Developing junior high school students' worksheet to foster mathematics communication ability

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Abstract
This study aims to develop student worksheets based on mathematical communication skills. It used the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) to develop and evaluate the worksheet. The subjects of this study were students of class VII in one of the junior high schools in Yogyakarta. The testing consisted of two stages, namely the small-scale trial consisting of 5 students and a large-scale trial consisting of 31 students. We collected the data using questionnaire for material and media experts' judgment as well as for the students' responses. Then, we analyzed the validity and practicality of the worksheet. Finally, the results of the assessment of material experts and media experts obtained an overall average score of 4.29 (very good category), so that the mathematical communication skills worksheet considered valid. Meanwhile, the students' responses to the worksheets were practical with an average score of 3.1 (good category).

Keywords: communication skills, mathematics, students' worksheet

INTRODUCTION

Education is closely related to the learning process. There are many components in learning, one of which is teaching materials. According to Hernawan et al (2012), teaching materials contain material that includes the competencies of students compiled by the teacher in a systematic, coherent manner. So that teachers are required to have the ability and skills in developing teaching materials that are in accordance with the needs to convey material and stimulate students to carry out learning activities.

One of the printed media teaching materials that teachers often use in learning activities is the student worksheet (Istikharah & Simatupang, 2017). Based on research conducted by Suryaman (2009) it was found that there are still teachers who have difficulty in developing these teaching materials, this makes many teachers only use textbooks which make students bored and not active in learning activities because according to Pansa (2017), a good worksheet is one that gives students the opportunity to be active in learning such as asking and answering questions independently or in groups. In addition, the NCTM (National Council of Teachers of Mathematics) explains that students should have mathematical communication skills consisting of problem-solving reasoning, proof, communication, connection, and representation. Therefore, the teaching materials used by the teacher should forge students to have these abilities.

According to Umar (2012), mathematical communication skills are important for students to communicate their mathematical ideas through five aspects of communication, namely representation, listening, reading, discussing, and writing. In addition, there is the term mathematics as a language, meaning that mathematics is a tool that can communicate mathematical ideas clearly, precisely, and efficiently so that social activities in learning mathematics can be used as a place for students and teachers to interact. This is in accordance with the characteristics of students in the society 5.0 who should possess communication skills (Arofah & Nawantara, 2019).

Student worksheets contain instructions for use, activities and problem solving by students in accordance with learning strategies to instill mathematical communication skills (Pansa, 2017). Mathematical communication is the ability of students to express their mathematical ideas orally or in writing, so that students can develop their understanding and knowledge, and students are able to build the concept of real mathematical understanding (Syasri et al, 2018). Mathematical communication directs students to explain mathematical ideas and relations orally, in writing, mathematical models, pictures, and graphs.

Mathematical communication skills provide benefits to students to be skilled in doing calculations and have an influence on learning outcomes (Haji, 2012). On the other hand, data from the national exam results from the Center of Education Assessment of the Indonesian Ministry of Education and Culture suggest that the percentage of students who answered correctly on the rectangle and triangle material, especially in the school where the study was conducted, was 51%.

Based on the results of interviews with mathematics teachers at the school, worksheets support learning and assist teachers in delivering learning materials. worksheets also make it easier for teachers to design learning activities. According to the teacher, students get bored easily if the teacher only provides material through explanations, with the worksheets, students' interest in learning also increases and students do not get bored easily. In learning activities in the classroom, the teacher already has worksheets but has not used worksheets based on mathematical communication skills, the worksheets given by the teacher is only in the form of multiple-choice questions. In addition, students still have difficulties and are not precise when solving problems in mathematical notation and symbols. Worksheets used still does not contain indicators of mathematical communication skills. This is evidenced by the existing worksheets only directing students to answer questions using one solution and referring to the completion steps that are usually conveyed by the teacher using numerical representation only. According to the results of interviews, students have difficulty determining the perimeter and area of quadrilaterals and triangles. In addition, students have difficulty understanding the problem, translating the problem into a mathematical model and students have not been able to apply the formula to the given problem.

