JURNAL PENDIDIKAN DAN PENGAJARAN
Volume 55 Nomor 3 2022, 653-665
E-ISSN: 2549-2608; P-ISSN: 2301-7821
DOI: https://doi.org/10.23887/jpp.v55i3.44618

Student Worksheets of Angle Relationships Based on Indonesian Realistic Mathematics Education

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Abstract

Pembelajaran matematika akan mendapatkan hasil yang optimal jika prosesnya didukung dengan fasilitas yang tepat, salah satunya adalah lembar kerja siswa. Penelitian ini bertujuan untuk mengembangkan lembar kerja siswa berbasis Pendidikan Matematika Realistik Indonesia pada materi hubungan sudut yang dianggap valid. Penelitian ini merupakan penelitian pengembangan dengan model 4D meliputi Define, Design, Develop, dan Disseminate. Instrumen yang digunakan adalah lembar validasi ahli materi dan media. Data yang diperoleh dalam penelitian ini diklasifikasikan menjadi data kuantitatif dan data kualitatif. Data kuantitatif berupa skala penilaian validitas lembar kerja siswa dianalisis dengan cara mengubahnya menjadi data kualitatif dengan menggunakan teknik analisis yang dirumuskan oleh Aiken dan dikenal dengan rumus Aiken's V. Hasil penelitian menunjukkan bahwa lembar kerja siswa berbasis Matematika Realistik Indonesia Pendidikan hubungan antar sudut yang dihasilkan dianggap valid oleh ahli materi dengan nilai rata-rata 0,88 dan dianggap valid oleh ahli media dengan nilai rata-rata 0,94. LKS yang dikembangkan telah dinilai valid oleh ahli materi dan ahli media. LKS tersebut direvisi berdasarkan masukan dari para ahli hingga akhirnya dinilai valid dan layak untuk diujicobakan.

***Keywords*:** *Bahan ajar, lembar kerja siswa, Pendidikan Matematika Realistik Indonesia.*

Abstract

Mathematics learning will get optimal results if the process is supported by the right facilities, one of which is student worksheets. This study aims to develop student worksheets based on Indonesian Realistic Mathematics Education on the material of angle relationships that are considered valid. This research is development research with a 4D model covering Define, Design, Develop, and Disseminate. The instrument used is a material and media expert validation sheet. The data obtained in this study are classified into quantitative data and qualitative data. Quantitative data in the form of an assessment scale for the validity of student worksheets were analyzed by converting them into qualitative data using an analytical technique formulated by Aiken and known as Aiken's V formula. The results showed that the student worksheets based on Indonesian Realistic Mathematics Education on the relationship between angles produced were considered valid by material experts with an average value of 0.88 and were considered valid by media experts with an average value of 0.94. The developed student worksheets have been assessed as valid by material experts and media experts. The student worksheets were revised based on input from experts until they were finally judged to be valid and feasible to be tested.

Keywords: Teaching materials, student worksheets, Indonesian Realistic Mathematics Education.

History:
Received : February 13, 2022
Revised : February 17, 2022
Accepted : July 26, 2022
Published : October 25, 2022

Publisher: Undiksha Press

1. INTRODUCTION

Mathematics as a source of all sources of knowledge has an important role in the development of science and technology, because mathematics is a means of developing reasoning, logical, systematic, and critical thinking (’Atun & Rosmala, 2018; Khuzaeva, 2014). This shows that mathematics is very close and has enormous benefits in everyday life without realizing it (Septian et al., 2019). However, everyone's impression when they hear the word math is difficult so it makes the interest in learning math less (Puspitasari & Airlanda, 2021). Mathematics subjects ideally are logical and useful subjects, but so far they are not liked by students because they already consider mathematics as an abstract subject and difficult to learn (Hapsyah, R. et al., 2019). It is exacerbated by learning activities in

