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The Developing of Teaching Materials Oriented to Problem-Based Learning to Improve Students' Mathematical Communication Ability

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Abstract

This research was aimed to know the validity, practicality, and effectiveness of teaching material oriented to problem-based learning in improving students' mathematical communication ability. The matery which did not relate the problem on real life context and lacked of students' mathematical communication ability are the reasons why this reaserch was done. This is a development research. This research used 4-D Thiagarajan, Semmel and Semmel development research by developing teaching materials oriented to problem-based learning approches. Teaching materials developed were teachers book and students' book. The trial was done to 32 students on VII-4 and VII-5 classes in SMP Negeri 1 Pangkalan Susu. From First and second trial obtained: (1) According to experts, the teaching materials were valid, teaching materials' practicality was practical in terms of: a) Validator said that teaching materials can be used with a little revission; b) Observation result on teaching materials usage was also good, and teaching materials was also effective in terms of: a) students' learning completeness classically; b) Students' activeness on tolerance llimit decided; c) students' response on teaching material components and positive learning activity. (2) Increasing students' mathematical communication ability on the first trial post-test, from 64.84 became 75.50 on the second trial.

Keywords: Developing; teaching material; problem-based learning; Mathematical Communication.

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1. Introduction

One of teachers' effort to explain mathematical teaching activity is in the form of teaching material. Reference [6] says teaching material is any form of material used to help teachers or instructors in doing teaching and learning process in a class. Teaching materials have important functions for teaching and learning process, both for teachers and students. From this fact, developing the teaching materials is becoming very crucial for teachers. Therefore, teachers should develop their own teaching materials themselves so that they would be able to implement harmonious, quality, and beneficial learning. So, teaching materials developing should be based on a certain developing model to create a good material. Teaching materials grouped by [10] explained that based on technology used, teaching materials are grouped become four categories, they are printed like handout, book, module, students' work sheet, brochure, leaflet, wallchart, photo/picture, model. Audio like cassette, radio, vinyl record, and compact disk audio. Audio visual like video compactdisk , film. Interactive teaching material like CAI (Computer Assisted Instruction), compact disk (CD) intercative multimedia learning, and web-based learning materials. A good teaching material should be valid, practical, and effective. Reference [13] said that in a learning model research needs quality criterion such as validity, practically and effectiveness. So, it can be concluded that a good learning material meets those thre aspects. But now adays, teachers do not develop teaching materials, or if there is a developed material by teacher, it has not eased the students in learning process and it does not support the accomplished expected ability by mathematic learning. Whereas teaching materials started by facing students to contextual problem can make students feel challenged to finish the contextual problem. This is becuse the book used leads to pattern concept directly and example given are routine questions. It can be seen from the teaching materials used are from publisher, not made by themselves. Based on the conditions, this research would develop teacing materials in the form of teacher's book and students' book which were expected becoming the solution to increase students' mathematical learning ability. Subject-oriented teaching and learning process. Reference [7] said teacher-centered learning will create a passive students in learning process in the class. One of learning process which is started by contextual problem is problem-based learning (PBL). According to [14] PBL is the use of some intelligences needed to do confrontation to the real life challenge, an ability to face new things and the complexity. While according to [11] problem-based learning as a learning method, built with constructivism idea and students-centered learning approach. If problem-based learning is used, teacher will help students to focus on problem solving in the real life context and will force students to think the problem situation when they try to solve the problem. So, problem-based learning steps are: (1) students' oriented on problem, (2) organize students to learn, (3) guide individual or group investigation, (4) develop and serve work, and (5) analyze and evaluate problem solving process. It is in line with [3] in her research said that PBL implementation can increase students' mathematical communication ability. It could be seen from the increasing average score between cycle 1 and cycle 2, it was from 70-81,82. It is also in line [16] research that students' mathematical communication ability by using PBM is better than usual learning. According to [15] this happens because of the mathematics presented in a form that is less appealing and seems difficult for students to learn; as a result students often feel bored and do not respond well lesson. Those problems caused the low of Indonesia achievement on mathematic lesson. One of the abilities should be mastered by students is mathematical communication ability to increase the achievement in learning mathematic. On [1] research, mathematical communication ability is an ability to deliver mathematic

