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THE DEVELOPMENT OF MATHEMATICS LEARNING TOOLS TO IMPROVE HIGH SCHOOL STUDENTS' CRITICAL THINKING ABILITIES

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ABSTRACT

This research aims to produce high school mathematics learning tools to improve students' critical thinking skills which include Student Worksheets (LKPD), and learning outcome assessment test sheets that are valid, practical and effective. The combination of learning methods and technological devices provides a fun learning process and helps students improve their critical thinking skills so as to provide benefits to students' learning outcomes. The type of research carried out is the research and development method. The development model referred to is using a 4-D development model which consists of four stages, namely the define stage, the design stage, the develop stage and the disseminate stage. The research instruments used were validation sheets, teacher practicality sheets, student practicality sheets, learning implementation observation sheets, and test sheets. The research data obtained that the level of device validity was in the valid category with an average score of 74.5. The teacher obtained a score of 60.5 for practicality and 61.88 for student practicality, so that the product met the practical category, and the results of students' mathematics learning achievement tests in the field trial showed that 83.3% of students had achieved the Minimum Completeness Criteria (KKM) so that the product The worksheet meets the effective category. Based on the obtained validity, practicality and effectiveness figures, it can be concluded that the learning tools developed are suitable for use in the classroom learning process.

Keywords: Learning Tools, LKPD, Critical Thinking

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INTRODUCTION

The quality of education today needs to be improved considering the changing times that are increasingly advanced. Changing times present challenges that are not easy for the world of education. Education must be able to produce human resources who are able to compete globally and master skills capable of solving complex problems. In the 21st century, human resources are needed with critical thinking and problem solving skills, creativity and innovation, communication and collaboration. Producing human resources with these abilities

can be obtained through learning activities at school, students are prepared by training their critical thinking skills from an early age so that they get used to it and are able to produce new innovations that can be applied in their lives. Some thinking skills that can increase processing intelligence in life skills are critical thinking skills, brain organizing skills, and analytical skills (Sulardi et al., 2015). Critical thinking is a thinking skill that involves cognitive processes and invites students to think reflectively about problems. Critical thinking contains mental activities in terms of solving problems, analyzing assumptions, providing rationale, evaluating, conducting investigations, and making decisions.

Thinking is the main thing in learning activities, where students concentrate on the lessons delivered by the teacher and solve problems or problems and provide logical conclusions. Practicing critical thinking habits must start when they are in school as a place that is supposed to develop and bring out all abilities that may arise as a result of the educational process (Syahbana, 2012). Critical thinking is a higher level thinking ability. Some applications of higher level thinking are that students are able to solve problems related to everyday life and are able to make the right decisions.

However, in reality, students' critical thinking skills are still very low, students are still used to simple thinking skills, this is because students are not trained in critical thinking so they still experience difficulties when given questions with a high level of thinking. Most high school (SMA) students in the city of Merauke do not have maximum critical thinking skills, this can be seen from teaching and learning activities where students only listen to the teacher's explanation and tend to be passive. Students are less able to express opinions or ideas in learning, this is also caused by the lack of media or learning tools prepared by teachers to train students to think critically.

Students as individuals need teaching that suits their developmental needs in order to become individuals who are able to solve problems in the future (Fitriyah, 2016). Learning activities train students' abilities to be able to think in constructing their own knowledge. Therefore, mental and psychological functions must be developed through students' existing skills (Handoko & Winarno, 2019). Learning mathematics is able to stimulate students' thinking abilities to be able to solve problems accurately and innovatively, this agrees with Anwar et al. (2015) who states that learning mathematics aims to train thinking, understanding, reasoning, communication, and student creativity and can improve problem solving abilities in everyday life. Critical thinking in mathematics learning is a mental activity carried out using the steps 1) understanding and formulating problems in mathematics, 2) gathering the necessary information that can be trusted, 3) analyzing the required information by clarifying the information that is needed and what is not needed, 4) formulate conjectures (conjectures) or hypotheses, 5) prove conjectures or test hypotheses using logical rules, 6) draw conclusions carefully (reflectively), 7) carry out evaluations, 8) make decisions, 9) carry out estimates and generalizations.