Learning that is supported by learning materials, especially quality worksheets, will make it easier for teachers and students to be more active so that learning becomes more meaningful and in the end students' mathematical communication can be instilled. Thus, the use of worksheets is the right solution to instill mathematical communication in students (Khoiriyati et. al., 2017). Based on the description that has been presented, this study aims to determine the validity and practicality of worksheets based on mathematical communication skills.

RESEARCH METHOD

This study uses the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) and produces a worksheet based on mathematical communication skills. According to Pribadi (2016), the ADDIE model is one of the models or approaches to learning system design to develop a research product. The ADDIE development model has the advantage that the structure of this model is systematic, has a clear sequence and cannot be randomized (Perwita & Kandika, 2019).

The steps for developing worksheets based on the ADDIE model are (1) the first stage is analysis; this stage refers to gathering information on learning needs. This stage analyzes the character of students, curriculum, and material to be used as a reference in developing worksheets, (2) the second stage is design, this stage designs worksheets based on mathematical communication skills such as designing covers, contents of worksheets, and compiling worksheet assessment instrument, (3) the third stage is development, which includes collecting references that are used as material benchmarks in the worksheet, making worksheet products, and validating worksheets with material experts and media experts to provide suggestions for improvement and assessment of the worksheets which has been made. Furthermore, revisions to the worksheets are carried out according to the advice of experts. (4) the fourth stage is implementation, at this stage a small class trial consists of 5 students and a large class research subject of 31 students as research subjects to respond to the given worksheet by filling out a questionnaire that has been completed, distributed via google form, and (5) evaluation, this stage is carried out an analysis of the results of the questionnaire from the validator to determine the validity of the product, and student response questionnaires to determine its practicality. So that the evaluation results can be used to measure the feasibility of a worksheet based on mathematical communication skills.

The instrument used is an assessment questionnaire filled out by material experts and media experts, and a student response questionnaire. The data analysis technique used in this study is divided into two, namely the analysis of validity and practicality. According to Widoyoko (2017), valid and practical assessment data on worksheets obtained from assessment questionnaires and response questionnaires are described qualitatively as a reference for improving the worksheets. Qualitative data in the form of scores with the steps (1) tabulating the data obtained by the validator, (2) calculating the score and the average score, [3] then changing the average score into a qualitative value, so that the validity and practicality of assessment criteria are obtained.

RESULTS AND DISCUSSION

The analysis of the assessment questionnaire by material experts and media experts is obtained in Table 1 and Table 2 as follows.

Table 1. Material expert validation

Aspect	Validator		Average	Category
	1	2		
Content Eligibility	35	43	4,33	Very good
Grammar	15	18	4,13	Good
Presentation	10	13	3,83	Good
Mathematical Communication	15	11	4,33	Very good

Based on the results from Table 1, the average content feasibility aspect is 4.33 (very good category). In the linguistic aspect, an average of 4.13 was obtained (good category), in the presentation aspect, an average of 3.83 was obtained (good category), and the suitability aspect of the worksheet with mathematical communication got an average of 4.33 (very good category).

Table 2. Media Expert Validation

Aspect	Validator		Average	Category
	1	2		
Language	17	17	4,25	Very good
Presentation	21	24	4,5	Very good
Graphics	25	27	4,33	Very good

Based on the results of the assessment from media experts (See Table 2), the average linguistic aspect was 4.25 very good category, the presentation aspect was 4.5 very good category, and the graphic aspect obtained an average of 4.33 very good category. In addition to providing an assessment, the validator also provides suggestions and comments on the developed worksheet. Suggestions from material experts can be seen in Table 3 and suggestions from media experts can be seen in Table 4.

Table 3. Suggestions for improvement from material experts

Aspect	Suggestions
Language	1) Some practice questions have not used exclamation marks and question marks
	2) In the competency section and indicators of competency achievement, the title is added
	3) Change text to san serif
Presentation	1) On the cover the words "mathematical communication skills" are changed to a color other than yellow
	2) In the example questions there are pictures that have not been shown
Graphic	1) In the table of contents, add a color or box
	2) The writing on the concept map is too thick so that it is difficult to read, and the words "concept map" are enlarged
	3) Add a symbol to the indicator hint