idea, both oral and written and also be able to understand and receive others' mathematical idea accurately, analysis, critical, and evaluative to sharpen the understanding. Reference [9] told that there are two important reasons which made communication in mathematical learning needs focuss, they are (1) mathematics as a language; Mathematics are not only as tool to aid thinking, tool to find pattern, or to solve problems, but also as an invaluable tool for communicating a variety of ideas clearly, precisely, and succinctly and (2) mathematics learning as social activity; in mathematical learning, interaction among students, as the communication among students and teacher is an important part to nurture children's mathematics potential. Several criteria used in seeing how big the students ability in mathematical communication ability are NCTM [4] said as follow: 1) the ability to express mathematical idea by oral, written, and demonstrate it also describe it visually, 2) the ability to understand, interpret, and evaluate mathematical idea both oral and other visual form, 3) the ability to use mathematical terms, notation, and structures to serve idea, describe relationship and situation model. The indicator which show mathematical communication ability in this research are: 1) serve the mathematical statement in written in the form of picture and description from the problem given, 2) make mathematical model in the form of symbol from the problem given, decide the strategy and solve the problem, 3) explain idea, solution strategy, or the answer got by writing, in the form of picture, graphic, or algebra. But, the fact nowadays shows students' mathematical communication ability are still low. Based on the communication task given to 32 students in SMP Negeri 1 Pangkalan Susu class VII-3 with one variable linear equations and inequality (PLSV). Based on the result, students were wrong because they were not be able to make the complete mathematical model from the questions. The students were difficult to understand tose questions and change it to mathematical model, the students were wrong to interpret the questions, so the students' mathematical were low. From the students' answers, there were 23 or about 71,9% students answered wrong, answer process which was not described and students had not communicated mathematical idea questins correctly. Then, there were only 5 or 15,6 % students who were able to describe in the form of mathematical model correctly. And 4 students (14,5%) who did not answer at all. So, based on the case, researcher can conclude that the problem happened was students were not able to communicate the problem given. The low of students' mathematical communication was also described in [2] research that junior high school students' mathematical communication ability were still in low category, students' work was categorized in level (lowest level 0 and the highest level IV) on comparison matery and linear equation with two variables where the score result using mathematical communication score rubric to 160 junior high school students in Semarang shown that for comparison matery: level I 78%, level level II 15 %, level III 5%, level IV 2%. While for linear equation two variable matery: level I: 67 %, level II: 18 %, level III: 8%, level IV: 7%. Then [17], based on observation result from daily test done by students of State Senior High School Simpang Ulim, showed that mathematical communication ability were still low, this could be seen from students' answer process that almost all students felt difficult to describe the problems given. Based on those opinions, the researcher needs to observe about "The Developing of Teaching Materials Oriented to Problem-Based Learning to Improve Students' Mathematical Communication Ability. In that way, it is needed to design a teaching material which focuss to students mathematical communication ability. The aim of this developing research is answering a question where can problem-based learning material be said as valid, practical, and effective in increasing students' mathematical communication ability.

2. Research Method

This is a Reseach and Development (R & D) research with 4-D model developed by Thiagarajan consist of four steps: define, design, develop and disseminate. This research developed teaching material orinted to problem based learning to increase students' mathematical communication ability. Products developed were teacher books and students books. The subject in this research were students in State Junior High School 1 Pangkalan Susu class VII-4 and VII-5 for each as 32 students. Instruments and tools to collect the data in this research were validation sheet, questionnaire and observation sheet. To be more clear, it can be seen in Table 1 below:

Table 1: Instruments and tools to collect the data

Aspects	Instrument	Observation data	Respondent
Validity	Validation sheet	Teachers' books and students' books validity	Experts
Practical	Validation sheet	Teachers' books and students' books practical	Experts
	Observation sheet	Implementation of teaching material	Observer
Effectivity	Test	Completeness classically	Subject test
	Observation sheet	Students' activity	Observer
	Questionnaire	Students' response	Subject test

Criteria described that problem-based learning material has a good validity, if the minimum validity reached is the valid level ($4 \leq Va < 5$). Then criteria said that problem-based learning material has a good practical, which consist of 2 indicators, (1) all validators/experts said that problem-based learning can be used with "little revision" or "no revision". While to see the ability of problem-based learning material implementation on the high minimum category and good if it has reliability coefisien as 0,75 or 75%. Then, criteria of problem-based learning material developed are effective if fulfill 85% which follows mathematical communication test by the the smallest average score 56 or in category C, students' activity in learning process is effective if four from those six ideal time tolerance achievement limit criteria used in category 1,2,3,4,5, and 6 are fulfilled. With note, tolerance limit criteria 3 and 4 should be fulfilled and minimal 80% from subject observed give a positive response to the teaching material component developed.

3. Result

This research produces some conclusion from the research done based on problem of the study, they are teaching material validity, teaching material practical, and teaching material effectiveness.

3.1. Teaching Material Validity

Teaching material validity can be measured by experts analysis. Based on experts analysis problem-based learning material in the form of teachers' book and students' book get the total average score of validity in teachers' book and students' book are 4,46 and 4,38. Based on validity criteria can be concluded that problem-

based learning material developed is valid.