Teachers as controllers in the teaching and learning process in the classroom are required to be able to create enjoyable learning and train students' critical thinking skills. The teaching and learning process in the classroom really requires assistance in the form of learning tools so that the process can run well and effectively. A teacher must be able to deliver interesting and innovative learning in order to create a pleasant learning atmosphere for students. It is hoped that the learning tools prepared can help students understand the material and improve their thinking abilities towards higher level thinking and increase student activity in the classroom. According to Astuti et al. (2017) so that all students are actively involved, teachers must look for other alternatives that can facilitate students to develop their thinking abilities. One way is by using Student Worksheets (LKPD) where each student can express their ideas and opinions in criticizing mathematics problems. Teaching materials and assessment sheets are prepared as learning media that can help students think critically and

creatively (Faishol et al., 2017). The LKPD in this research is prepared based on critical thinking steps, namely formulating problems, developing problem solving strategies, carrying out evaluations and making decisions.

METHOD

The type of research carried out is the research and development method (*Research and Development*). The development model used is the Thiagarajan, Semmel & Semmel 4D development model. The development model consists of four stages, namely the defining stage (*define*), planning level (*design*), developing stage (*develop*), and the degree of decimating (*disseminate*) (Kartikasari et al., 2023).

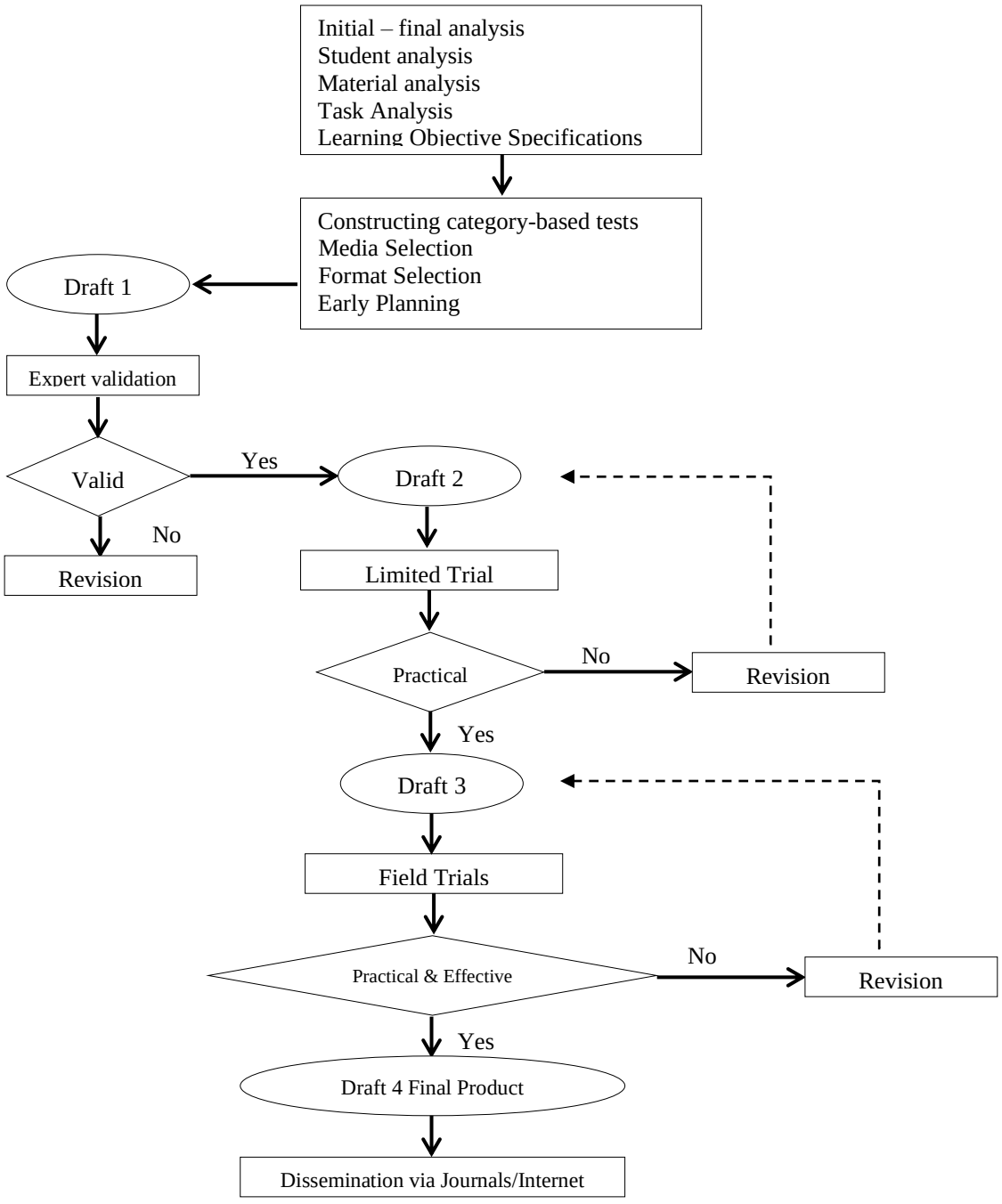


Figure 1. Device Development Flow

The instruments used in this research were validation sheets, practicality assessment sheets by students and learning achievement tests. Through this research instrument, research data is obtained in the form of qualitative and quantitative data. Student achievement test scores are quantitative data, while the results of students filling in validation sheets and practicality assessment sheets are qualitative data and are grouped into 5 categories. Next, the data is calculated to obtain an average score using the reference used in table 1 (Yanuarni et al., 2021).

