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Development of Missouri Mathematics Project Learning Worksheet to Improve Mathematical Communication and Critical Thinking Skill

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Abstract: This study aims to develop a valid, effective, and practical mathematics learning tool. This study aims to develop student worksheets based on mathematical communication and critical thinking on data presentation material. The type of research conducted by researchers is research and development (R&D). This worksheet development model uses 4-D, namely the model from Thiagajar, among others: Define (defining), Design (design), Develop (development), Disseminate (deployment). Based on the purpose of this study, the worksheet develop by the researcher was declared valid with a final score of 3.89 which was obtained from the validation sheet of all instruments given to the two validators, namely lecturers and teachers and showed that it was feasible to be tested on students. The worksheets developed by the researchers were stated to be very practical with a final score of 84,93%, meaning that the worksheets were easy to use and achieved the learning objectives that had been determined. The worksheet developed by the researchers showed a very effective category with an average final score of 5.86% and an average N-Gain score of 0.55 and the percentage of N-gain scores was 55.73% with a moderate improvement category, meaning that the worksheet had influence on students so as to bring results in achieving learning objectives.

Keywords: students' worksheet, Missouri mathematics project, mathematical communication, critical thinking.

Abstrak: *Penelitian ini bertujuan untuk mengembangkan perangkat pembelajaran matematika yang valid, efektif, dan praktis. Penelitian ini bertujuan mengembangkan LKS berbasis komunikasi matematis dan berpikir kritis siswa pada materi penyajian data. Jenis penelitian yang dilakukan oleh peneliti yaitu penelitian pengembangan atau Research and Development (R&D). Model pengembangan LKS ini menggunakan 4-D yaitu Model dari Thiagajaran antara lain: pendefinisian, perancangan, pengembangan, penyebaran. Berdasarkan tujuan penelitian ini, LKS yang dikembangkan oleh peneliti dinyatakan valid dengan skor akhir 3,89yang diperoleh dari lembar validasi semua instrumen yang diberikan kepada kedua validator yaitu dosen dan guru dan menunjukkan layak untuk diuji cobakan kepada siswa. LKS yang dikembangkan oleh peneliti dinyatakan sangat praktis dengan skor akhir 84,93% artinya LKS mudah dalam penggunaannya dan mencapai tujuan pembelajaran yang telah ditentukan. LKS yang dikembangkan oleh peneliti menunjukkan kategori sangat efektif dengan rata-rata skor akhir 5,86% dan rata-rata skor N-Gain yaitu 0,55 serta persentase skor N-gain adalah 55,73% dengan kategori peningkatan sedang, artinya LKS memiliki pengaruh kepada siswa sehingga membawa hasil dalam mencapai tujuan pembelajaran.*

Kata kunci: *lembar kerja siswa, proyek matematika Missouri, komunikasi matematis, berpikir kritis.*

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▪ INTRODUCTION

The Regulation of the Minister of Education and Culture of the Republic of Indonesia in the guidelines for implementing learning communicates student learning activities to think systematically, express opinions using short and clear, and develop good and correct language skills. Based on some of the sentences above, it can be concluded that the ability to think inductively and deductively in concluding is obtained when students are taught honesty, thoroughness, discipline in all things, obeying rules, working hard and being able to carry out strategies. Competencies that must be achieved in 21st century education (4C): communication, creative, collaborative, and critical (Abidin, 2016). According to Convey Missouri Mathematics Project (MMP) is an experience-based model through structured research which is packaged in his book according to the steps (Krismanto R, 2009). The Missouri Mathematics Project (MMP) learning model will be given project assignments whose contents include a series of questions or instructions to develop ideas or expand the teacher's concepts. The MMP model is a program to help teachers in terms of student training so as to achieve significant improvements. (Wulandari & Ansori, 2013). MMP model learning tools is a learning tool that can make students accustomed to solving problems systematically and precisely. In addition to the interest in learning from the teacher, the success of students in the learning process is a learning tool packaged by the teacher. Learning tools are used to guide the ongoing learning process. Being able to reason and be able to solve mathematical solutions well, doing student activities must also be able to contribute to oral and written skills (Krismanto, 2003). This is in line with the researcher's goal to analyze student learning outcomes through the MMP learning model with mathematical communication and students' critical thinking which includes problem solving skills, students must have a lot of experience with various problems. Pugalee describes that in improving mathematical communication skills, students must get used to answering questions caused by related arguments and be able to provide comments made by students, so that students understand mathematical concepts and their arguments are meaningful (Rahmawati, 2013). Giving explanation questions in mathematics learning can improve students' mathematical communication skills (Umar, 2012). Critical thinking is an attitude about problems in solution and things that are within the scope of their own experience (Sulianto, 2008). Researchers believe that critical thinking skills have been recognized as key skills for success in learning, working and living in the 21st century (Riyadhotul et al., 2019). The importance of critical thinking analysis is to emphasize that mathematics involves and requires critical, systematic, logical and creative thinking because learning mathematics, students can improve their thinking patterns. (Hasratudin, 2010).