schools that do not carry out less communicative, monotonous, and non-communicative math learning practices, ignore the emotions of students, and seem to only use numbers and symbols (Ibrahim, 2012). Lines and Angles are important materials for junior high school students to learn because lines and angle material are some of the basic concepts of geometry (Misri & Zhumni, 2013). Lines and angles are some of the materials used in other fields, such as engineering, architecture, astronomy, physics, and geology as well as materials tested on the national exam (Nurdiyanto et al., 2019). Learning angle material can be started by using phenomena or contexts that are near students so that they easily understand the concept (Ayunis, A. & Dorisno, 2022; Dewi & Agustika, 2020; Novita et al., 2018; Nursyahidah et al., 2020). However, the mastery of geometry material by students is still low, including angle material (Al Amin & Murtiyasa, 2021; Ayunis, A. & Dorisno, 2022; Dewi & Agustika, 2020; Misri & Zhumni, 2013; Novita et al., 2018). The low mastery of geometry material is indicated by the number of students who have difficulty measuring angles so students become uninterested and unmotivated, finally, they have difficulty solving problems with angle material (Novita et al., 2018). Another difficulty, students have difficulty understanding angle material, when the name of the angle is replaced with a different symbol (Nursyahidah et al., 2020; Sari, 2017).

The results of observations at SMPN 01 Belitang III class VII October 2020 provide information that one of the materials that are difficult for students to understand is the material about angles. Students have difficulty understanding mathematical concepts conveyed by the teacher, giving the impression that mathematics is a difficult subject (Inayati & Rahayu, 2020). These observations are supported by several research results which found that students' mathematics learning outcomes on geometry material were very low (Ibrahim, 2019; Misri & Zhumni, 2013; Yustianingsih et al., 2017). The low learning outcomes of geometry can be seen in f understanding concepts, identifying and answering questions, as well as difficulties in determining the formula to be used (Novita et al., 2018). The description presented above motivates me to make improvements. These improvements, one of which is the improvement of learning through the provision of teaching materials that are by the characteristics of teaching materials and learning approaches. Related to this, suggested using a learning approach that begins with everyday phenomena that can help students understand the material (Nursyahidah et al., 2020), mathematics learning includes contextual or realistic mathematics learning (Ayunis, A. & Dorisno, 2022; Dewi & Agustika, 2020; Nursyahidah et al., 2020; Putri & Syahputra, 2019; Yilmaz, 2020).

Indonesian Realistic Mathematics Education (IRME) is an approach to learning mathematics adopted from Netherlands' Realistic Mathematics Education (NRME) (Nursyahidah et al., 2020; Yilmaz, 2020). Context is very important and is the starting point for learning mathematics at IRME (Yilmaz, 2020). The context used by IRME is everyday context so that students understand the concepts and learning objectives easily. NRME is a learning approach that is implemented based on three principles, namely (1) guided reinvention and progressive mathematization, (2) didactical phenomenology, and (3) self-developed models (Yilmaz, 2020). In addition, there are five characteristics of NRME, namely (1) using contextual problems, (2) using models, (3) using student contributions, (4) interactivity occurs, and (5) integrated with learning topics (Nusaibah & Mareta, 2014; Putri & Syahputra, 2019; Wiwin Rita Sari, 2016; Yilmaz, 2020). The principles and characteristics of the NRME were also adopted by IRME.

IRME focuses on everyday experiences that apply mathematical concepts (Dewi & Agustika, 2020). The context of daily life becomes the starting point in the implementation of mathematics learning using IRME (Sari, 2017). In IRME, mathematical modeling and the interpretation of everyday experiences into mathematical models involve generalization and formalization, this is commonly called horizontal mathematization and vertical

mathematization (Putri & Syahputra, 2019; Yilmaz, 2020). IRME also emphasizes mathematical process skills, discussions, and collaborations, so that students find their mathematical concepts and use these concepts in solving problems (Sari, 2017). In addition, PMRI is oriented to students' reasoning in solving problems and oriented to developing practical, logical, critical, and honest thinking patterns in students (Adha & Refianti, 2019; Ahmad & Asmaidah, 2017; Aljufri et al., 2020).

