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Development of Student Worksheets Using The Missouri Mathematics Model with Peer Feedback on Linear Programming Material

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ABSTRACT

This study aimed to develop a valid, practical, and effective student worksheet (LKS) for linear programming material based on the Missouri Mathematics Project (MMP) model with peer feedback. Using a Research and Development (R&D) design comprising definition, design, development, and dissemination stages, data were collected through validation sheets, questionnaires, and tests. The developed worksheet was assessed as valid by experts 80%, practical based on student and teacher responses 85%, and effective in improving learning outcomes. Effectiveness was indicated by 79% classical completeness and a significant improvement in Post test scores compared to Pre test results ($p < 0.05$). The findings show that the MMP-based worksheet with peer feedback meets the criteria for valid, practical, and effective learning tools.

1. Introduction

One important factor that can support more meaningful mathematics learning is the availability of adequate learning resources. Many learning resources can be used as guides in learning activities, one of which is student activity sheets. However, in reality, many mathematics teachers have not developed independent student worksheets according to student needs. The student worksheets used usually only contain a collection of materials and questions that are still conventional, without any innovative learning models that can create learning that

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can make students active in learning the subject. The lack of student involvement in building conceptual understanding results in students being less motivated and easily forgetting the material. Low learning motivation will have implications for learning outcomes, as stated by (Sardiman, 2012), namely that good motivation in learning will show good results.

Observing these conditions, a solution is needed to address this problem, namely the development of student worksheets with innovative learning models by curriculum demands that can increase student activity, motivation, and learning outcomes. According to (Juwita et al., 2019), student worksheets are one of the learning tools that support the optimal learning process. Student worksheets play a crucial role in guiding students' mindsets in discovering new knowledge and engaging students' creativity in finding various questions to solve problems (Novyani et al., 2020).

Selecting the right learning model can increase student learning activities and success (Basori, 2017). The implementation of learning with the Missouri Mathematics Project can help foster learning independence in students. The Missouri mathematics project learning model can make students play an active role in the learning process, both in discussion activities and individual exercises. In the implementation of the MMP Model, some processes or stages must be raised, namely (a) review; (b) development; (c) cooperative work (controlled exercises); (d) self-employment; and (e) assignment/closure (Rohman, 2023; Ummah & Sari, 2018) (Karim et al., 2023) (Syam et al., 2024). Students have the opportunity and flexibility to think independently or in groups to apply their understanding during cooperative work and independent work (seat work).

One of the important parts of the education process is feedback. According to Baerh and Bayerlein (Basuki & Hariyanto, 2017), quality assessment must meet the principle of improvement based on feedback from the assessment. The feedback provided as part of the formative assessment has the purpose of helping students become aware of the gap that exists between their desired goals and their current knowledge, understanding, or skills, and guiding them through the actions necessary to obtain their goals.

The learning process using peer feedback provides greater insight to students, interprets feedback, and supports mathematics learning (Reinholz, 2018). Peer feedback involves students in facilitating collaborative and social processes between students to help each other, so as to make the learning process more meaningful. By letting students take part in giving feedback, a student is trained to use and express themselves understandable way.

The innovation of the Missouri Mathematics Project model-oriented student worksheets with peer feedback is considered very important in mathematics learning, where students are required to learn cooperatively among each other to construct their knowledge in finding problem-solving solutions, and helping students actively participate in assessing and providing feedback on assignments independently. It found that developing student worksheets using the Missouri Mathematics Project model effectively improved students' mathematical conceptual understanding (Aufa et al., 2021) and effectively improved students' mathematics learning outcomes (Sofwani & Panggabean, 2023). The use of peer feedback at the Missouri Mathematics Project model stage guides students to assess each other and provide feedback on the results of their work. If this is a habit, it will improve students' abilities in mathematics.

