciprocal teaching. The test is validated by experts to find out the validity.

Development

There are three stages in the product development phase, namely the preparation of a prototype module, product validation, and module product testing. The stage of preparing a prototype product consists of three parts, namely the initial part, the core part, and the final part. Based on the initial analysis up to the theoretical product preparation stage, the initial part module is in the form of cover which is shown in Figure 2 below.

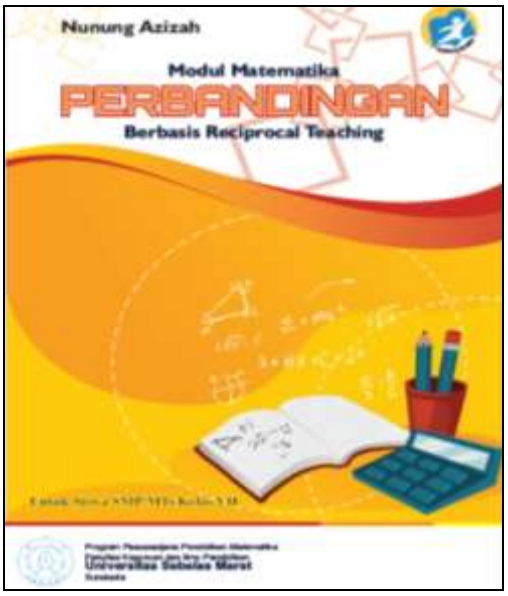

Figure 2. Module cover design

The cover of the mathematics module is interestingly designed, so that the module users are interested in reading and studying the mathematics module. The cover consists of the author's name, the title, supporting images of proportion material, subject, and target users. The core part of the module is a core part of learning consisting of learning material and students' learning activities based on a reciprocal teaching approach. These learning activities adjust the reciprocal teaching syntax. The first step in the reciprocal teaching syntax is questioning generating. In this strategy, students are given the opportunity to make questions related to the material being discussed. The question is expected to reveal the mastery of the concept being discussed. Reciprocal teaching can produce a significant increase in the quality of questions (Qohar & umarmo, 2013). So, it will trigger students to convey ideas. Questioning generating helps students to convey ideas and that has been presented previously. The second step is clarifying, this activity is important especially for students who have difficulties in understanding the material or questions. Students can explain and clarify concepts or answers to questions. By presenting a story problem, students are expected to work in groups to explain / clarify the problem by giving an explanation

correctly. Figure 3 is the design of the questioning generating and clarifying stages in the module.

Figure 3. Questioning Generating and Clarifying Design

The third step is predicting, a strategy in which students estimate answers to questions independently and pass on to other students or teachers. The fourth step is summarizing; students identify the information contained in the material. In the summarizing part of module design, there are commands for students to summarize important information and material that has been studied in each sub-lesson. The concluding activity helps students to convey these ideas according to indicators of communication skills. One achievement of mathematical communication is that students are expected to be able to understand the material and convey mathematical ideas in the form of written or mathematical expressions (Rahman, Yusof, Kashefi & Baharudin, 2012). Figure 4 is an example of a part of a summarizing design.

Figure 4. Predicting and Summarizing Design

The subsequent step is product validation. It aims to assess and provide input to the mathematics module. The module is validated by several experts, namely material experts and media experts. Material experts are selected from mathematics education lecturers because they have good competences in the field of mathematics and understand the substance of the material in this module, which is proportion. Material expert validation is intended to find out whether the prototype meets the aspects of content eligibility, the feasibility of presentation, or conformity with the reciprocal teaching approach. The assessment sheet on the draft module is in the form of a checklist using a Likert scale and there is a suggestion section from material experts and media experts. Suggestions from experts aim to obtain better modules. The following are the follow-up actions taken from the experts' recommendations on material and media shown in Figures 5 to 6.

Figure 5. Cover before revision

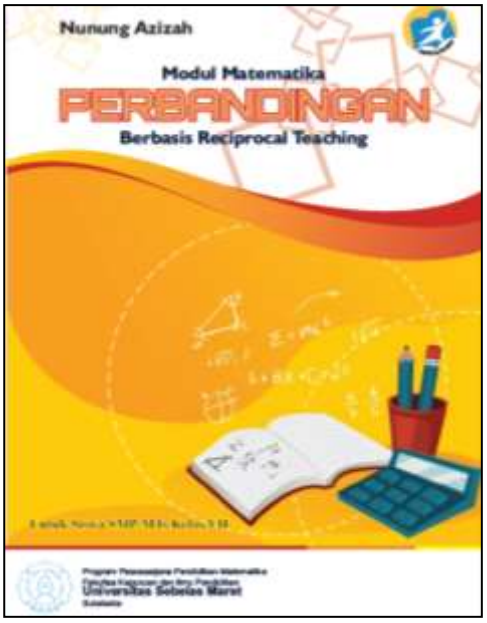

Figure 6. Cover after revision

Figure 7. Layout before revision

Figure 8. Layout after revision

The assessment sheet on the draft module is the form of a checklist using a Likert scale with a scale of 5 which is very poor (score 1), not good (2), good enough (score 3), good (score 4) and very good (score 5). The validity scores of the modules that have been obtained are converted into qualitative data based on the conversion of the average score of the five Benchmark Reference Scale. Following in table 1 is the average score conversion used for module assessment.

