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Development of Student Learning Programs with a Realistic Mathematic Education (RME) Approach to Improve Students' Critical Thinking Skills

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Abstract

This study aims to produce student worksheets with a Realistic Mathematic Education (RME) approach to solving valid, practical, and effective linear program problems. The development of this learning program is based on the Four-D Model adopted from Thiagarajan, Semmel, namely defining(define), design (design), and action (develop). The implementation of the criteria set by conducting validation and field trials. The learning tools developed are in the form of RPP and MFI. The subjects of the development trial were students of the mathematics education study program. Based on the results of data analysis, mathematics learning programs with a Realistic Mathematic Education (RME) approach can be applied and carried out correctly. This is shown from the results of the MFI trial with an average score of 83, which is included in the excellent category. In addition, the test questions test got an average score of 86.8, which also fell into the outstanding category. From this, it is known that the student learning program is ethical and practical for learning.

Keywords: learning programs; linear programs; realistic mathematic education.

INTRODUCTION

Mathematics is a science that must be learned from elementary school to university. In addition, mathematics is also a science of logic that contains axioms, definitions, theorems, and lemmas in its learning materials. Therefore, in learning mathematics, unusual thinking skills are needed. By definition, thinking can be interpreted as an activity to develop ideas to produce something new. The ability to think in learning mathematics includes analyzing, evaluating, and making decisions that refer to evidence. The ability to feel like this in mathematics is referred to as the ability to think critically. Hendriana et al. (2018) mentioned that critical thinking is a reflective ability focused on basic clarification skills, decision making, inference, further explanation, estimation and integration, and additional skills. Sumarmo et al. (2017) said that in critical thinking, a person does not readily accept the truth of information without knowing the origin. Still, the person can put forward logical reasons to account for it.

Based on the initial observations of researchers at Tribhuwana Tunggadewi University, Malang shows that students do not understand the concept of linear programs. Students experience this difficulty, supported by the results of observations when learning activities take place. Of the 21 students observed, only four could answer correctly in changing the problem from a story question form to

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a mathematical structure. Other students have not understood the issue at hand and have been unable to change the situation from the state of story questions to the state of mathematics. This indicates that learning mathematics is just giving formulas and doing practice problems. Students only memorize materials and formulas without understanding mathematical concepts, so as a result, students learn mathematics only as a necessity, for example, graduating to take mathematics courses.

According to Soejono (1983) several reasons students have difficulty in solving the form of story problems, namely: (1) students do not understand what is read as a result of students' lack of knowledge about concepts or some terms that should have been known, (2) students cannot change the form of story questions into mathematical models, (3) students are unable to set variables to compile equations and inequalities, (4) students use irrelevant principles, (5) students are unable to understand what is told in the questions.

Based on the description above, mathematics lectures in the classroom should be emphasized the relationship between mathematical concepts and the experiences that students already have. In addition, it is necessary to reapply the mathematical concepts that students already have in everyday life is very important to do. One of the mathematics learnings that is oriented towards the mathematics *of simple experience (mathematize of everyday experience*) and applies mathematics in solving daily life is through problem-solving lectures.

Everyone has different critical thinking skills, so an educator, to measure the essential thinking ability of his students, must understand the indicators of critical thinking ability, which include the stages of interpreting, evaluating, analyzing, and manifesting or concluding correctly. This also applies to students of Tribhuwana Tunggadewi University, especially students of the Mathematics Education Study Program who are required to have more critical thinking skills. This is because the student is a prospective mathematics teacher who will be required to teach critical thinking to his students as well. This diversity of student mindsets needs to be formed by accelerating efforts in learning patterns. Appropriate and targeted learning patterns can provide significant results in expanding the critical thinking patterns of Mathematics Education students of Tribhuwana Tunggadewi University. In this case, the researcher chose *the Realistic Mathematics Education (RME)* Approach as the most significant effort to improve students' thinking ability. Furthermore, this RME has carried out design development to obtain a suitable and up-to-date design. As De Moor (in Fauzan: 2002) states that RME can serve as a bridge that connects students' thinking abilities with their experiences when participating in lecturer design frameworks in RME-based learning activities. In addition, according to Wijaya E. & Iriant N. (2021), *the Realistic Mathematics Education (RME)* approach can improve students' critical thinking skills. In making a learning design, it is necessary to consider the flow of thinking of students and make the anticipation of all possibilities that will occur during learning activities. Thus, from the description above, it can be concluded that a learning design is needed t to make students understand mathematical concepts and improve their critical thinking skills. In addition, it is also necessary to design the alleged flow of thinking of students and their anticipation.