The problem about learning mathematics at State Junior High School 26 Malang based on observations of internships I, II, and III is that many students still think that mathematics is difficult, on the other hand, the way teachers deliver to students is still somewhat less creative. The assumption that mathematics is difficult. Lack of understanding of mathematical concepts so that students only memorize formulas. Lack of relationship between students and mathematics teachers, so students are afraid to ask questions if they do not understand the material. One of the factors that become difficulties in learning mathematics is the lack of mathematical communication and critical thinking of students when experiencing problems in mathematics. Observation results show that students still have difficulty in capturing mathematical material.

Pugalee describes that in improving mathematical communication skills, students must get used to answering questions caused by related arguments and be able to provide comments made by students, so that students understand mathematical concepts and their arguments are meaningful (Rahmawati, 2013). Giving explanation questions in mathematics learning can improve students' mathematical communication skills (Umar, 2012). The final result of the research (Sukwandani, 2011) shows that the interest in learning mathematics for grade VII students of SMPN 3 Colomadu 2010/2011 using the MMP learning model has increased, grades, and no student has scored less. Research (Sari, 2012) concludes that the final result using the MMP model is a good category where many students get grades according to the KKM. The results of several previous researchers concluded that the MMP model had an effect on the mathematics learning process.

Critical thinking is an attitude about problems in solution and things that are within the scope of their own experience (Sulianto, 2008). Researchers believe that critical thinking skills have been recognized as key skills for success in learning, working and living in the 21st century (Riyadhotul et al., 2019). The importance of critical thinking analysis is to emphasize that mathematics involves and requires critical, systematic, logical and creative thinking because learning mathematics, students can improve their thinking patterns. (Hasratudin, 2010). This research aims to develop a valid and effective mathematics learning tool, especially the Missouri Mathematics Project (MMP) model for junior high school students that produces mathematical instruments to measure students' mathematical communication and critical thinking skills.

▪ METHOD

Research development or Research and Development (R&D) is a type of research that will be carried out, because the purpose of the research is to find, grow, and validate a creation (product) designed by the researcher. According to Sugiyono, developing is expanding and deepening the actions and knowledge of an existing product (Kurniawan & Dewi, 2017). A learning tool that will be developed in this research is the Student Worksheet (LKS). The model for developing this LKS learning device uses 4-D, namely the Model from Thiagajari (Yahya, 2020). As the name implies, this model has 4 stages, including: Define, Design, Develop, Desseminate. Trial was carried out for four meetings from August 2, 2021 to August 5, 2021. The worksheets were tested on class VII C students at State Junior High School 02 Nglegok, totaling 6 students.

Research subjects that will be used in this study are six grade VII C students of State Junior High School 02 Nglegok who will be selected randomly by considering low, medium, and high abilities who are able to provide arguments for a statement and valid conclusions. Not only that, but based on the scores of the pretest, posttest, observation sheets, and student response questionnaires. Stages of research entitled the development of learning tools for the missouri mathematics project model include

The research instruments used include validation sheets, pre-test and post-test (there are 10 multiple choice questions for the pre-test and 15 questions for the post-test), teacher activity observation sheets, student activity observation sheets, student response questionnaires, worksheets, and lesson plans. indicators of critical thinking according to (Cahyono, 2016) include; Identify the facts given clearly and logically, formulate the main issues carefully, apply methods that have been studied accurately,

reveal data/definitions/theorems in solving problems correctly, evaluate relevant arguments in solving a problem carefully, and Distinguish between conclusions based on valid/invalid logic

Table 1. Categorization criteria for validation of worksheet and lesson plan

Score Interval	Category
$\overline{M_v} > 3{,}50$	Very valid
$3{,}00 < \overline{M_v} \leq 3{,}50$	Valid
$2{,}50 < \overline{M_v} \leq 3{,}00$	Not valid
$\overline{M_v} \leq 2{,}50$	Invalid

There are 3 data analysis: (1) analysis of validity which is measured based on the results of the validator to validate the worksheet, lesson plan, pre-test and post-test (2) analysis of practicality is measured based on the observation sheet of student activities assessed by the validator (3) analysis of effectiveness is measured based on the effect of increasing the results student learning scores obtained from student response questionnaires and pre-test and post-test.