3.2. Teaching Material Practical

Problem-based learning material practical which was developed was seen from 2 aspects, they are: (1) experts/practical evaluation of the developed teaching material said that it can be used with a little revision; (2) observation result of teaching material implementation in the class was becoming high minimum category (the teaching material is practical or can be implemented). Based on data analysis resuult, the observation of teaching material oriented to problem-based learning implementation got observation average score on trial 1 and trial 2 can be shown in the table below:

Table 2: Average Score for Teaching Material Implementation on trial I and II

Average score for 2 observers	**MEETING** $\overline{P_2}$				**Total Average Score** $\overline{P_3}$	**Explanation**
	1	**2**	**3**	4		
TRIAL I	3,79	3,79	3,85	4,02	3,86	High (Practical)
TRIAL II	3,82	3,76	3,81	4,13	3,88	High (Practical)

Based on table 2, it is shown that average score for observers in problem-based learning material implementation is in high category ($3 \leq P \leq 4$). interval: $4 \leq Va < 5$. Based on the implementation criteria, it can be concluded that teaching material oriented to problem-based learning developed is practical. This is supported by the research result of [12] which showed that observation result on mathematical teaching material implementation of the developing of Mathematical problem-based learning teaching material to facilitate reasoning ability achievement showed that average score of all implementation observation components were 1,97 and were on the accomplished category at all (practical). Reference [5] Total average score was 21,4 with average mathematical learning implementation precentage was 90,63 %, means that learning precentage has exceeded minimum criteria, that was 80%. Therefore, problem-based learning mathematical devices could be concluded as a practical teaching material with a very good category.

3.3. Teaching Material Effectiveness

Criteria to determine the teaching material oriented to problem-based learning effectiveness on Trial I and Trial II consist of tree indicators:

3.3.1. Classical Completeness

Based on research result on trial I and trial II, the classical completeness result as follow:

Table 3: Mathematical Communication Ability Classical Completeness Level on Trial I and Trial II

Category	Mathematical Communication Ability			
	Total Students		Precentage	
	Trial I	Trial II	Trial I	Trial II
Complete	23	30	71,88%	93,75%
Not complete	9	2	28,13%	6,25%
Total	32	32	100%	100%

Based on the data on the table 3, it can be seen that post test result on mathematical communication ability on trial I had not fulfilled the classical completeness criteria. According to students' learning classical completeness criteria was minimum 85% students who followed the learning process are able to get score ≥71. Thus, posttest result on mathematical communication ability on trial II had fulfilled the classical completeness criteria. This thing is also supported by [18] research, students' learning completeness reached from students' understanding classically as 88,57%. Then [5] classical completeness precentage reached as 84,38%. Therefore, it can be concluded that the communication ability test was effective.

3.3.2. Students' Activity

students' activity in learning process is effective if four from those six ideal time tolerance achievement limit criteria used in category 1,2,3,4,5, and 6 are fulfilled. With note, tolerance limit criteria 3 and 4 should be fulfilled. Based on the research result in trial I and trial II, the result got from students' activity as follow:

Table 4: Analysis Rsult on Students' Activity Ideal Time Achievement Percentage on Trial I and Trial II

Percentage Average	Students' Activity Ideal Time Achievement Precentage for Indicator (%)					
	1	2	3	4	5	6
Trial I	25,63	13,44	20,00	27,81	9,06	4,06
Trial II	25,63	13,54	20,63	27,50	9,79	2,92

Based on data on table 4, it can be seen that students' activity ideal time achievement percentage on trial I had not fulfilled time ideal percentage criteria. Therefore, students' activity ideal time achievement percentage result on trial II had fulfilled students' activity time ideal achievement criteria. This is supported by [18] who said that active students' activity during learning process on problem-based learning had been on learning effectiveness limitation criteria.

3.3.3. Students' Response

Students' response criteria is effecetive if minimum 80% from many subjects observed give positive response to the component of teaching material developed. Based on research result on trial I and trial II, the objects had given a positive response to the activity and the component of teaching materials developed. This is supported

by research result of [18] that students' response to the component on problem-based learning had shown positive response.

3.4. The Increasing of Mathematical Communication Ability

Data got from posttest result, students' matheatical communication ability on trial I and trial II were analyzed to know the increasing of students' mathematical communication ability by comparing to students' average score from post test result of students' mathematical communication ability on trial I and trial II. Description of the increasing students' mathematical communication ability using problem-based learning material which was developed on trial I and II were shown in table 5.