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Based on the description above and to meet the demands of a rapidly changing situation, it is necessary to develop a lecture procedure that is focused on the ability to improve students' critical thinking processes. Therefore, the problem raised in this study is the Development of Student Learning Programs with *a Realistic Mathematics Education* (RME) Approach which is valid and practical and aims to improve the critical thinking skills of Tribhuwana Tunggadewi University students in linear program materials.

RESEARCH METHOD

The development of student learning programs with *a Realistic Mathematic Education* (RME) approach is included in this research. The learning program that will be developed as a Student Worksheet (LKM) is equipped with a Learning Implementation Plan (RPP) and learning outcomes test questions. The development model used was the Four-D Model adopted by Thiagarajan & Sivasailam (1920). Four-D consists of four stages: Define, *Design*, *Develop* and *Disseminate*. The *dissemination* stage was not carried out due to limited research time. This research was carried out at Tribhuwana Tunggadewi University, Malang. The Trial subjects were 21 students of the Mathematics Education Study Program, Tribhuwana Tunggadewi University, Malang.

The *Define* stage consists of four steps, namely (1) *the Front-end analysis* stage, which is to collect information about learning tools that have been used to determine what needs to be developed. The collection of this information was carried out by interviews with mathematics education lecturers and students at Tribhuwana Tunggadewi University; (2) At the *Learner Analysis* stage, namely interviews with mathematics education lecturers at Tribhuwana Tunggadewi University to study the curriculum used at Tribhuwana Tunggadewi University and teaching materials used for the development needs of the teaching program to be developed. (3) *task analysis* stage is carried out in an interview with the lecturer to obtain an overview of the tasks and exercises that are usually given in mathematics learning. (4) *the Concept Analysis* stage carried out is the identification of the material to be studied, namely a linear program, and observing and analyzing student behavior in teaching and learning activities to find out the characteristics of students of Tribhuwana Tunggadewi University in general about the way students think in a way interviews and observations.

In the *Design* stage consisting of (1) *Constructing Criterion-Referenced Test* (Compiling Criteria-Based Tests), the preparation of an exercise grid on the Student Worksheet is carried out equipped with answer keys and scoring guidelines as well as the preparation of instrument designs, aiming to assess the LKM developed valid (2) *Media Selection* (media election). The teaching material chosen for this learning program is the Student Worksheet (LKM) because the mathematics education study program at Tribhuwana Tunggadewi University rarely uses LKM in its learning. Still, the LKM that is commonly used has not led to students' critical thinking process. Therefore, the prepared LKM is equipped with a Learning Implementation Plan (RPP), which aims to make learning easier for Lto. (3) *format selection*, a *Realistic Mathematics Education* (RME) approach is used in learning.

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And the last step (4) *Initial Design* (Initial Design) is the Learning Program in the form of a Student Worksheet (LKM) equipped with a Learning Implementation Plan (RPP) using *a Realistic Mathematic Education* (RME) Approach to the linear program material.

In the *Develop* stage, *Expert Appraisal* and developmental *Testing.* Are carried out. *Expert Appraisal* is a way to obtain advice for improvement from the draft Of The Student Worksheet (LKM) and RPP. The experts consisting of two Mathematics Education Lecturers who are material experts and educational experts, assess and respond to the LKM design that has been made. From here, it can be known whether the LKM and RPP that have been prepared are worthy of being continued at the next stage, namely *Developmental Testing* and whether improvements still need to be revised. How to find out whether the MFI, RPP, and test questions that are compiled are valid or invalid need to be changed or not, then the guidelines for assessing the validity of the study program design are used in table 1 below.