Table 2 . Criteria for categorizing critical thinking worksheet

Interval Skor	Kategori
$\bar{x} > 5$	Very effective
$4 < \bar{x} \leq 5$	Effective
$3 < \bar{x} \leq 4$	Effective enough
$2 < \bar{x} \leq 3$	Less effective
$0 < \bar{x} \leq 2$	Ineffective

▪ RESULT AND DISCUSSION

Research development or Research and Development (R&D) is a type of research that will be carried out, because the purpose of the research is to find, grow, and validate a creation (product) designed by the researcher. According to Sugiyono, developing is expanding and deepening the actions and knowledge of an existing product (Kurniawan & Dewi, 2017). A learning tool that will be developed in this research is the Student Worksheet (LKS). The model for developing this LKS learning device uses 4-D, namely the Model from Thiagajari (Yahya, 2020). As the name implies, this model has 4 stages, including: Define, Design, Develop, Desseminate. Trial was carried out for four meetings from August 2, 2021 to August 5, 2021. The worksheets were tested on class VII C students at State Junior High School 02 Nglegok, totaling 6 students.

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▪ RESULT AND DISCUSSION

This study uses a 4-D development model procedure which consists of 4 stages. The results of each stage of research and development procedures carried out by researchers are as follows. (1) Defining Stage: This stage is carried out by researchers to prepare what needs to be prepared in developing learning media in the form of worksheets before conducting research. 5 steps of analysis (preliminary final analysis, student analysis, assignment analysis, basic concept analysis, and analysis of learning objectives). (2) Design stage : this stage the researcher describes the results of the design, including: (text preparation, media recovery, and format selection). (3) Development stage: at this stage the researcher finds the final result of the worksheet that has been validated to the validator through several corrections based on input from the validators, and the results after the worksheet has been tested on students of State Junior High School 02 Nglegok class VII C, totaling 6 students among others : (a) reviewer validation includes teachers and lecturers, along with several corrections of the research instrument. Before knowing the results of the validity data analysis, Table 3 shows suggestions for improving the design in the form of tables and pictures from validator 1 (lecturer) used as worksheet improvements.

Table 3. validator improvement suggestions

Number	Aspect	Suggestions for improvement	Repair results
1.	langue	The language used is inconsistent in the width of the validator with the questions given by students using the word choice of UH or pre-test and post-test	The writing is precise and consistent
2.	contents	Other instruments have	The neatness of the

		their format tidied up	format has been fixed
3.	Format	The numbering format of the pre-test and post-test questions does not match the validation sheet	The numbering format has been fixed

Based on the picture above, improvements were made because the numbering in the pre-test and post-test did not match the validation sheet. (b) testing, the worksheet test was carried out after getting the validation results and revising the two validators. The worksheets were tested on class VII C students at State Junior High School 02 Nglegok, totaling 6 students. Six students were selected based on the recommendation of a teacher at SMPN 02 Nglegok through test scores. The six students included two students with high ability categories, two students with moderate abilities, and two students with low abilities. some of the results of the researcher's analysis include: (1) validity analysis. The data from the validation results are obtained from the validator who has filled out the validation sheet provided. The data from the validation results are then carried out with a basic analysis to revise/improve the media for test questions, worksheets and lesson plans that you want to use and develop.