Learning mathematics with the IRME approach requires teaching materials. One of the benefits of using teaching materials is to increase the effectiveness of learning and improve the quality of learning, especially in the 2013 curriculum (Efuansyah & Wahyuni, 2019). Student worksheets (SW) are printed teaching materials that fulfillment of several aspects to attract students' attention as well as teaching materials used as learning tools by teachers to improve learning activities (Haryonik & Bhakti, 2018; Sipayung & Simanjuntak, 2018). Based on the results of observations made in schools, most teachers have not developed worksheets for the learning process they are doing. Teachers usually use teaching materials in the form of worksheets from those sold by general stores which are only in the form of materials, questions, and their contents are not adapted to the student's condition so that it has an unfavorable impact on mathematics learning outcomes (Fitriani et al., 2017). Whereas teaching materials in the form of worksheets can be one of the supporting factors for student success in learning activities and teachers can also develop teaching materials according to student needs. In addition, math worksheets made by teachers can be started from local contexts or everyday phenomena, so that the worksheets developed are more interesting for students. Quality learning requires the use of worksheets that can optimize learning outcomes. In this study, the use of worksheets is expected to achieve optimal mathematics learning outcomes about angle material, based on the basic competencies and higher-order thinking skills contained in the 2013 curriculum, and also to know the development process and find out the validity of the Student Worksheet to be developed. Based on the above considerations, student worksheets on the material on the relationship between angles based on Indonesian realistic mathematics education need to be developed.

2. METHODS

This study is a Research and Development (R&D) research using the 4-D research model proposed by Thiagarajan and Semmel (Thiagarajan, 1974). The steps used in the 4-D model are the Define, Design, Develop, and Disseminate stages. Each step in the 4-D model is carried out in this development process, but not until the dissemination stage. The development process did not reach the fourth stage, due to time constraints and the impossibility of conducting direct trials in schools. At the definition stage, the researcher conducts several analyzes and provides alternative solutions by developing products based on Realistic Mathematics Education. The first draft produced from the definition stage was developed again at the design stage by selecting teaching materials, formats, and the initial design in the form of a draft 1 Student Worksheet. The last step is a development by conducting expert validation and revision.

The subjects used in this study were divided into 2, namely material experts and media experts. In practice, the material experts involved in this research are expert lecturers in the field of material and mathematics teachers, and media experts involved are expert lecturers in the media field. This study uses two different types of instruments. The research instrument uses a product assessment sheet which is divided into two focuses, namely the material expert validation instrument and the media expert validation instrument. Before the assessment instrument is used to validate the product, the research instrument is tested for feasibility by two experts. Experts who carry out the feasibility test consist of experts with a

doctoral education background in mathematics education and experts with a master's education background in mathematics education. The results of the feasibility test of the two experts stated that the assessment instrument to be used had met the feasibility standard. The data obtained in this study are classified into quantitative data and qualitative data. Quantitative data in the form of an assessment scale for the validity of student worksheets were analyzed by converting them into qualitative data using an analytical technique formulated by Aiken and known as Aiken's V formula. Aiken's V formula is used to calculate the *content-validity coefficient* (Aiken, 1985). While qualitative data was obtained from notes or suggestions on the validation assessment scale of experts.

3. RESULTS AND DISCUSSION

Result

The results of analysis using the Aiken formula are made in the form of categorizing or classifying validity by paying attention to the number of assessment scores and the number of validators. The minimum score for each assessment item is 0.80 for material experts and the minimum score for each assessment item is 0.88 for media experts. The results of the analysis of research that has been carried out obtained the results as shown in Table 1.

Table 1. Table of Validation Results of the First Material Expert

Question Points	V	Question Points	V
1	0.90	14	0.60
2	0.90	15	0.65
3	0.70	16	0.60
4	0.55	17	0.50
5	0.75	18	0.65
6	0.70	19	0.70
7	0.50	20	0.65
8	0.75	21	0.65
9	0.55	22	0.55
10	0.40	23	0.60
11	0.40	24	0.70
12	0.45	25	0.65
13	0.50	26	0.50

The results of the material expert validation analysis in the first stage of Table 1, there are 2 out of 26 assessment items that are declared valid with the validity criteria for each assessment item $V \geq 0.80$ and an error probability of 0.05. Therefore, the results of the first validation analysis show that the developed SW has not been declared valid. SW in this first validation still requires many revisions and improvements. The SW that has been repaired and revised by suggestions and input from the validator is then submitted to the validator again to be assessed. Table 2 shows the results of the assessment scores given by each validator in the second validation.