Table 1. Guidelines for Assessing the Validity of Learning Programs with the RME Approach

No.	Percentage (%)	Validity Criteria	Information
1	81 – 100	Very Valid	No Revision
2	61 – 80	Valid	No Revision
3	41 – 60	Valid Enough	No Revision
4	21 – 40	Less Valid	Revision
5	0 – 20	Invalid	Revision

source: Riduwan (2012)

The MFI design, RPP, and test questions can be tested on students if the expert test results meet the minimum criteria and are valid enough. Furthermore, at the *Developmental Testing* stage, the LKM design, RPP, and test questions that have met the requirements for minimizing validity and have been improved according to suggestions and comments from experts were tested on students of Tribhuwana Tunggadewi University Malang. The trial instrument of the learning program is a Student Worksheet (LKM), which aims to determine the student's critical thinking process toward linear program material. The subjects of the LKM trial consisted of 21 students in the mathematics education study program. The data obtained are then processed using guidelines for assessing practicality and effectiveness. The practicality value of the MFI is considered sufficient to be continued at the next stage if it reaches a minimum value of 65. The practicality assessment guidelines can be seen in table 2 below.

Table 2. Guidelines for Assessing the Validity of Learning Programs with the RME Approach

No.	Value	Information
1	90 – 100	Very Practical
2	80 – 89	Practical
3	65 – 79	Pretty Practical
4	55 – 64	Less Practical
5	0 – 54	Impractical

source: Riduwan (2012)

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RESULTS AND DISCUSSION

Define

The Define stage consists of four steps, namely (1) *Front-end analysis*, which collects information about learning tools that have been used to determine what needs to be developed. This information was collected from mathematics education lecturers and students at Tribhuwana Tunggadewi University. The results showed that students rarely use MFIs in learning linear program materials. Still, the MFIs used only contain examples of questions with discussion and practice questions, so critical thinking skills cannot be improved because students only imitate and memorize. (2) At the *Learner Analysis* stage, namely interviews with mathematics education lecturers at Tribhuwana Tunggadewi University to study the curriculum used at Tribhuwana Tunggadewi University and teaching materials used for the needs of developing learning programs to be developed. The results found that students did not have teaching materials other than those provided by the lecturer. (3) *the Task Analysis* stage (task analysis), in obtaining an overview of the tasks and exercises usually given in mathematics learning. (4) the *Concept Analysis* stage identifies the material to be studied, namely a linear program.

Design

The design stage consists of (1) *Constructing Criterion-Referenced Test; at this stage,* an exercise grid on the Student Worksheet is prepared with answer keys and scoring guidelines. (2) *Media Selection*, at this stage, it was obtained that the teaching certificate chosen in the development of this learning program is the Student Worksheet (LKM) because the mathematics education study program at Tribhuwana Tunggadewi University rarely uses LKM in its learning, will but the commonly used LK M has not led to the student's critical thinking process. (3) *Format Selection*, a *Realistic Mathematics Education* (RME) approach, was chosen that was used in learning. (4) *Initial Design*, namely the Learning Program in the form of Student Worksheets (LKM) equipped with a Learning Implementation Plan (RPP) using *a Realistic Mathematic Education* (RME) Approach to the linear program material.

Develop

The *Develop* stage consists of 2 stages, namely (1) *Expert Appraisal; at this stage, it is* carried out by two validators, namely lecturers of mathematics education at Tribhuwana Tunggadewi University. (2) *Developmental Testing*, carried out on 21 students of the mathematics education study program at Tribhuwana Tunggadewi University. The design of learning tools validated by two validators is in the form of Student Worksheets (MFIs) and Learning Implementation Plans (RPP) for linear program materials. The validation results determine whether the developed device needs revision before trial or immediate improvement to be tested in the field. In table 3, the following is the result of the validation of *a Realistic Mathematics Education* (RME) based learning program in the form of a Lesson Implementation Plan(RPP), and in table 4, the following is the result of the validation of student worksheets (MFIs).