Table 1. Criteria for converting Quantitative Data to Qualitative Data

No	Interval Shoes	Category
1	$(M + 1{,}50s) < \bar{x}$	Very good
2	$(M + 0{,}50s) < \bar{x} \leq (M + 1{,}50s)$	Good
3	$(M - 0{,}50s) < \bar{x} \leq (M + 0{,}50s)$	Pretty good
4	$(M - 1{,}50s) < \bar{x} \leq (M - 0{,}50s)$	Not good
5	$\bar{x} \leq (M - 1{,}50s)$	Very bad

Information :

$\bar{x}$: Average actual score

M : Mean ideal

M = ½ (score max ideal + score min ideal)

s : Ideal standard deviation

s = 1/6 (score max ideal + score min ideal)

Expert and Practitioner Validation

Validate these experts and practitioners to validate the product before it is tested in the field. Expert and practitioner validation was carried out by mathematics learning experts, namely lecturers in the mathematics education department and experienced mathematics teachers to assess and provide criticism and suggestions on the initial results of the tools developed. The instrument used to measure the validity of the device is a validation sheet which contains an assessment with a measurement scale using a Likert scale with 5 points, namely 1, 2, 3, 4, and 5. Determining the validation result category based on the data obtained produces a validation interval category table.

Table 2. Validation Interval Category

Interval LKS	Category	Decision
$72 < \bar{x}$	A	Very Valid
$60 < \bar{x} \leq 72$	B	Valid
$48 < \bar{x} \leq 60$	C	Fairly Valid
$36 < \bar{x} \leq 48$	D	Less Valid
$\bar{x} \leq 36$	E	Invalid

Limited Trial

The limited trial is a test of the practicality and readability of the device which is carried out by giving students an assessment sheet on the learning device being developed, namely the LKPD. Students involved in the limited trial can provide their opinions on the LKPD tool. Limited trials were carried out to get an initial picture from students of the resulting LKPD to become the basis for the development stages so that the LKPD could be used in field trials. Student opinions are very necessary so that LKPD can provide benefits or convenience for

students in the learning process. Limited trials were given to class X students, totaling 24 students. The practicality sheet consists of 15 statements so that the practicality interval categories can be seen in table 3.