Table 4. Suggestions for improvement from media experts

Aspect	Suggestions
Content Eligibility	Improvements to the placement of the meaning of quadrilaterals and triangles (placed at the end)
Linguistic	1) Unclear questions fixed
	2) Font size changed to 12pt
Presentation	1) Include examples of problems that students often encounter in everyday life
	2) Provide a description of the questions on page 20 and so on.
	3) Fix typing errors

After the worksheet was revised according to the advice of material and media experts, and the worksheet was declared valid, the next step was a small class trial. The trial aims to test the worksheets based on mathematical communication skills consisting of 5 students selected by the teacher. The implementation of this small class trial was carried out online using the Whatsapp application. At this stage, the researcher gives the worksheet product and asks students to read, discuss and ask things that are not understood about the material in the worksheet. After conducting a small class trial, it was continued with a large class trial consisting of 31 students. The researcher provided a worksheet that had previously been reviewed based on a small class trial. At this stage the researcher gave a worksheet through the Whatsapp group then students read, had discussions, and asked if there was material that had not been understood. Furthermore, students fill out student response questionnaires compiled by researchers through google forms and students respond to the developed worksheets. At this stage it can be concluded that the worksheet is practical according to the results of the student response assessment questionnaire. The results of the student response questionnaires can be seen in Table 5.

Table 5. Result of student response questionnaire

Item number of questionnaires	Average	Category
1	3,23	Good
2	3,10	Good
3	3,19	Good
4	3,13	Good
5	3,19	Good
6	2,90	Good
7	3,10	Good
8	3,16	Good
9	3,03	Good
10	3,06	Good
11	3,13	Good
12	3,06	Good
13	3,10	Good
14	3,10	Good

Based on the results of the questionnaire, the students' responses obtained in each statement item were well/good. Therefore, based on the assessments made by material experts and media experts as well as from the results of student response questionnaires, it can be concluded that the worksheets based on mathematical communication skills are valid and practical. The characteristics of a valid and practical mathematical ability-based worksheet are summarized in Table 6.

Table 6. Characteristics of the valid and practical worksheet for mathematical communication skills

Number	Characteristics	Information
1	The suitability of the material and learning objectives on the	The material compiled is in accordance with the Core Competence and Basic Competence in the 2013 Curriculum

Number	Characteristics	Information
	worksheets with the applicable curriculum in Indonesia	which is then described in the competence achievement indicators
2	Clarity of learning objectives to be achieved	Competence achievement indicators contains the material to be achieved in studying quadrilaterals and triangles in accordance with the 2013 Curriculum
3	Consistent arrangement of material on the worksheet	The sequence of material presented is summarized in a table of contents which shows the sub-materials on the worksheet
4	Presentation of varied material to clarify the content in the worksheet	Example questions are given for each sub-material to clarify the description of the material
5	Practice questions related to the material	The practice questions presented in the worksheet are given in each sub-material section which consists of two practice questions
6	The truth of the answer key to the questions given	The answer key consists of 10 answers to practice questions which are essay answers
7	Compatibility of writing in worksheets with good and correct Indonesian language rules, provisions for effective language use, and using easy-to-read font sizes and types	This worksheet uses good and correct Indonesian rules. The font size used is 12 pt and uses a san serif typeface
8	The suitability of the image presented	The images presented serve to visualize the material so as to make it easier for students to understand the material.
9	Clarity of activity instructions in worksheets	Instructions are used to provide an explanation of the use of the worksheet. In this section, information has also been given that students will carry out learning activities using mathematical communication.
10	Contains elements that attract students' interest to learn the material	This worksheet is interesting for students because it is developed using mathematical communication which is a new thing for students
11	Guide students in using symbols, notation and mathematical equations correctly	This characteristic refers to the second indicator of mathematical communication. The worksheet presents eleven questions that refer to these indicators. Two questions are in the sub-material of types and

Number	Characteristics	Information
		properties of quadrilaterals, seven questions are in the sub-material of perimeter and area of a rectangle, one question is in the sub-material of triangles, and one question is in the sub-material of combined area of quadrilaterals.
12	Guide students to express ideas verbally, in writing and demonstrate verbally	This characteristic refers to the first indicator of mathematical communication. In the worksheet there are seven practice questions that refer to these indicators. One question is in the sub-material of the properties of quadrilaterals and triangles, two questions are in the sub-material of the properties of quadrilaterals, three questions are in the sub-material of the perimeter and area of a quadrilateral, and one question is on the types and properties of triangles.
13	Guiding students to visually describe mathematical ideas	This characteristic refers to the first indicator of mathematical communication which consists of three practice questions. Two questions are in the quadrilateral characteristic sub-material, and one item is in the quadrilateral perimeter and area sub-material