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Table 3 Learning Implementation Plan (RPP) Assessment Data

No.	Statement	Validators		$\sum_{i=1}^{2} x_i$	$\sum_{i=1}^{2} x_j$	P
		x_1	x_2			
1	This learning activity in the online RPP based on *Realistic Mathematics Education* (RME) makes students able to solve problems	3	4	7	8	88%
2	This learning activity in an online RPP based on *Realistic Mathematics Education* (RME) makes students able to turn problems into mathematical forms or models	3	3	6	8	75%
3	Learning activities in this *realistic mathematics education* (RME)-based online lesson plan will make students able to compile and organize a hierarchy of linear program concepts	4	3	7	8	88%
4	This *realistic mathematics education* (RME)-based online RPP learning activity will make students able to determine the set of completions	3	4	7	8	88%
5	This learning activity in the online RPP based on *Realistic Mathematics Education* (RME) makes students able to improve their critical thinking skills	3	3	6	8	75%
	Total			**33**	**40**	**82%**

Table 4 Student Worksheet Assessment Data (MFI)

No.	Statement	Validators		$\sum_{i=1}^{2} x_i$	$\sum_{i=1}^{2} x_j$	P
		x_1	x_2			
1	The presentation of material at LKM makes students able to solve problems	3	4	7	8	88%
2	The presentation of material in LKM makes students able to turn problems into mathematical forms or models	3	3	6	8	75%
3	The presentation of material at LKM will make students able to compile and organize a hierarchy of linear program concepts	3	4	7	8	88%
4	The presentation of material at LKM will make students able to determine the set of completions	4	3	7	8	88%
5	The presentation of material at LKM makes students able to improve student's critical thinking skills	4	4	8	8	100%
	Total			**35**	**40**	**88%**

Information:
x_1 : Validator 1
x_2 : Validator 2
$\sum_{i=1}^{2} x_i$: Number of assessment scores
$\sum_{i=1}^{2} x_j$: Maximum number of assessment scores
Q: Percentage of assessment

Based on table 3, the validation results of the *Realistic Mathematics Education* (RME)-based Learning Implementation Plan (RPP) obtained an assessment percentage of 82%, then following the Assessment Qualification Level in table 1, it is concluded that the Learning Implementation Plan (RPP) is very valid, so it does not need to be revised. Meanwhile, in table 4, the validation results of the Student Worksheet (MFI) obtained an assessment percentage of 88%, so by the Assessment Qualification Level in table 1, it is

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concluded that the Student Worksheet (MFI) is very valid so that it does not need to be revised.

LKM practicality data were obtained from the observation sheet of LKM implementation for three meetings, the LKM practicality questionnaire was given at the third meeting, and the results of interviews with mathematics education lecturers who taught in the class. The observation of the implementation results shows that LKM is practically used in terms of ease of use, content, and time. Thus, based on the questionnaire, the practicality of LKM is categorized as practical, which can be seen from the effective and efficient readability, convenience, and time in using LKM based on the principles of *Realistic Mathematics Education* (RME). LKM instructions are easy to understand, LKM is easy to use, how to pitch the blanks on LKM is easy to understand, the size and model of letters used in LKM are easy to understand, and the clarity of the steps given to LKM makes it easier for students to find the concept of linear program material categorized as practical. The statements and sentences on LKM are easy to understand, and the images presented in LKM are clear, namely 83% classified as valid. The time provided to complete activities at LKM is sufficient, and 81% is categorized as applicable by class hours. Based on the practicality test, it can be concluded that LKM is classified as valid.

Expert test The Student Worksheet (LKM) showed very valid results and has been corrected according to expert advice and comments. At this stage, it was tested on 21 students. The LKM trial aims to determine the level of understanding of students' understanding of the material presented in LKM. In table 5, the following is a presentation of LK M assessment data and student understanding.