Table 3. Practicality Interval Category

Interval	Category	Decision
$60 < \bar{x}$	A	Very Practical
$50 < \bar{x} \leq 60$	B	Practical
$40 < \bar{x} \leq 50$	C	Quite Practical
$30 < \bar{x} \leq 40$	D	Less Practical
$\bar{x} \leq 30$	E	Very impractical

Field Trials

At this stage, the learning process is carried out in a trial class. Mathematics teachers carry out learning in class and researchers act as observers to observe learning activities in class. The field trial was carried out on 24 class X students and aimed to determine the effectiveness of the learning tools. Effectiveness analysis is carried out by calculating the percentage of learning completion of students taking learning achievement tests. Students are said to be complete when their score has reached the minimum completion criteria (KKM) that applies at school, namely 68. The percentage of completeness is calculated using the formula:

$$Completion\ percentage = \frac{number\ of\ students\ who\ reach\ the\ KKM}{Total\ number\ of\ students} X\ 100\%$$

The LKPD developed is said to be effective if the student's percentage of completion reaches a minimum of 75% (Magdalena et al., 2018).

RESULT AND DISCUSSION

The preparation of learning tools starts from the definition stage which consists of:initial – final analysis, student analysis, material analysis, task analysis and specification of learning objectives. Each stage is carried out as an initial step in designing learning tools so that they can produce tools that suit needs in the field. The second stage is the design stage, this stage aims to produce an initial draft of the LKPD which will be developed for further validation and testing in the specified schools. Selecting appropriate media to support learning is quite important in achieving learning objectives (Edi & Rosnawati, 2021). Based on the analysis of the main material of the selected three-variable linear equation system, the learning media required is in the form of LKPD. The learning format developed is tailored to the learning objectives, namely improving students' critical thinking skills in the three-variable linear equation system (SPLTV) material.

The results obtained from the definition stage until the selection of the format are then reflected and used as a basis for designing the LKPD tool so that the results of the LKPD design stage obtained at the design stage are said to be draft-1. After producing the LKPD tool which was developed in draft-1 form, a validation process was then carried out to determine the validity of the product. After validation, the product is revised based on input from validators and produces draft-2.

Validation of Learning Tools

Data from the validation stages carried out were obtained from two validators who carried out an assessment using a validation sheet. Based on the average score of the LKPD validation (Table 4) results, namely 74.5, it is in the very valid category (A), so it can be concluded that the product developed is valid and suitable for use in the mathematics learning process. Moreover, it can be seen that the results of the LKPD validation analysis for each aspect assessed in Table 5 are in categories A and B or very valid

Table 4. LKPD Validation Result Data

Validator	LKPD Validation Score
1	73
2	76
Shoes Total	149
Rate-rate	74,5

Table 5. Validation of LKPD Based on Aspects Assessed

No	Rated aspect	Score	Category
1	Suitability of Content/Material	21	A
2	Compliance with didactic requirements	15,5	B
3	Compliance with construction requirements	25	A
4	Compliance with technical requirements	13	A

Limited Test Data

Data collection to assess the practicality of the LKPD aims to see the readability of the LKPD so that students can use it independently or with teacher guidance without experiencing difficulties. Seeing that students' abilities vary, improvements are needed based on criticism and suggestions from all students involved in the limited trial. Practicality assessment data by students in table 6 was obtained the average score of student assessments of LKPD products is 61.88. This score is in the very practical category (A). So that the developed LKPD product can be practically used in the mathematics learning process.