Table 4. validation calculation results from two validators

Aspect	**Analysis of the two Validators**	**Validation sheet**				
		Lesson plan	**worksheet**	**Test (*Pre-&Test Post-Test*)**	**Student Activity Observation**	**Student Response Questionnaire**
Format	$\sum \bar{x}_i$	23	23	72	23	23
	$\bar{V}$	3.83	3,83	4	3.83	3.83
Content	$\sum \bar{x}_i$	38	24	96	24	24
	$\bar{V}$	3.8	4	4	4	4
Language	$\sum \bar{x}_i$	14	24	69	24	24
	$\bar{V}$	3.5	4	3.83	4	4
$\bar{M}_{\bar{v}}$				3.89		
				VALID		

Based on the table and graph of the calculation results of all instrument validation sheets from the two validators above, the worksheet that is assessed from the aspect of format, content and language is declared VALID based on table 4 with a final score $(\overline{M_{\bar{v}}})$ 3,89 $(3{,}4 \leq \overline{M_v} \leq 4{,}2)$. (2) practical analisysis. with the results of the calculations above, the average percentage of student activity observation sheets is 86.11. the average percentage of Student Response Questionnaires is 83.75. if added up the result is 169.86. for the average practicality value of 84.93, the practicality value category is very practical. Based on the results of the calculation of the final average percentage of the two data (student activity observation sheets & student response questionnaires above the worksheet it is stated very practical $(\bar{S})$ 84,93 $(\bar{S} > 80\%)$. (3) effectiveness analysis, effectiveness data obtained from the test results (pretest and posttest). The

pretest was done by the students at the first meeting before the students worked on the worksheet developed by the researcher. The posttest was done by the students at the fourth meeting after the students worked on the worksheet developed by the researcher. After the research has been completed, the researcher will analyze all the test results (pretest and posttest) that have been obtained from the sixth grade VII-C students of SMP Negeri 2 Nglegok who are the research subjects. from 6 students, the following scores include NDS (pretest 100 and posttest 100), HMS (pretest 95 and posttest 100), DBP (pretest 75 and posttest 100), MBRP (pretest 75 and posttest 100), IM (pretest 60 and posttest 70), and WN (pretest 45 and posttest 60).

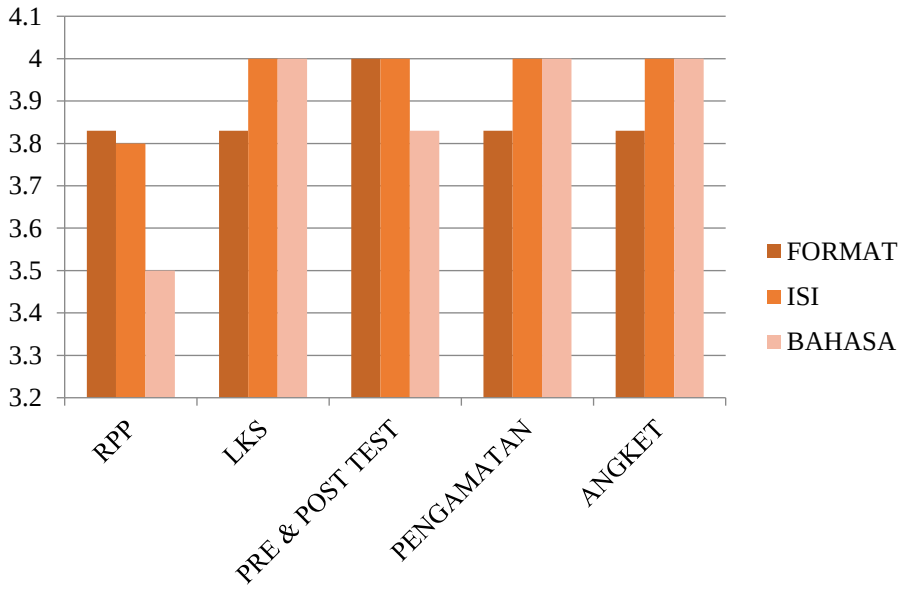

Figure 1. graph of validation calculation results from two validators

The pretest & posttest assessments of students in the table are the scores of high-ability students, in accordance with the assessment of critical thinking indicators. If you look at the assessment based on the conclusions from the critical thinking indicators above, among others: (a) students are able to write what is known in the question statement (b) students are able to know the meaning of the question statement by writing asked on the answer sheet (c) students are able to solve the problem using the formula -the calculation process formula on the data presentation material and supported by the right answer.

The pretest & posttest assessments of students in the table are the scores of students with moderate abilities, according to the assessment of critical thinking indicators. If you look at the assessment based on the conclusions from the critical thinking indicators above, among others: (a) students are able to write what is known in the question statement (b) students are able to know the meaning of the question statement by writing asked on the answer sheet (c) students are able to solve the problem using the formula -the calculation process formula on the data presentation material and but some answers are not correct. So that students with moderate abilities only meet two critical thinking indicators.