Table 2. Table of Validation Results of the Second Material Expert

Question Points	V	Question Points	V
1	0.95	14	0.90
2	0.95	15	0.90
3	0.85	16	0.90
4	0.85	17	0.90
5	0.85	18	0.90
6	0.85	19	0.90
7	0.90	20	0.85
8	0.85	21	0.90
9	0.85	22	0.90
10	0.85	23	0.90
11	0.85	24	0.95
12	0.90	25	0.90
13	0.85	26	0.85

Table 2 shows that the results of the second validation have the value of each assessment item meeting the valid criteria. Therefore, the developed SW product was declared valid and suitable for use in field trials.

Table 3. Table of First Media Expert Validation Results

Question Points	V	Question Points	V
1	0.44	11	0.69
2	0.62	12	0.62
3	0.50	13	0.81
4	0.56	14	0.75
5	0.81	15	0.50
6	0.56	16	0.62
7	0.69	17	0.44
8	0.62	18	0.62
9	0.56	19	0.75
10	0.69	20	0.50

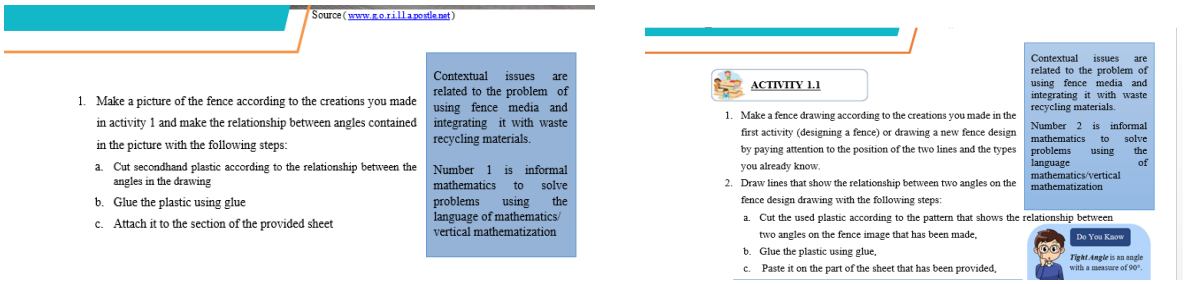
The results of media expert validation in Table 3 show that the first stage does not have an assessment item that is declared valid. This is because the items assessed do not have a value of more than 0.88 with an error probability of 0.05. So, the SW needs repair. SW is improved based on criticism and suggestions from material expert validators. Then, the SW is returned to the validator for reassessment. Table 4 are the results of the assessment scores given by each validator in the second stage of validation.

Table 4. Table of Second Media Expert Validation Results

Question Points	V	Question Points	V
1	0.94	11	0.94
2	0.94	12	0.94
3	0.94	13	0.94
4	0.94	14	0.94

Question Points	V	Question Points	V
5	0.94	15	0.94
6	0.94	16	0.94
7	0.94	17	0.94
8	0.94	18	0.94
9	0.94	19	0.94
10	0.94	20	0.94