At points 11, 12, and 13 in Table 6, there are 3 indicators of mathematical communication skills contained in the developed worksheet. This shows that the developed worksheets direct students to communicate their mathematical ideas, both orally and in writing, through problem solving in questions that lead students to various representations of answers. These representations are (1) verbal representations that direct students to answer questions both verbally and in writing (2) visual representations that direct students to answer questions with pictures, and (3) symbolic representations that direct students to answer with mathematical symbol notation.

Based on the assessments made by material experts and media experts, and responses by potential users, it can be concluded that the worksheets based on mathematical communication skills developed are valid and practical. The valid and practical categories refer to the results of the assessment questionnaire by media experts which show a value of 4.21 and from media experts which is 4.37 which means the worksheet is included in the very good category, and the response questionnaire by prospective users (students) which shows a value of 3,11 which means the worksheet is included in the good category. This is in line with the research and development conducted by Pansa et al. (2017) which states that the developed worksheets show valid, practical and effective categories for improving students' communication skills. Likewise, research conducted by Fara et al (2019) that the development of worksheets is

categorized as good because there is an increase in mathematical communication as measured by using normalized N-gain obtained an average score of 0.760.

Based on the scores and categories obtained from the results of the expert's assessment of the worksheet, there are 3 (three) indicators that show the highest value, namely efficient use of language, completeness of information, and use of letter combinations and there is one indicator that shows the highest value based on the response of potential users to worksheets that encourage students to have a high willingness to learn. The four indicators show 4 main characteristics of the developed worksheets that distinguish them from other research results or become the novelty of this research.

In addition to the four main characteristics above, the development of the worksheet is based on 2 (two) indicators of mathematical communication skills taken from NCTM. This can be seen through 2 (two) statements in the questionnaire for material experts which refer to the first indicator of mathematical communication skills, namely worksheets guiding students to express mathematical ideas verbally, and worksheets guiding students to express mathematical ideas visually. The two indicators scored 4.25 so that they were included in the very good category and 1 (one) statement in the questionnaire for material experts which referred to the second indicator of mathematical communication skills, namely worksheets guiding students to use symbols, notations, and mathematical equations correctly. This indicator gets a value of 4.5 so it is included in the very good category.

On the other hand, Ismail, Arnawa, & Yerizon (2020) states that the characteristics of an effective worksheet to improve students' mathematical communication skills are through a realistic mathematics education approach. This is because realistic mathematics education encourages (1) the use of real contexts (the teacher presents contextual problems and asks students to understand the problems given), (2) the use of mathematical models (students model using visual aids to solve problems), (3) construction knowledge by students so that students are motivated to express their opinions through interactions between teachers and students, and between students with one another, and the integration of mathematics material with other scientific fields (Pratiwi & Waziana, 2018).

Yerizon et al (2019) with their research developed a worksheet based on M-APOS where the element "O" denotes Objects, which is an activity that helps in improving using ideas, situations and expressing solutions to problems. The process increases in expressing events or problems expressed in a language or mathematical symbol. This is claimed as one of the steps in improving students' mathematical communication skills. Riyati & Suparman (2019) added that through research on the development of worksheets designed to improve students' mathematical communication skills through problem-based learning. This is claimed because student worksheets developed contain material and are rich in practice questions that will guide students in finding concepts. This leads students to be able to communicate their mathematical ideas verbally, visually, or symbolically.

CONCLUSION

Based on the research that has been done, a worksheet based on the mathematical communication skills of quadrilateral and triangle material is valid and practical. Based on the results of these studies, this worksheet can be used in the learning process on quadrilateral and triangle material. Efforts to

improve students' mathematical communication skills can be done through the development of worksheets by taking into account the indicators of achievement of students' mathematical communication skills that are integrated in each activity in the worksheet. In addition, various learning approaches whose essence is aimed at developing students' abilities in expressing their opinions in visual, verbal, or notation and symbols, through interactions between teachers and students, or students with other students, can also be taken into consideration in designing activity in the worksheet. This shows that in fact there are many learning approaches that can be applied to improve students' mathematical communication skills.