Table 6. Limited of Datatest

No	Class	The number of students	Score
1	X Mia 1	24	1485
	Average		61,88

Field Test Data

Field test data was obtained from the results of learning achievement tests in the form of test sheets to determine students' critical thinking abilities. The test questions consist of 10 questions in essay form with a processing time of 90 minutes. The test is given to students in the field trial class at the last meeting after the learning process using the developed LKPD is complete. Test result data is used to determine the effectiveness of the product based on the percentage of student completion in taking the test. This is in line with (Susanto & Retnawati, 2016) who said that data analysis to determine the effectiveness of the learning tools being developed is carried out by determining the proportion of the percentage of completeness of students' learning achievement test results after learning. It is known that the percentage of completion for class X students is 83.3%. These results show that many students achieved a KKM of more than 75%. So, it can be categorized that the LKPD developed is effective for use in the learning process.

Table 7. Learning Achievement Test Data

No	Class	Rate-rate	KKM	Number of students ≥ KKM	Number of students < KKM	Total students	Completion Percentage
1	X	76,21	68	20	4	24	83,3%

Based on the results of observations and interviews conducted at the beginning of the research process, it is known that mathematics learning in schools has not been supported by the use of student worksheets in the learning process to train students' critical thinking skills. Teachers still give practice on low-level thinking questions so that when students are given high-level thinking questions, students still have difficulty solving these questions. The material chosen to be developed in the LKPD is three-variable linear equation systems as a basis for students to practice critical thinking because the implementation of this material is widely used in real life. This also aims to ensure that students learn mathematics that has real benefits. (Herlina Rusiyanti, 2011) Says that students need meaningful learning to improve their ability to solve problems in their lives. Mathematics can provide real benefits for students by applying methods and materials that are up to date with current developments.

Device Revision

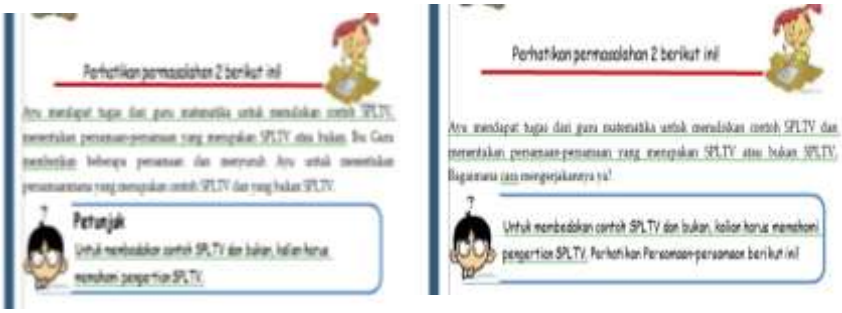
At the validation stage, apart from providing an assessment of draft-1, the validator also provided various suggestions and input. These suggestions are used as a reference for revising the product being developed. The product developed after revision is called the draft-2 product. There are several sentences in the LKPD that have undergone changes based on criticism and suggestions from student assessments on limited tests. Suggestions and input from validators for improving the products being developed are presented in Table 8.

