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Development of Learning Tools Assisted by Manipulative Teaching Aids Through Problem-Based Learning

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ABSTRACT: *The purpose of this research is to produce valid, practical, and effective teaching materials assisted by manipulative teaching aids through problem-based learning. The study was conducted on students of class XI at SMK YPK Medan, North Sumatra. This type of research is Research and Development (R&D) with a 4-D Model (Define, Design, Develop, Disseminate). The instrument used in data collection consisted of a problem-solving ability test that had been validated, and a learning independence questionnaire. The results of the study indicate that the results obtained in this study are (1) Learning tools assisted by manipulative teaching aids through problem-based learning are included in the valid category; (2) Learning tools assisted by manipulative teaching aids through problem-based learning produced are practically used in learning; (3) Learning tools assisted by manipulative teaching aids through problem-based learning produced are effectively used in increasing problem solving abilities and student learning independence.*

KEYWORDS *-Manipulative Teaching Aids, Problem Based Learning, Problem Solving Ability*

I. INTRODUCTION

Mathematics as one of the subjects which is a basic science has an important and useful role for the development of science and technology. Mathematics subject matter taught in schools plays a role in training students to think logically, critically and practically, as well as to have a positive and creative spirit. Because of the importance of the role of mathematics in life, in the education curriculum in Indonesia, mathematics is taught at every level of education from elementary school to high school.

The learning process in the classroom cannot be separated from the role of a teacher. Teachers are professional educators. Teachers have the main task of educating, teaching, directing, guiding, training, assessing and evaluating students from early childhood education to secondary education. A teacher should have professional abilities that support the performance of a teacher. Learning will produce maximum results if the teacher can carry out truly effective teaching. Related to effective learning, Borish[1] "What makes teaching effective is how teachers try to be role models (Modelling) by showing personality and positive attitude, experienced in teaching, proficient in conveying reflective information, motivational, and passionate to also participate in learning.

Learning tools are one of the important points in the learning process[2]. In addition, other points that can support the learning process are the abilities possessed by the students themselves. The ability of students to accept the learning process is very important. One of the mathematical abilities that need to be developed is problem solving ability[3]. This is because mathematics cannot be separated from mathematical challenges and problems. As Silver and Cai[4]say "when solving mathematical problems, students adapt and expand their

existing understanding by connecting new information with their current knowledge and building new relationships in the structure of their knowledge".

In addition to the ability to solve mathematical problems in learning, student learning independence also affects students' knowledge and understanding of mathematics. Because it is also necessary to have attitudes that must be possessed by students including learning initiatives, monitoring, regulating, controlling learning and evaluating the process of learning outcomes and this is an indicator of independence Student learning [5][6]. Student learning independence is a process of designing and self-monitoring of cognitive and affective processes that contribute to the success of a student in completing assignments well.

To improve students' low mathematics learning outcomes caused by lack of mathematical problem solving abilities and student learning independence, it is necessary to improve learning through efforts to select appropriate and innovative learning models in learning mathematics in schools, because the use of learning models that are not in accordance with student development will have an impact to the stage of student learning development. The demand from the K-13 curriculum is to activate students, as written in Permendikbud no 60 attachment III [7]says "one of the models discussed and developed is Problem Based Learning".

Problem-based learning model is expected that students can develop thinking skills and problem solving skills can also increase student learning independence including by presenting contextual problems at the beginning of learning which is one of the stimulus and triggers students to think[8][9]. In addition to developing learning tools using problem-based learning models, it is also necessary to use manipulative teaching aids that can improve mathematical problem solving abilities and student learning independence.

Students need teaching aids that are able to explain abstract mathematical concepts [10], [11], and [12]. Suydam and Higgins' research[13] also shows that teaching using material manipulatives (objects that can be tampered with) tends to produce better performance than teaching that does not use materials. For this reason, optimal use of the environment and manipulative teaching aids is expected to be a solution so that learning becomes more meaningful and the achievement of student learning outcomes is better [14]. Students easily understand the concept. With manipulative object props, students are expected to be motivated in participating in the learning process.

Using teaching aids will provide material that will be easily accepted by students[15]. Besides that, it can attract students' attention and can stimulate students to think, but the use of educational media must see to whom the media will be given, so that the media used can have meaning in learning mathematics.

II. METHOGOLOGY

This type of research is development research using the Thiagarajan, Semmel and Semmel learning device development model, namely the 4-D model (define, design, develop, disseminate)[16]. The product in this study is a learning device assisted by manipulative teaching aids through problem-based learning, including Learning Implementation Plans (RPP), teacher books, student books, student activity sheets (LKS) on line material. The research was carried out in class XI SMK YPK Medan on line material whose implementation took place for three meetings.