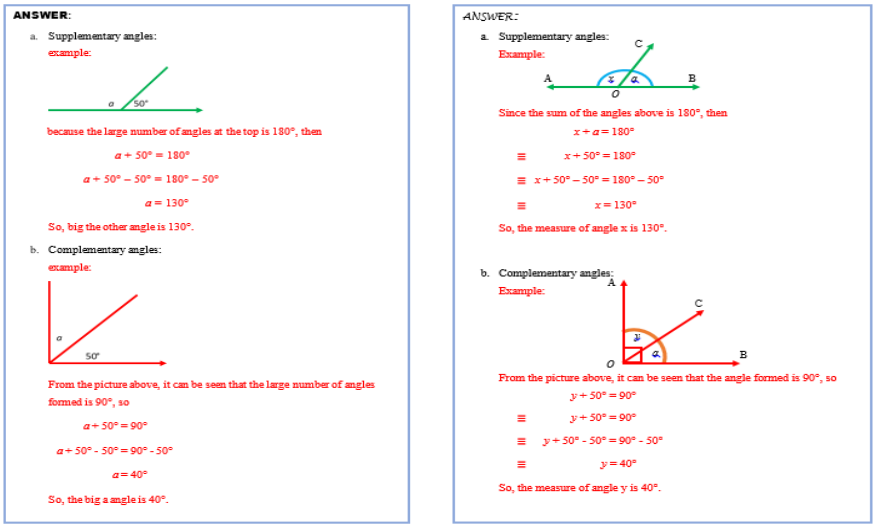
Table 4 shows the results of the revised SW assessed to meet the valid criteria for each item. Therefore, the SW product developed was declared worthy of field testing. The validator provides some suggestions for improvement of the developed SW. The suggestions given by the validator are used to improve the SW until the SW can be said to be valid.



Before revision After revision

Figure 1. Correcting Unclear Questions

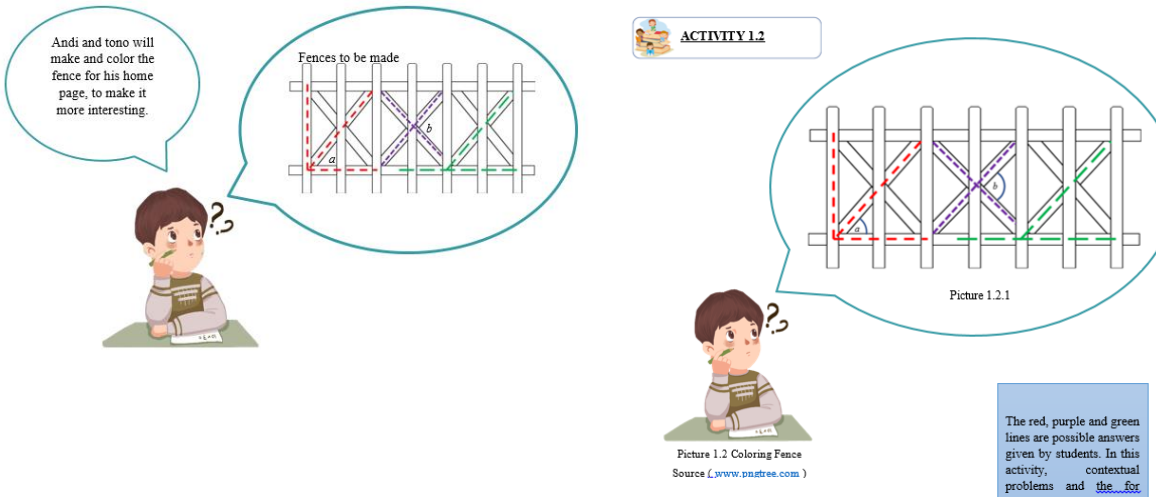
The first suggestion in Figure 1 is that some questions should be corrected so as not to cause misunderstandings. Based on this suggestion, the grammar and vocabulary in the interrogative sentences are corrected or replaced so that they are easily understood by students.