The students' pretest & posttest assessments in the table are students' scores in the low category, according to the critical thinking category. If you look at the assessment

based on indicators of critical thinking, the answers of low-ability students include: (a) students are able to write what is known in the question statement (b) students are able to mention but have not been able to understand the meaning of the question statement (c) students are less careful when the work is answered, causing answers which is not correct. Students with low abilities only meet 2 conclusions from the critical thinking indicators. The following is an analysis table of the effectiveness of the LKS obtained from the test data.

Table 5. results of worksheet effectiveness analysis

Number	**Name student**	**Pretest**	**Postest**	**Posttest-Pretest**	**Skor Ideal**	**Skor Ideal-Pretest**	**N-Gain Skor**	**N-Gain Skor %**
1.	NDS	70	95	25	100	30	0.83	83.33
2.	HMS	65	85	20	100	35	0.57	57.14
3.	DBP	75	90	15	100	25	0.6	60
4.	AZA	55	85	30	100	45	0.66	66.66
5.	IM	50	70	20	100	50	0.4	40
6.	WN	45	60	15	100	55	0.27	27.27
many students				6				
Total Average				70.41				
Average				11.73				
Effectiveness Average Results				5.86				
Worksheet Effectiveness Category				VERY EFFECTIVE				
		Average Increase					0.55	55.73
		Category N-Gain					MEDIUM IMPROVEMENT	

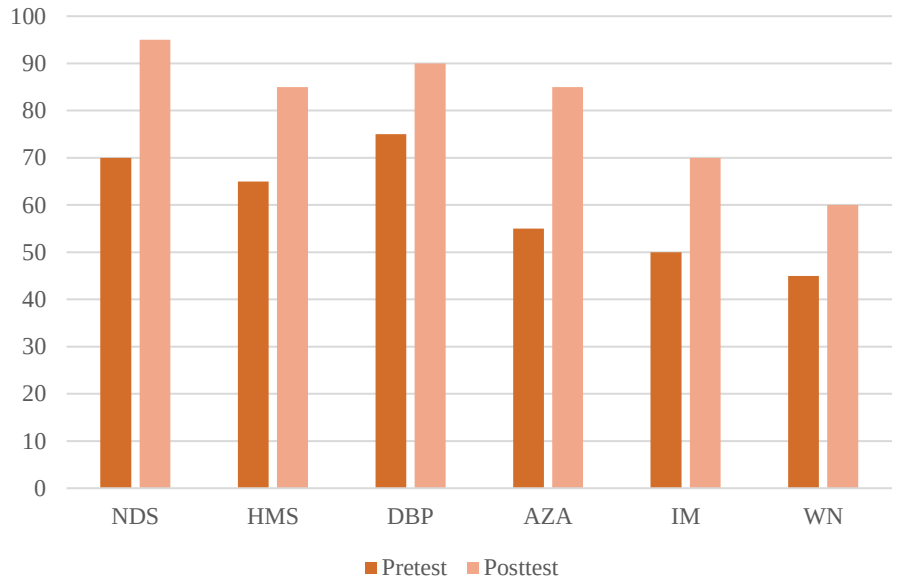

Figure 2. worksheet effectiveness analysis results

Based on the Table 5 and Figure 2, the calculation result of the average effectiveness is 5.86, indicating the very effective category, with an average increase of 55.73% in the N-Gain category, which is a moderate increase. This result proved the effectivity of Missouri mathematics project learning worksheets to improve mathematical communication and critical thinking skill.

▪ CONCLUSION

Based on the presentation of the results of the discussion above, the products that developed by researchers has fulfilled and answered the research objectives, namely student worksheets based on mathematical communication and students' critical thinking developed by researchers are declared valid, very practical, and very effective in improving students' critical thinking and mathematical communication on data presentation material. Worksheet is declared valid based on the results of the validation with the final score an average of 3.89 proves that it is feasible to be tested on students. The worksheet is stated to be very practical with a value of 84.93% which means that the worksheet is easy to use and achieves the learning objectives that have been determined. worksheet was declared very effective with an average of 5.86 and an average N-Gain score of 0.55 and a percentage of N-Gain score of 55.73% in the moderate improvement category, meaning that worksheet had an effect on students in order to bring the results to achieve learning objectives.

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