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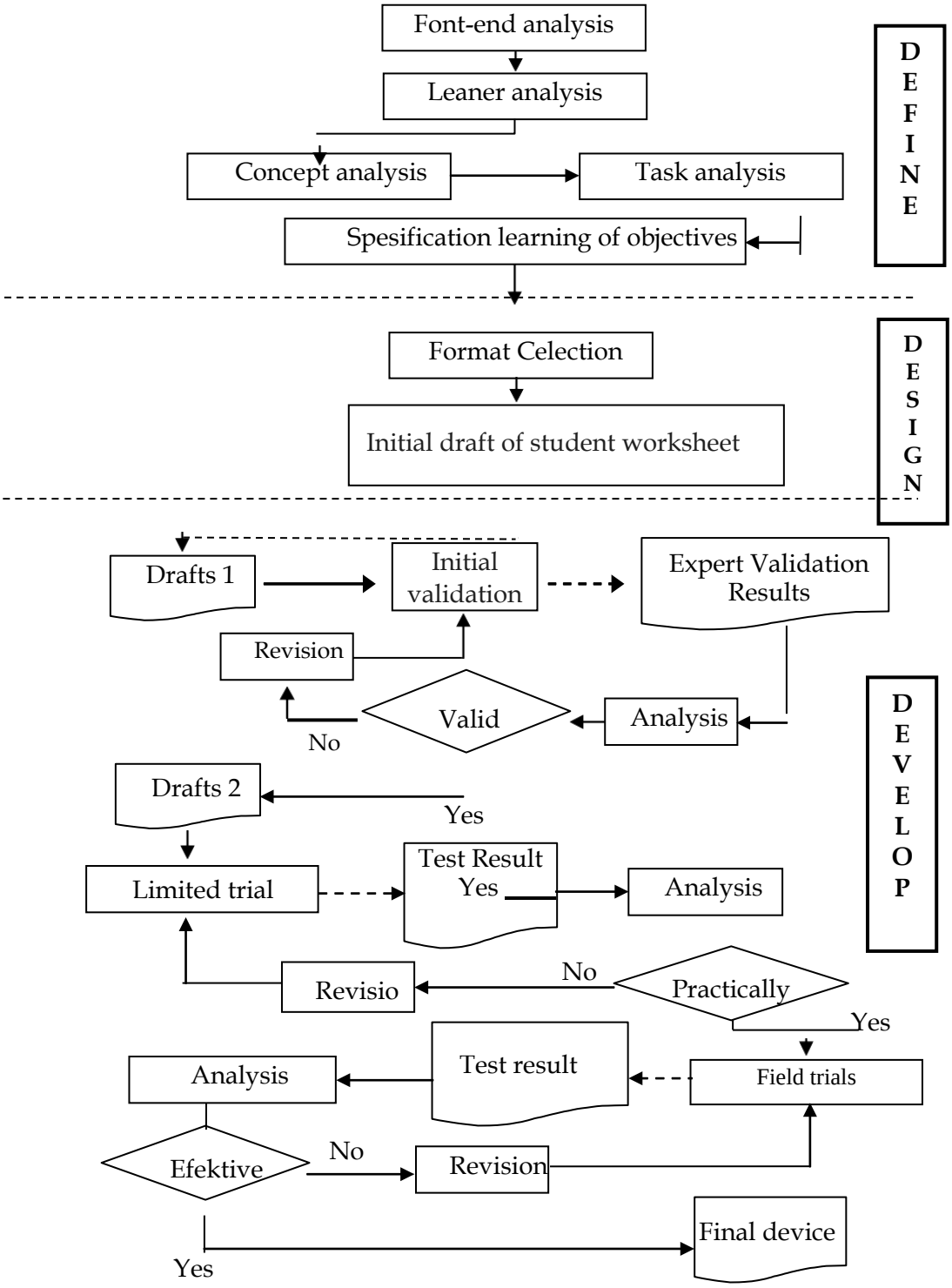
2. Method

The design of this research refers to the research and development (R&D) model of (Thiagarajan et al., 1974), consisting of four stages, namely: (1) define, (2) planning (design), (3) development, and (4) dissemination. However, due to time considerations, this research is limited to the third stage, namely: 1) definition, 2) planning, and 3) development. The steps of the development procedure are as follows.



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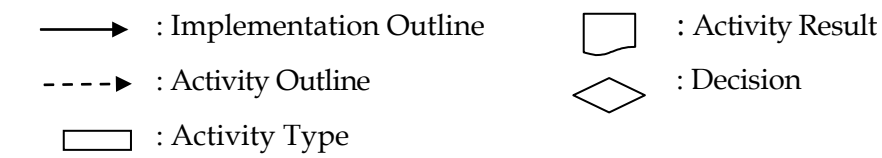

Figure 1. Development Model of 4-D Learning Tools
Source: (Thiagarajan et al., 1974)

The data collection instruments in this study consist of student worksheet validation sheets as well as teacher and student response questionnaires as well and linear program material test questions. The technical data analysis used in this study is as follows.