Table 2. Average Conversion of Modification Score

Range Score	Category
$1{,}00 \leq \bar{X} < 1{,}80$	Not Valid
$1{,}80 \leq \bar{X} < 2{,}60$	Less Valid
$2{,}60 \leq \bar{X} < 3{,}40$	Valid Enough
$3{,}40 \leq \bar{X} < 4{,}20$	Valid
$4{,}20 \leq \bar{X} < 5{,}00$	Very Valid

Validation Calculation Results from material experts can be seen in table 2; Assessment from media experts can be seen in table 3.

Table. 3. Validation Results from Media and Material Experts

Validator	Score viewed from materials		Score viewed from materials	
	Average	Category	Average	Category
Validator 1	4.311	Very Valid	4.5667	Very Valid
Validator 2	3.977	Very Valid	3.9333	Very Valid
Validator 3	4.444	Very Valid	4.433	Very Valid
Average	4.224	Very Valid	4.3111	Very Valid

The assessment results of the three validators is 4,224 and it is in the range of $4{,}20 \leq \bar{X} < 5{,}00$ It reveals that the module is very valid in material terms. The assessment result by media experts is 4,311, which is in the range of $4{,}20 \leq \bar{X} < 5{,}00$ It means that the module is very valid in terms of media. The assessment of the material and media expert validator explains that the module is very good for use in the learning process.

Then the product is tested on the students, and the teacher evaluates the response to find out the practicality of the module. The results of practicality assessments by teachers and students can be seen in table 3.

Table 4. Assessment Result of Module's Practicality

Response	Average	Category
Students	82.96	Very practical
Teachers	92.30	Very practical

The questionnaire results assessed by students and teachers state that the average of practicality assessment results by students is 82.96 and the average assessment results of educators is 92.30. Based on the assessment, the module meets the practicality criteria and it can be said to be very practical to use.

Disseminate

Dissemination process is the final stage of development. Dissemination is carried out to promote the product. The objective is to determine the effectiveness of the use of module in the learning process. The researchers conduct effectiveness tests. The effectiveness of mathematics module based on reciprocal teaching is indicated by the improvement of students' mathematical communication skills after the use of the module. The module effectiveness test employs the average t-test. The results show that $t_{obs} = 10{,}897$ with $t_{0,05;31} = 1{,}693.$ Based on the benchmark critical area $DK = \{t | t > 1{,}693\}$ and the test decision, H_0 is rejected. So it can be concluded that the average score of students' mathematical communication skills after using the mathematics module based on reciprocal teaching is better than that before using it. Based on the analysis results, it can be inferred that the mathematics module based on reciprocal teaching enhance students' mathematical communication skills.

Discussion

The developed product in this study is the mathematics module based on reciprocal teaching on proportion material to improve students' mathematical communication. It is intended to enhance students' mathematical communication skills. The aim of development is looking for general problems supported by preliminary data. These found that the value of students' mathematical communication skills is still relatively low. Case study also shows that today's learning resources are difficult to understand, do not lead students to be active in learning, and do not convey ideas in writing or verbally. According to National Council of Teachers of Mathematics (NCTM), one of the abilities that must be mastered by students is communication skills. Communication skills have also been stated in the learning objectives of mathematics that students are expected to be able to convey ideas. Improved mathematical communication needs to be supported by learning resources and appropriate learning models. Based on the needs analysis, it is found that the required teaching material is in the form of module to improve students' mathematical communication. Therefore, it is necessary to develop learning resources to enhance mathematical communication. Based on previous research, the effects of using reciprocal teaching learning models can provide opportunities for students to learn actively, communicate with other friends, and discuss each other to convey mathematical ideas (Mulyono, Asmawi & Nnuriah, 2018). The development of teaching materials is mostly applied by researchers. It shows the students' mathematical abilities increase. The significant improvement in students' mathematical communication through reciprocal teaching learning models (Freihat & Al-Makhzoomi, 2012; Palinscar & Bron, 1984; Seymor & Osana, 2003) strongly supports the findings of this study. The results of the development reveal that there is a significant improvement when the students use the module. There are differences in students' mathematical communication skills before and after using the module. The mathematics module based on reciprocal teaching can improve students' mathematical communication skills.

Conclusion

Based on the results, it can be concluded that there are several problems faced by the students; they have difficulties in understanding the material, their mathematical communication skills are still low, the teaching materials have not been able to fully instil and improve students' mathematical communication skills. This is development research by producing the mathematics module based on reciprocal teaching to improve students' mathematical communication skills. The Four-D development model is employed to develop module designs that are compatible with the reciprocal teaching model and integrate students' mathematical communication skills. The development phase consists of Define, which is conducting a preliminary study by looking at the general conditions of the learning process, and Design, namely compiling theoretical products and designing test instruments and then Development,

namely developing the module, expert validation, and product trials. The results of the validation from material experts and media experts indicate that the module is very valid and excellent to use. The product trial results show that the mathematics module is very practical in the learning process. And the last step is Disseminate, which is to find out the effectiveness of using the module. The effectiveness test results reveal that the module can improve students' mathematical communication skills.

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