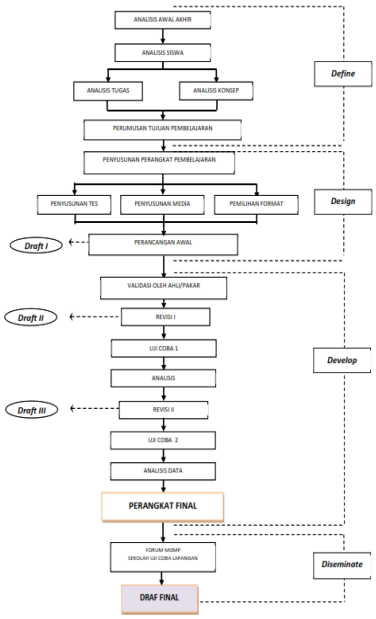

Figure 1 Chart of 4D model learning device development

Data analysis techniques were used to answer the validity, practicality and effectiveness of learning tools assisted by manipulative teaching aids through problem-based learning. Validation assessment is carried out by expert validators. The criteria for the validity of learning tools can be seen in Table 1:

Table 1 Criteria for Validity Level

V_t or the total average value	Validity Criteria
$1 \leq V_a < 2$	Invalid
$2 \leq V_a < 3$	Less Valid
$3 \leq V_a < 4$	Quite Valid
$4 \leq V_a < 5$	Valid
$V_a = 5$	Very Valid

The effectiveness of learning tools using problem-based learning-oriented learning is determined based on the achievement of learning objectives for each item of students' problem-solving abilities and classical completeness. 67. And from the test results obtained, it can be seen whether achieving the learning objectives of at least 75% of the formulated learning objectives can be achieved by at least 65% of students. At least 80% of the many subjects studied gave a positive response to the components of the learning tools developed.

III. RESULTS AND DISCUSSION

RESULTS

The learning device developed in this study uses a 4-D development model from Thiagarajan, Semmel and Semmel, namely the definition stage, the design stage, the development stage and the dissemination stage. Data analysis and research results obtained in each stage of development is presented as follows:

Defining Stage (Define)

a. Early-End Analysis

At the initial stage the researchers conducted a curriculum analysis carried out in class XI of Vocational High School where the curriculum used was the 2013 Curriculum. The 2013 curriculum aims to encourage students to be able to make more observations, ask questions, reason and present what students get or know after receiving the material. lesson. This curriculum refers to the active participation of students (active learning) both physically, mentally, intellectually and emotionally, which is expected to produce students who are productive, creative, innovative and affective.

b. Student Analysis

Characteristics of class XI students at SMK Sw YPK Medan for the 2018/2019 academic year include cognitive development and student attitudes. Class XI students are 15-17 years old. The characteristics of class XI students of SMK YPK Medan that were studied included: (1) the ability of students' initial knowledge in solving mathematical problems, (2) attitudes towards mathematics (3) the use of language that was in accordance with students' cognitive development.

c. Concept/Material Analysis

Analysis of the material to be studied by students aims to identify, detail and systematically arrange the concepts that will be studied by students in the line material into a concept map.

d. Task Analysis

This task analysis includes general tasks and specific tasks. General tasks refer to the Core Competencies that have been set in the 2013 curriculum, while special tasks refer to learning indicators.

Design Stage (Design)

This stage is designing learning tools, so that prototypes (examples of learning tools) are obtained for the subject matter of problem-based learning models assisted by manipulative teaching aids. Activities at this stage are preparation of tests, selection of media, selection of formats and initial design of learning devices.

a. Results of Preparation of Tests and Non Tests

To design the test and non-test, a grid was arranged based on indicators of problem solving ability and student learning independence. The developed test is adapted to the students' cognitive abilities. The scoring of the test results uses an evaluation guide that contains keys and scoring guidelines for each item. The test results compiled will be the initial design of the learning device or draft I.

b. Media Selection Results

The results of media selection were adjusted to concept analysis and task analysis. The media used in this study were visual media in the form of student books and worksheets. In the book, illustrations are presented, key words are bolded, and concepts are given boxes so that the book is interesting to study.

c. Format Selection Results

The results of the selection of the learning implementation plan format used are adjusted to the learning plan format in the 2013 curriculum. RPP includes Core Competencies (KI), Basic Competencies (KD), learning indicators, learning objectives, materials, learning models and methods, learning activities, assessment and learning resources, and answer keys and scoring guidelines. Students (BS) refer to the rules of the BSNP (National Education Standards Agency) and the LKS format is made in color so that students will be interested and motivated to learn.

d. Preliminary Design Results

At this initial design stage, learning tools were produced in the form of Learning Implementation Plans (RPP), Teacher's Books (BG), Student Books (BS), and Student Worksheets (LKS) for 3 (three) meetings, test of problem solving ability scoring guidelines, and alternative test answers.