2.1. Validator Data Assessment Analysis

The validity test of the student worksheet is oriented to the Missouri mathematics model with peer feedback developed from material and media experts. After the data is collected, the data analysis is carried out using the formula,

$$TV = \frac{total\ score\ obtained}{maximum\ score} \times 100\% \quad (1)$$

The TV is Validity Level. The interpretation of the validity data of the student worksheet can be seen in Table 1.

Table 1. Interpretation of student workshet Validity Data

No	Interval	Criterion
1	$81\% - 100\%$	Highly Valid
2	$61\% - 80\%$	Valid
3ce	$41\% - 60\%$	Quite Valid
4	$21\% - 40\%$	Less Valid
5	$0\% - 20\%$	Invalid

Source: (Riduwan, 2018)

2.2. Teacher and Student Response Test

The worksheet that has been validated by experts is then used in a limited trial of 15 students and 1 mathematics teacher with the aim of testing the practicality of the learning worksheet developed. The results of the practical test of the LKS that have been developed are analyzed using a formula (Riduwan, 2018),

$$P = \frac{TS_e}{TS_h} \times 100\% \quad (2)$$

The variable P is percentage of practicality, TS_e is total empirical score, and TS_h full total score. The interpretation of the student worksheet practicality data can be seen in the Table 2.

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Table 2. Interpretation of student worsheet Practicality Data

No	Interval	Criterion
1	$81\% - 100\%$	Very Practical
2	$61\% - 80\%$	Practical
3	$41\% - 60\%$	Quite Practical
4	$21\% - 40\%$	Less Practical
5	$0\% - 20\%$	Impractical

Source: (Riduwan, 2018)

2.3. Effectiveness Test Analysis

The design of this study uses a one-group pretest-post test design. The research was carried out on only one group that was randomly selected. This one-group pretest-post test design is measured using pre test, treatment, and post test after treatment. The data analysis technique was carried out using normality tests, completeness tests, and paired sample t-tests. The quantitative research design of the one-group pretest-post test design can be seen in Table 3.

Table 3 Research Design: One-Group Pretest-Post test Design

Pretest	Treatment	Post test
O1	X1	O2

Information:
O1: Pre test done before being given treatment
O2: Post test done after being given treatment
X1: Learning with the Use of Model-Oriented student worksheet Missouri Mathematics Project with Peer Feedback

3. Results and Discussion

The Thiagrajan Development Model is called the 4-D model, with the development steps being Define, Design, Develop, and Disseminate, or adapted into the 4-P Model, namely Define, Design, Develop, and Disseminate, but in this development research, the Disseminate stage is not carried out.

3.1. Definition Stage

At the definition stage, there are several things that the researcher does, namely: font-end analysis, student analysis, task analysis, concept analysis, and specification of learning objectives.

3.3.1. Font-end analysis

This stage involved interviewing one of the mathematics teachers at Noemuti State High School. The analysis obtained from the interview revealed the following:

1) The curriculum used in Mathematics at Noemuti State High School still adheres to the 2013 Curriculum.
2) The learning challenge faced is that students are highly dependent on the teacher.
3) The learning resources used in class are 2013 Curriculum mathematics textbooks, which contain a mix of material from various subjects, resulting in minimal material, particularly mathematics.

At the final analysis stage, the development of Student Worksheets oriented

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towards the Missouri Mathematics Project model with peer feedback on linear programming material was carried out to enable students to learn actively, creatively, and independently in line with the existing curriculum objectives, motivating students to be directly involved in learning and assessment/evaluation activities.

3.3.2. Leaner Analysis

This analysis aims to determine the characteristics of 12th-grade students at Noemuti State Senior High School. Based on observations, it was found that:

1) 12th-grade students at Noemuti State Senior High School are aged 15 and above, with each student possessing varying levels of knowledge and diverse learning experiences. Based on Piaget's theory, this age group is at the formal operational level. This means that students are now able to understand abstract material.
2) Students are less effective in learning and wait for teacher explanations to understand the material. Most students lack the confidence to express their ideas.
3) Teachers have not developed innovative learning tools from various sources. The materials provided in the lessons come from textbooks published by specific publishers.