Before revision After revision

Figure 2. Repairing and Completing Possible Student Answers

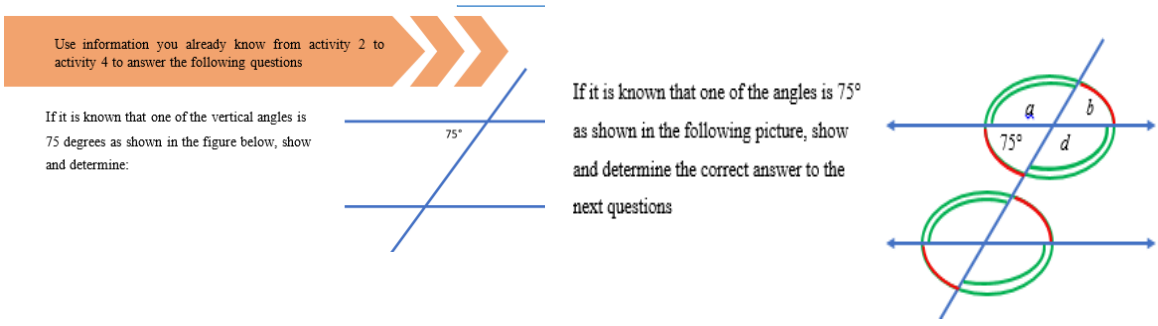
The second suggestion in Figure 2 is to improve and complete the students' possible answers. The development of teaching materials needs to be equipped with a teacher's book, namely student worksheets that already contain alternative answers to questions in SW (Ningrum et al., 2022). In this regard, the validator provides suggestions for revising alternative answers by writing alternative answers with more than one alternative answer.



Before revision After revision

Figure 3. Considering the Relationship of Included Stories

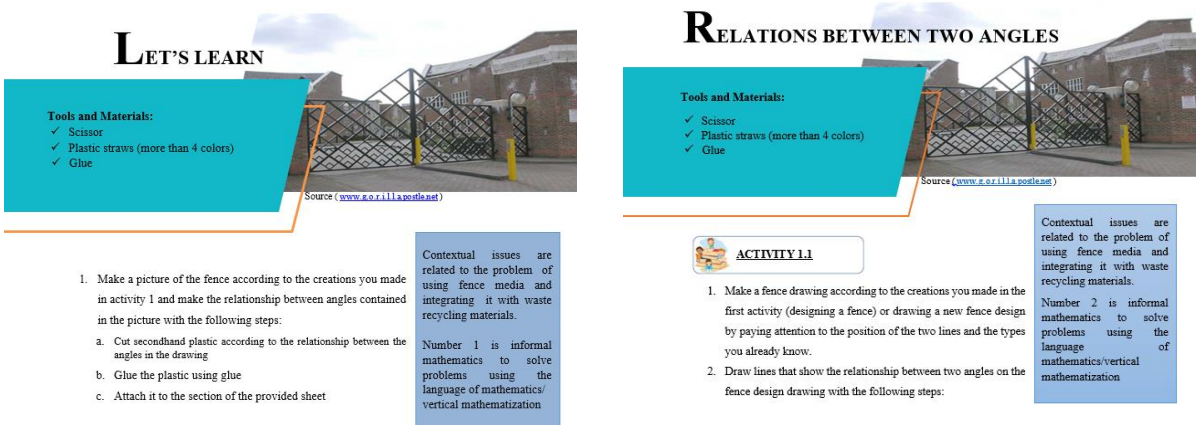
The third suggestion in Figure 3 is to improve the context used in the angular material. The context of the short story is used as an introduction to the questions asked. The context of the story is suggested to have a relationship with the material being studied.