Table 8. Revision of the LKPD based on suggestions from the Validator

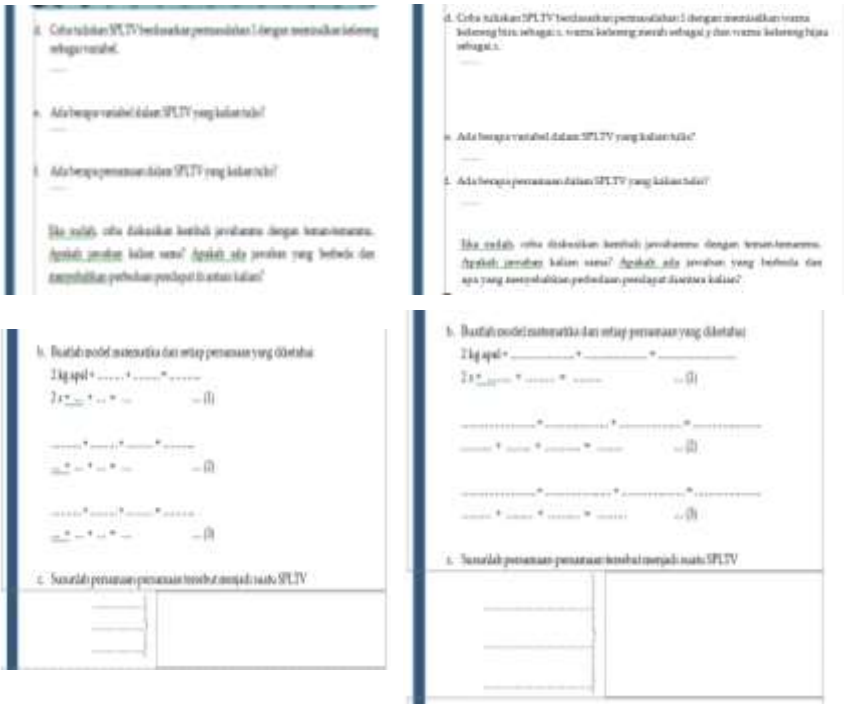
Regarding Revision	Revision	
	Before	After
1) Column for group name		

2) Steps for completing the answer

3) Improve the sentences in the LKPD



4) Space to write answers



Final Device Review

The learning tools were developed with the aim of improving students' critical thinking skills in solving problems in the real world. LKPD is prepared in systematic and structured stages so that students get used to thinking and reasoning critically. The feasibility of the final LKPD can be seen from three aspects, namely validity, practicality and effectiveness. Based on the results obtained through the learning device development stages which begin with device validation, the validation results are carried out by the validator and then revisions are made based on the validator's input and suggestions. The LKPD was prepared referring to the 2013 curriculum so that it added validation value and the LKPD developed was in the very valid category, namely an average score of 74.5 was obtained. Based on the validity criteria, it shows that the LKPD is suitable for use in the learning process in the classroom. This is in line with the results of research (Maya Sari, 2020) which states that the LKPD learning tool is said to be valid and suitable for use if it is at least in the valid category.

The results of limited trials showed that the LKPD developed was in the very practical category for use in the mathematics learning process. Practicality is measured from analysis of student assessment sheets with the average score being in the very practical category. From the results of the field trials, data was obtained that showed that the LKPD applied to the learning process met the effective criteria, where the percentage of student learning achievement test results to measure critical thinking skills that achieved the KKM score was 83.3%. These data illustrate that students' critical thinking abilities can be improved with the help or application of learning tools in the form of LKPD. This agrees with (Herlina Rusiyanti, 2011) the existence of learning support devices such as LKPD has a potential effect on students' critical thinking abilities. This is also supported by the results of research (Mayasari et al., 2022) the development of mathematics learning tools helps students be more active, independent, able to work together in groups, confident in expressing opinions, and student-centered and can improve student learning outcomes.

CONCLUSIONS AND SUGGESTIONS

Based on the research results and discussion, the following research conclusions can be stated after the validation stage was carried out by the validator, the mathematics LKPD product developed was in the valid category so that the LKPD product was suitable for use in mathematics learning. The mathematics LKPD product developed was in the practical category based on the results of analysis of teacher and student practicality sheets as well as observations of learning implementation so that the LKPD product was practically used in mathematics learning. After carrying out the learning achievement test, data was obtained if students who achieved the minimum completeness criteria reached more than 75% so that the LKPD product developed was effective for use in mathematics learning. The verification procedure for the LKPD product being developed has been carried out by testing the validity, practicality and effectiveness of the LKPD product in trials.

The development of mathematics learning tools to improve high school students' critical thinking skills can continue to be developed in subsequent material as a means for students to practice and hone their critical thinking skills so that it is hoped that students will easily understand mathematics subject matter and students' mathematics learning outcomes will improve.

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