Table 5. Assessment of Student Worksheets (MFIs) and Student Understanding

No.	Name	Value			Completion Criteria
		A	L1	L2	
1	Ym	81	83	85	Complete
2	UMR	79	80	79	Complete
3	Ad	90	90	85	Complete
4	MMTT	94	100	96	Complete
5	DIK	77	78	81	Complete
6	Date	94	96	92	Complete
7	Mba	86	91	87	Complete
8	Yr	78	68	74	Incomplete
9	Mu	95	92	80	Complete
10	Afb	79	73	60	Incomplete
11	Fr	86	78	78	Complete
12	FCJ	81	80	78	Complete
13	Yao	94	83	85	Complete
14	Po	87	83	94	Complete
15	YKM	90	74	73	Incomplete
16	Nc	81	80	92	Complete
17	Hb	92	91	88	Complete
18	Srb	95	87	80	Complete
19	LIKE	92	86	83	Complete
20	Ag	77	82	80	Complete
21	AMB	94	78	83	Complete
SUM		1.822	1.753	1.733	
AVERAGE		86,76	83,48	82,52	

Information:
A: Student Activities
L1: Playing with Linear I Programs

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L2: Playing with Linear II Programs

In the activity aspect, trial students get an average score of 86.76. Based on the assessment scale of the student's level of understanding, it was concluded that the trial was included in the category of excellence in achieving indicators of aspects of activity on the Student Worksheet. In practice playing with the Linear I Program, the trials got an average score of 83.48. Based on penile he the students' level of understanding, it was concluded that the problem belongs to the excellent category. At practice playing with the Linear II Program, the trials got an average score of 82.52. Based on the assessment scale of the student's level of understanding, it was concluded that the problem was included in the excellence category in achieving indicators of aspects of playing with the Linear II Program. Based on the student test in table 5, it was obtained that out of 21 students consisting of 18 (85.71%) students completed, and 3 (14.29%) students were not complete it. It can be concluded that developing student learning programs with *a Realistic Mathematic Education (RME)* approach can improve students' critical thinking skills on linear program materials.

Development and Results

The design of the learning tools, namely the Learning Implementation Plan (RPP) and student worksheets (MFIs), have passed the expert test stage, and both obtained valid results. The learning tools are then improved based on expert advice and comments. In the next step, student worksheets (MFIs) were tested on 21 students. In the MFI, there are aspects of student activities, Play with Linear I Program exercises and Play with Linear II Programs. Analysis of trial data shows that trial students have achieved indicators of student activity aspects very well and have achieved the play with Linear Programs I and II exercise indicators well. After going through the assessment process, the final results of the development of student learning programs through the *Realistic Mathematics Education* (RME) approach, namely the Learning Implementation Plan (RPP) and Student Worksheets (MFIs) of Linear Program Materials.

a. Learning Implementation Plan (RPP)

Learning activities in the Realistic *Mathematics Education* (RME)-based Learning Implementation Plan (RPP). The RPP consists of 3 meetings; each meeting is allocated as much as 2 X 30 minutes online. In the RPP appendix is a Student Worksheet Answer Key (MFI), a Play Answer Key with Linear Programs I and II, a Student Activity Assessment Rubric, a Play Practice Assessment Rubric with a Linear Program, and an Attitude Observation Rubric.

b. Student Worksheet (MFI)

The presentation of material on MFIs includes *realistic mathematics education* (RME) criteria. The MFI consists of Part 1, Part 2, and Exercise. Sections 1 and 2 contain presentations of student materials and activities. The details of the components of the MFI are:

1. MFI Title
2. Subject matter
3. Instructions for use
4. Information as a support for students in carrying out their activities using MFIs
5. Structured tasks, questions, and work steps
6. Evaluation questions and answer keys

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CONCLUSION

This development has resulted in student learning programs through *the Realistic Mathematic Education* (RME) approach to linear program materials that can improve students' critical thinking skills. Student learning programs through *the Realistic Mathematic Education* (RME) approach are produced in the form of Learning Implementation Plans (RPP) and Student Worksheets (MFIs). Learning activities in the Learning Implementation Plan (RPP) and presentations of material and student activities packaged on the Student Worksheet (MFI) have included indicators or characteristics of *Realistic Mathematic Education* (RME). So it can be concluded that the design of online learning through *Realistic Mathematic Education* (RME) linear program material that can improve students' critical thinking skills can be seen in MFIs, test questions in the form of Playing with Linear Programs I and II. Based on the student test results, out of 21 students consisting of 18 (85.71%), were completed, and 3 (14.29%) students were not satisfied. It can be concluded that student learning programs through *the Realistic Mathematic Education* (RME) approach can improve students' critical thinking skills in linear program materials.

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