1. Learning implementation plan (RPP)

   Three lesson plans (RPP) were developed for three meetings (8 hours of lessons). The time allocation used is 10 x 45 minutes. The lesson plans are in accordance with the principles and characteristics of the preparation of the lesson plans in the 2013 curriculum.

2. Teacher's Book

The teacher's book that has been compiled is a guide for teachers in guiding and facilitating students in the classroom. The teacher's book is made in contextual problems in the form of essays and has alternative answers. The teacher's book from this phase is designated as draft I, which can be seen in Figures 2, 3, and 4 below:

Figure 2 Cover of Teacher's Manual

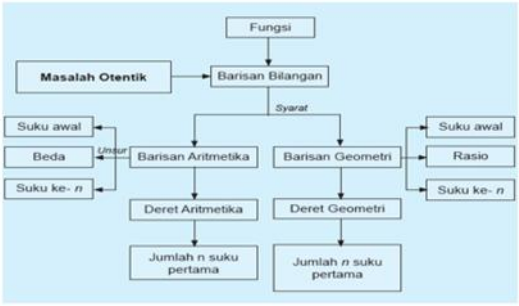

Figure 3 Concept Map Display

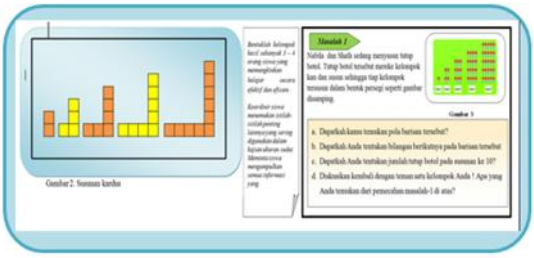

Figure 4 Display of Material in Teacher's Book

3. Student Book

The developed student book (BS) is structured so that students have guidelines in understanding the subject matter in accordance with the set learning objectives. The developed student book contains contextual problems that must be solved in groups and independently. The visual form of the cover used in the student book is shown in Figures 5, 6, and 7 below:

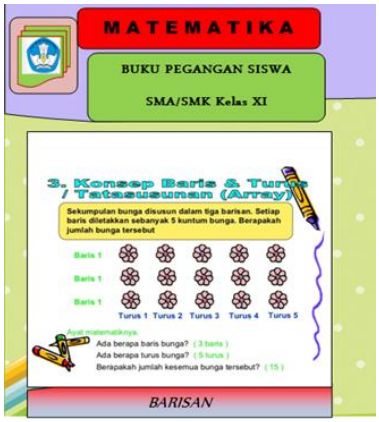

Figure 5 Student Book Cover

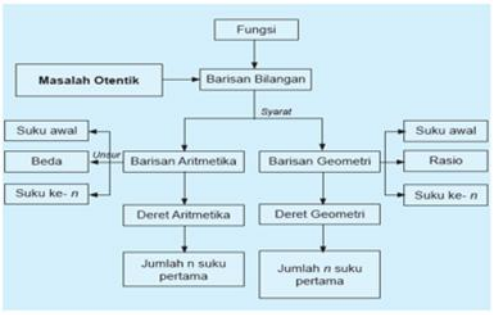

Figure 6 Concept Map Display

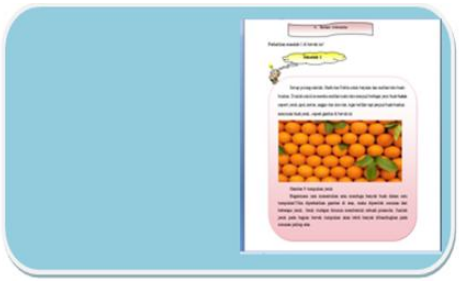
Figure 7 Display of Material in Student Books

4. Student worksheet
   Student worksheets (LKS) consist of 3 sets for 3 meetings. LKS is a place to write down answers and procedures that have been obtained in groups based on the problems contained in the LKS and student books. The worksheets developed are in accordance with the principles or procedures of the problem-based learning model. The visual form of the worksheets used by students is shown in Figure 8 below:

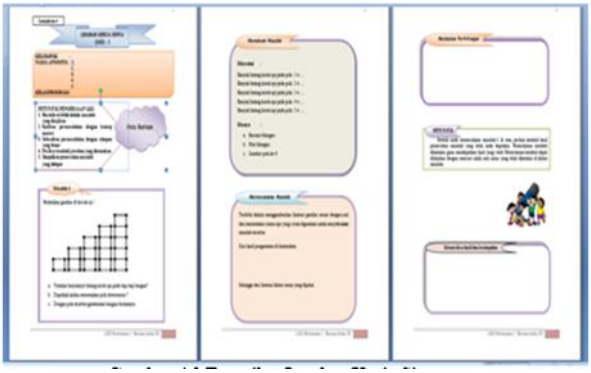

Figure 8 Display of Student Worksheets

Development Stage (Develop)

The development stage is the validation of the results from the defining and design stages resulting in the initial design of a learning device called draft I. Learning devices with problem-based learning models assisted by manipulative teaching aids that have been designed in the form of draft I are carried out validity testing by experts (expert review) and field trials.

a. Learning Implementation Plan (RPP)

The assessment carried out by the validator on the Learning Implementation Plan (RPP) includes indicators: format, language, and content of the RPP. The data analysis of the expert validation results on the learning implementation plan (RPP) is presented in Table 2:

Table 2 Results of Expert Validation on RPP

No	Aspect	Average	Category
1	Format	4,30	Valid
2	Bahasa	4,40	Valid
3	Contents	4,33	Valid
Average		4,34	Valid

b. Teacher's Book

The assessment carried out by the validator on the teacher's book includes: format, language, illustrations, and content. The following are the results of expert validation of student books presented in Table 3:

Table 3 Results of Expert Validation on Teacher's Books

No	Aspect	Average	Category
1	Format	4,33	Valid
2	Bahasa	4,25	Valid
3	Ilustrasi	4,33	Valid
4	Contents	4,35	Valid
Average		4,32	Valid

c. Student Book

The assessment carried out by the validator on student books includes: format, language, illustrations, and content. The following are the results of expert validation of student books presented in Table 4:

Table 4 Expert Validation Results on Student Books

No	Aspect	Average	Category
1	Format	4,33	Valid
2	Bahasa	4,43	Valid
3	Ilustrasi	4,40	Valid
4	Contents	4,40	Valid
Average		4,39	Valid

d. Student Worksheet (LKS)

The assessment carried out by the validator on the LKS includes: format, language, student activity steps, and content. The following are the results of expert validation of the LKS presented in Table 5:

Table 5 Expert Validation Results on LKS

No	Aspect	Average	Category
1	Format	4,37	Valid
2	Bahasa	4,43	Valid
3	Student activity steps	4,33	Valid
4	Contents	4,46	Valid
Average		4,40	Valid

e. Mathematical Problem Solving Ability Test

The validation of the developed instruments was carried out simultaneously with the validation of the learning tools. The assessment carried out by the validator includes indicators of the validity of the clarity of instructions, content, and language. The following are the results of expert validation on students' mathematical communication skills tests are presented in Table 6:

Table 6 Expert Validation Results on Problem Solving Ability Tests

No	Validator	Validator Assessment for Each Item				
		1	2	3	4	5
1	Validator 1	V	V	V	V	QV
2	Validator 2	V	V	V	V	QV
3	Validator 3	V	V	V	V	QV
4	Validator 4	V	V	V	V	QV
5	Validator 5	V	V	V	V	QV

f. Student Learning Independence Questionnaire

The assessment carried out by the validator includes indicators of format, content, and language. The following are the results of expert validation of the learning independence questionnaire, which can be seen in Table 7:

Table 7 Expert Validation Results on Learning Independence Questionnaire

Validator	Statement Validator each statement											
	1	2	3	4	5	6	7	8	9	10	11	12
Validator 1	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR
Validator 2	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR
Validator 3	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR
Validator 4	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR
Validator 5	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR
Validator	Statement Validator each statement											
	13	14	15	16	17	18	19	20	21	22	23	24
Validator 1	TR	TR	TR	TR	TR	TR	TR	TR	TR	RK	TR	TR
Validator 2	TR	TR	TR	TR	TR	TR	TR	TR	TR	RK	TR	TR
Validator 3	TR	TR	TR	TR	TR	TR	TR	TR	TR	RK	TR	RK
Validator 4	TR	TR	TR	TR	TR	TR	TR	TR	TR	RK	TR	RK
Validator 5	TR	TR	TR	TR	TR	TR	TR	TR	TR	RK	TR	RK

After the learning tools developed have met the criteria for validity according to experts. Then the learning device in the form of draft II was tested in the research field, namely students of class XI AK-2 totaling 32 students and XI AK 1 totaling 33 students at YPK Private Vocational School Medan. The field trial I was conducted in 3 meetings in accordance with the lesson plan (RPP) that had been developed. At the time of the trial, the researcher acted as a teaching teacher. Learning is designed by making students sit in groups consisting of 5-6 students in one group. Group members are chosen heterogeneously in terms of academic ability, gender, and ethnicity so that each student can get a diverse learning experience.