Before revision After revision

Figure 4. Fixing the Image Angle Relationships

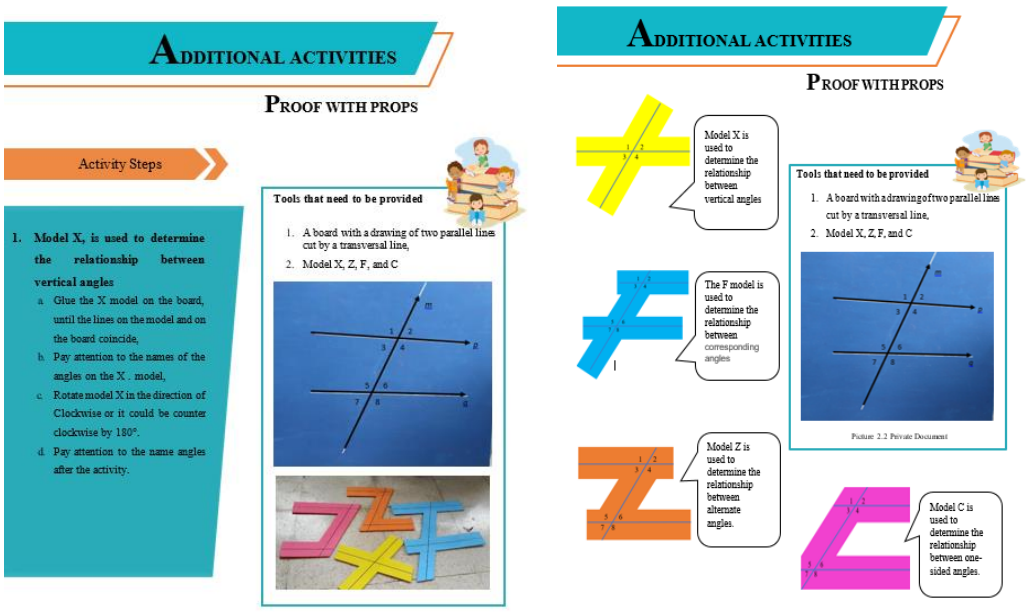
The fourth suggestion in Figure 4 is that the images presented in the questions need narration to clarify the meaning of the questions. The narration of the images presented makes it easier for students to understand the questions and there is no misunderstanding of the images.



Before revision After revision

Figure 5. Fixing Titles or Numbering Titles

The fifth suggestion in Figure 5 is to improve the title and title number so that it does not confuse students. The first draft from SW has a section entitled "Let's Get Creative with the Group". The title was changed to "Relations Between Angles" and added the words "Let's Learn". Improvements to this title are to clarify the contents of each part of the activity and make it easier to write a table of contents.



Before revision After revision

Figure 6. Clarifying Information on Each Problem

The sixth suggestion in Figure 6 is for information on each problem to be clarified by providing information on the X, Z, F, and C models in additional activities. Additional activities at SW are activities with teaching aids to help students understand abstract mathematical concepts (Marfu'ah et al., 2019). The first draft of the SW only provides drawings of the models that will be used in the props. According to the validator, this can make students confused about the intent and purpose of the model. Therefore, improvements

were made by describing the X, Z, C, F, and C models before the step of using the teaching aids. Another suggestion from the validator is related to this, namely that improvements need to be made to some sentences that are difficult for students to understand in the steps for using teaching aids.

Discussions

After revising the first draft of the SW, the validator reassessed it. The second assessment concluded that the developed SW already has sufficient validity. In other words, the developed SW is categorized as valid. The material expert validator assesses that the developed SW is valid with an average validity value of 0.88 with the limit of the validity value of each assessment item V value being 0.80. Meanwhile, the media expert's assessment assessed that the developed SW was valid with an average validity value of 0.94 with the limit of the validity value of each V assessment item being 0.80. Thus, the SW from the results of this second assessment can be tested in the field with the hope that it can improve student learning outcomes. This math student worksheet is designed using a variety of colors. The colors used in the development of SW are blue, green, and orange. The use of this color aims to attract students' attention and improve memory of the knowledge learned. This study develops an SW consisting of contextual problems. The questions presented to use the context of making garden fences from wood. One of the reasons for choosing this problem is the close and familiar environment with students. The context of the problem that is close to students can make it easier for students to understand the material they are learning (Josefin et al., 2016; Majidah et al., 2019; Sujarwo & Oktaviana, 2017).

The first activity is given to remind students of the material that has been studied the previous time. Activity 1.1 and Activity 2.1 relate to the first activity that has been presented. This activity is also expected to increase interaction between students and other students as well as students and teachers in working together to solve problems. The existence of a link with the material that has been studied previously can strengthen students' understanding of the material that has been studied and students can relate the material to material in other subjects. Problem-solving activities at this stage contain a horizontal mathematization process, namely, students can solve problems in informal language. The difference between activity 1.1 and activity 2.1 is only in the material presented. Activity 1.1 contains material about the relationship between angles, while activity 2.1 contains material about the relationship between angles to two parallel lines cut by another line.