In addition, there is a need for further research on the development of mathematical communication-based worksheets by involving other indicators that are not yet included in this worksheet, namely the ability to understand, interpret and evaluate mathematical ideas verbally or in other visual forms.

REFERENCES

Arofah, L., & Nawantara, R. D. (2019). Pentingnya critical thinking bagi siswa dalam menghadapi Society 5.0. In *Prosiding SEMDIKJAR (Seminar Nasional Pendidikan dan Pembelajaran, 3*, 538-545.

Fara, U., Noer, S. H., & Rasidin, U. (2019). Pengembangan LKPD berbasis inkuiri terbimbing untuk meningkatkan kemampuan komunikasi matematis siswa. *Jurnal Pendidikan, 12*(2).

Haji, S. (2012). Pengaruh pembelajaran kontekstual terhadap kemampuan komunikasi matematika siswa SMP Kota Bengkulu. *EXACTA, 10*(2), 115-118.

Hernawan, A. H., Permasih, H., & Dewi, L. (2012). *Pengembangan Bahan Ajar*. Direktorat UPI.

Ismail, R. N., Arnawa, I. M., & Yerizon, Y. (2020). Student worksheet usage effectiveness based on realistics mathematics educations toward mathematical communication ability of junior high school student. In *Journal of Physics: Conference Series* (Vol. 1554, No. 1, p. 012044). IOP Publishing.

Istikharah, R., & Simatupang, Z. (2017). Pengembangan lembar kegiatan peserta didik (LKPD) Kelas X SMA/MA pada materi pokok protista berbasis pendekatan ilmiah. *Jurnal Pendidikan Matematika dan Sains, 12*(1).

Khoiriyati, B., Caswita, & Bharata, H. (2017). Pengembangan LKPD dengan model pembelajaran kooperatif tipe Think Pair Share untuk meningkatkan kemampuan komunikasi matematis. *Jurnal Pendidikan Matematika Universitas Lampung, 5*(10).

Pansa, H. E. (2017). Pengembangan LKPD dengan model Problem Based Learning (PBL) untuk meningkatkan kemampuan komunikasi matematis siswa. *Prosiding Seminar Nasional Matematika dan Pendidikan Matematika, 1*(1), 229-238.

Perwita, D. P., & Kandika, P. S. (2019). *Analisis Model Pengembangan Bahan Ajar* (*4D, ADDIE, ASSURE, Hannafin & Peck).* DOI: 10.31227/osf.io/7bydx

Pratiwi, R., & Waziana, W. (2018). The effect of realistic mathematics education on student's mathematical communication ability. *Malikussaleh Journal of Mathematics Learning, 1*(1), 31-35.

Pribadi, B. A. (2016). *Desain dan Pengembangan Program Pelatihan Berbasis Kompetensi Implementasi Model ADDIE*. Kencana

Suryaman, M. (2009). *Panduan Pendidik dalam Pembelajaran Bahasa Indonesia SMP/MTs*. Pusat Perbukuan Departemen Pendidikan Nasional.

Syasri, S. I. R., Hasanuddin, H., & Noviarni, N. (2018). Peningkatan kemampuan komunikasi matematis: Pengembangan lembar kerja siswa berbasis model pembelajaran kooperatif tipe Think Talk Write untuk siswa Sekolah Menengah Pertama. *JURING (Journal for Research in Mathematics Learning), 1*(1), 43-54.

Umar, W. (2012). Membangun kemampuan komunikasi matematis dalam pembelajaran matematika. *Infinity Journal, 1*(1), 1-9.

Widoyoko, S. Eko Putro. (2017). *Evaluasi Program Pembelajaran.* Pustaka Pelajar.

Yerizon, Y., Armiati, A., Tasman, F., & Abdullah, B. (2019). Development of student worksheets based on m-apos approach with mind mapping to improve mathematical communication ability of grade VII students of middle school. *International Journal of Scientific and Technology Research, 8*(6), 352-356.