Dissemination Stage (Disseminate)

The dissemination stage is the final stage in the 4-D development model. After the valid, practical and effective criteria were met at the end of the second trial, the final draft was obtained. The next step is to carry out a limited distribution in the form of submitting the final equipment to the MGMP forum at SMK YPK for the development to all objects in this research. However, this stage is only limited to class XI SMK YPK Medan, due to time, cost and energy limitations so that this stage is not discussed in depth. The main step after the submission of the final toolkit is to submit the results of the development to all objects in this study in the hope of applying the learning tools to further learning.

IV. DISCUSSION

In producing good quality learning tools in accordance with Akker's [17] opinion, the learning tools must meet three criteria, namely validity, practicality, and effectiveness. The instruments used in this study consisted of on the instrument of the validity of the learning device, the instrument of the practicality of the learning device, and the instrument of the effectiveness of the learning device.

Based on the results of the post-test analysis in the first and second trials, it showed that the problem-solving ability of the sequence material increased, the increase in students' problem-solving abilities was also seen in each problem-solving indicator, namely the ability to understand problems, the ability to plan problem solving, the ability to perform calculations. and check the results.
From the post-test results, students' problem-solving abilities which have increased have also resulted in an increase in classical student learning outcomes from the first trial by 67.5%, increasing in the second trial by 87.5% and the achievement of learning objectives from 73% increasing to 76.8%. This shows that the use of the developed tools has an impact on increasing students' problem solving abilities.

Based on the results of research on the practicality of learning devices (Implementation of Learning Devices, and Student Responses), it can be said that the practicality of the developed learning devices can be implemented because they have met the established practicality indicators, namely the results of the implementation of learning device implementation sheets, and student responses have met the practicality criteria.

The implementation of learning tools based on field trials obtained a score of 4.05 (2.5 <in the practical category. Student responses to learning tools based on field trials obtained a percentage of 89.07% (≥80%). The largest student responses showed that students happy to learn by using learning tools that are applied.

Then to find out the effectiveness of the learning device, it is done by giving a test of learning outcomes that is seen through tests of mathematical problem solving abilities to students and student activities. From the post-test results, students' problem-solving abilities which have increased have also resulted in an increase in classical student learning outcomes from the first trial by 68.75%, an increase in the second trial by 87.5% and the achievement of learning objectives from 73.44% increased to 78.66%. This shows that the use of the developed tools has an impact on increasing students' problem solving abilities.

From the results of problem-based learning, it is known that the independence of students' learning increases seen from the responsibility and motivation of students in learning. Based on this research, problem-based learning can increase students' learning independence and support the 9 results of the questionnaire analysis of students' learning independence abilities in the first and second trials. student content. The average indicator of student learning independence in the 1st trial was 21.40 while the 2nd trial was 24.24 an increase of 2.84. An increase in student learning independence is also influenced by an increase in students' mathematical problem solving, based on the development process, it is found that the teaching materials developed have the effect of increasing the ability of learning independence in solving problems in the learning process.

Based on the statement above, this is in accordance with the indicators of the success of the learning device. So it can be concluded that the learning tools assisted by manipulative teaching aids through problem-based learning are declared valid, practical and effective for use in learning the line material.

V. CONCLUSION

Based on the results of research and discussion, it can be concluded that the development of mathematical tools assisted by manipulative teaching aids through problem-based learning using the Thiagarajan, Semmel and Semmel development model aims to improve students' mathematical problem solving abilities and student learning independence at YPK Private Vocational School Medan, it can be concluded that:

1. Valid, namely for Learning Device Plans (RPP), Teacher Books (BG), Student Books (BS) and Student Worksheets (LKS), Practical as seen from the average implementation of learning is in the well implemented category, and the average student responses regarding learning devices are in the good category. And effective in terms of the results of classical student learning completeness, achievement of learning objectives, student responses to learning, and time used in efficient learning does not exceed ordinary learning.
2. Increasing students' mathematical problem solving skills using learning tools assisted by manipulative

teaching aids through problem-based learning on line material, obtained the average achievement of students' solving abilities in the first trial of 68.75% and increased in the second trial to 87.5%.

3. Increasing student learning independence using learning tools assisted by manipulative teaching aids through problem-based learning on line material, the achievement of student learning independence in the first trial obtained an average of 21.40 and increased in the second trial to 24.24.

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