Table 5: Description of Mathematical Communication Ability Result

Explanation	**Mathematical Communication Posttest Trial I**	**Mathematical Communication Posttest Trial II**
Highest Score	91	93
Lowest score	45	48
Average	64,84	75,50

Then, description of the increasing of students' mathematical communication ability by using teching material oriented to problem-based learning which was developed on Trial I and trial II for each students' mathematical communication indicator could be seen on table 6 as follow:

Table 6: Students' Mathematical Communication Ability Average for Each Indicators

Mathematical Communication Indicator	**Average**		
	Trial I	**Trial II**	**Improvement**
Serve writtent mathematical questions in the form of picture or description from contextual problem given.	2,70	3,17	0,47
Make mathematical model in the form of mathematical symbol, decide the strategy and solve the problem.	2,66	3,13	0,47
Explain idea, solving strategy or answer got	2,45	2,92	0,47

To be more clear, it can be seen in picture 1

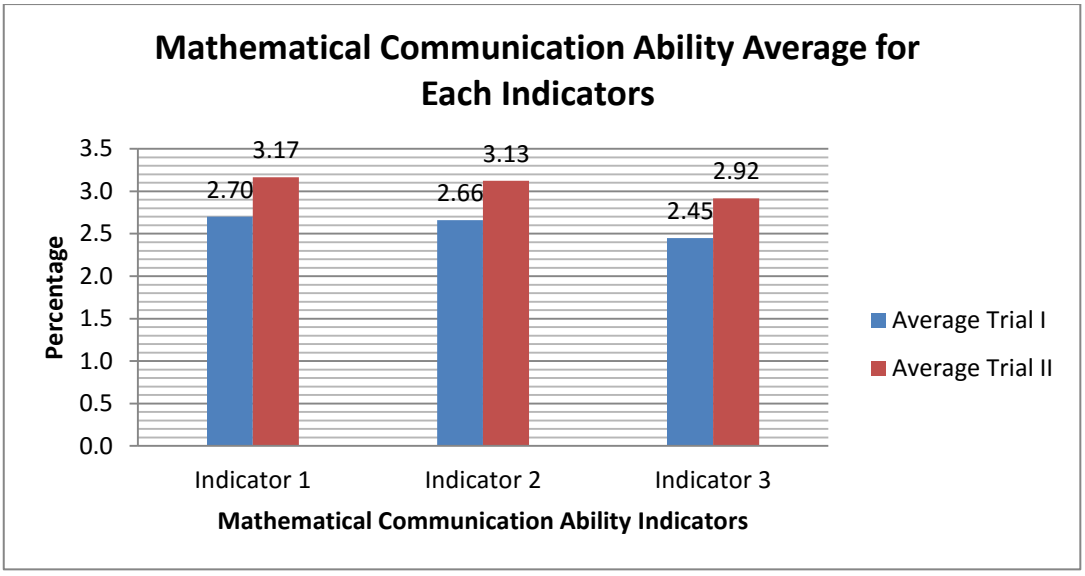

Figure 1: Students' Mathematical Communication Ability Average for Each Indicators

Based on table 6 and picture 1 above, it can be concluded that students' mathematical communication ability on trial I to trial II seen from total average and average score for each indicators are increasing by implementing teaching material oriented to problem-based learning which was developed. This is supported by [18] research that students' mathematical communication ability completeness level was classically 85,71% while students' mathematical communication ability improvement on trial I is 2,76 become 3,06 on trial II. Then according to [8], on problem-based learning indicator served written mathematical statement in the form of picture or contextual questions given got higher average score 3,23 compared to the realistic mathematical education model 3,07 and inquiry learning as 3,18. While indicator to make mathematical model in the form of symbol, to decide the strategy and solve the problem got higher average score as 3,07 compared to the realistic mathematical education 2,85 and inquiry learning 2,92. And on indicator to explain idea, solving strategy or answers got higher average score on problem-based learning as 3,10 compared to realistic mathematical education as 2,91 and inquiry learning as 2,99. It is seen clearly that students' mathematical communication ability in the three classes are different. Compared to the above table, average score of communication ability on problem-based learning is higher than using realistic mathematical education and inquiry learning.

4. Conclussion

Based on analysis results and discussion in this research, it can be concluded that:

1. Teaching material validity developed is valid.
2. Teaching material oriented to problem-based learning is practical if it is seen from: (1) experts/practical said that teaching material component oriented to problem based learning developed can be used with a little revision; and (2) teaching material implementation has reached high category, those are on trial I as 3,86 and on trial II teaching material implementation had reached high category as 3,88, and observation sheet on problem based learning material component implementation reached a good reliability.

3. Teaching material oriented to problem-based learning is effective. Effective criteria could be seen from (1) Students' classical completeness had reached 93,75% on trial II; (2) Students' activity during learning process had fulfilled time ideal tolerance decided; and (3) Students' responses are positive to teaching materials components and learning process developed.
4. Students' mathematical communication ability was improved from trial I to trial II using teaching material oriented to problem-based learning.

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