Activity 1.2 and Activity 2.2 relate to the previous activity. In this activity, students formulate contextual problems that are presented in a mathematical model. Students can solve the problem by using the strategies that have been made in the "model of", then proceed to the "model for" (Putri & Syahputra, 2019; Yilmaz, 2020). The thing that distinguishes activity 1.1 and activity 2.1 is the content of the material. Activity 1.1 developed material on the relationship of angles, while activity 2.1 developed material on the relationship of angles to two parallel lines cut by another line. Additional activities on student worksheets to strengthen students' understanding of the concepts that have been constructed. Additional activities using props in the form of a picture board with two parallel lines cut by another line with the lines and angles formed are given names, and 4 models resemble the letters X, F, Z, and C. These images help in the proofing mathematical. Several steps need to be taken by students to practice procedural thinking. The last activity in the learning resources developed is evaluation. In this activity, teachers can see the extent of students' understanding after carrying out several previous activities with confirmation from the teacher at the end of each activity. Indonesian Realistic Mathematics Education (IRME) is an approach to learning mathematics adopted from Netherlands' Realistic Mathematics Education (NRME) (Nursyahidah et al., 2020; Yilmaz, 2020). Context is very important and is the starting point

for learning mathematics at IRME (Yilmaz, 2020). The context used by IRME is everyday context so that students understand the concepts and learning objectives easily. NRME is a learning approach that is implemented based on three principles, namely (1) guided reinvention and progressive mathematization, (2) didactical phenomenology, and (3) self-developed models (Yilmaz, 2020). In addition, there are five characteristics of NRME, namely (1) using contextual problems, (2) using models, (3) using student contributions, (4) interactivity occurs, and (5) integrated with learning topics (Nusaibah & Mareta, 2014; Putri & Syahputra, 2019; Wiwin Rita Sari, 2016; Yilmaz, 2020). The principles and characteristics of the NRME were also adopted by IRME.IRME focuses on everyday experiences that apply mathematical concepts (Dewi & Agustika, 2020). The context of daily life becomes the starting point in the implementation of mathematics learning using IRME (Sari, 2017).

In IRME, mathematical modeling and the interpretation of everyday experiences into mathematical models involve generalization and formalization, this is commonly called horizontal mathematization and vertical mathematization (Putri & Syahputra, 2019; Yilmaz, 2020). IRME also emphasizes mathematical process skills, discussions, and collaborations, so that students find their mathematical concepts and use these concepts in solving problems (Sari, 2017). In addition, PMRI is oriented to students' reasoning in solving problems and oriented to developing practical, logical, critical, and honest thinking patterns in students (Adha & Refianti, 2019; Ahmad & Asmaidah, 2017; Aljufri et al., 2020). The development student worksheets based on Indonesian Realistic Mathematics Education were developed using a 4-D development model which includes the definition stage, the design stage, the development stage, and the dissemination stage. The developed student worksheets have been assessed as valid by material experts and media experts. The student worksheets were revised based on input from experts until they were finally judged to be valid and feasible to be tested. The development of student worksheets in this study did not reach the dissemination stage due to time constraints, and the constraints of the COVID-19 pandemic situation and conditions.

4. CONCLUSION

The development of student worksheets can have an impact on the mathematics learning process. The learning process can be carried out using an approach that is tailored to the needs of students, one of which is using the Indonesian Realistic Mathematics Education approach. In the implementation of learning using Indonesian Realistic Mathematics Education, it is expected that students can abstract contextual problems into concepts in mathematics material. The development of Student Worksheets with the Indonesian Realistic Mathematics Education approach is expected not only to be used in one mathematical material but also to be developed in other mathematics materials.

5. ACKNOWLEDGMENTS

We would like to thank the validators, namely the lecturers of the Department of Mathematics Education, UIN Sunan Kalijaga Yogyakarta, who have provided valuable input to improve product quality.

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