3.3.3. Concept Analysis

At this stage, a basic competency analysis is conducted related to the core material of the Linear Program. This stage also involves detailing and systematically organizing the concepts of the Linear Program material by creating a concept map of the material.

3.3.4. Task Analysis

At this stage, a basic competency analysis is conducted, and then learning indicators are outlined. Based on the analysis, a description of the tasks required in the learning process that align with the basic competencies is obtained.

3.3.5. Spesification Learning of Objectives

The learning objective specification aims to translate competencies derived from material analysis and task analysis into learning objectives to be achieved. The researcher's analysis of the learning competency specification indicates that through mathematics learning using the Missouri Mathematics Project-oriented worksheet with peer feedback, students are expected to:

1) Active, creative, and independent learning by existing curriculum objectives, enabling students to apply the learning and positive values to their daily lives.
2) Motivating students to be directly involved in learning activities and assessment/evaluation.

3.2. Planning Stage

At this stage, the researcher designed the student workksheet that are needed to support learning through. The learning tools needed to manage the teaching and learning process include a syllabus, lesson plan, teaching materials, student worksheets, evaluation instruments or learning outcome tests, and learning media (Trianto, 2011). The learning tool designed is a student worksheet implemented

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using the Missouri Mathematics Project model with peer feedback (Trianto, 2011). In addition to student worksheet, research instruments were also designed in this study, namely (1) Student worksheet validation sheet, (2) student and teacher response questionnaires. Design from student worksheet Missouri Mathematics Project model with Peer feedback can be seen in the image below.

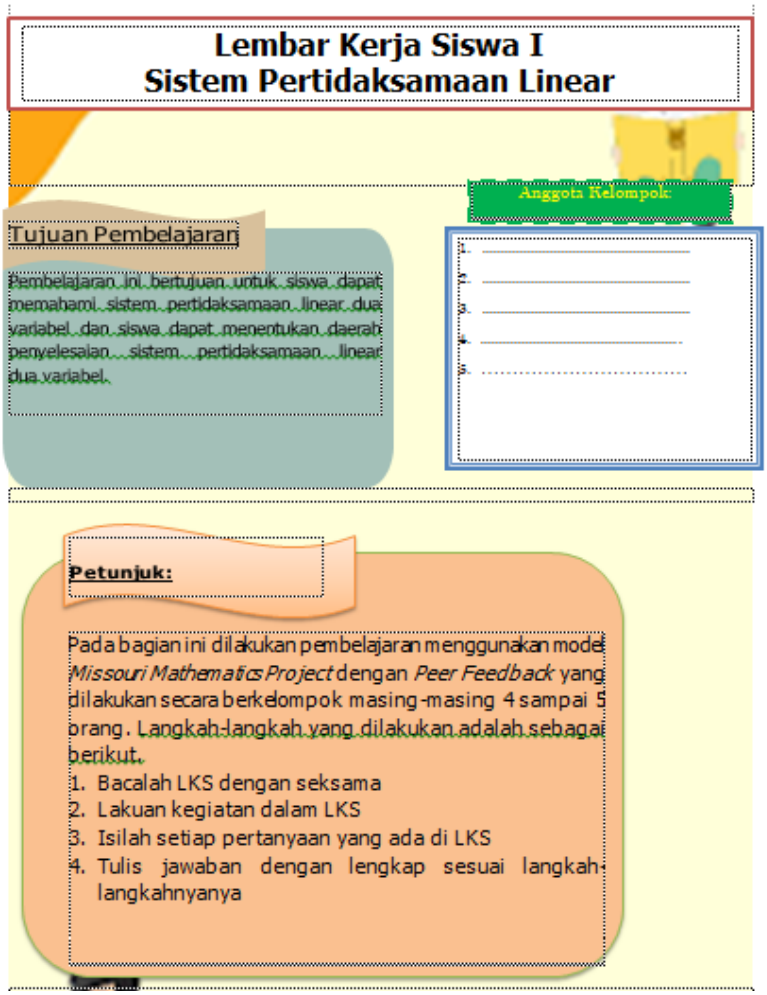

Figure 2. Design of the Missouri Mathematics Project Model-Oriented Worksheet with Peer Feedback, Preliminary Activities, and Exposure of Learning Materials

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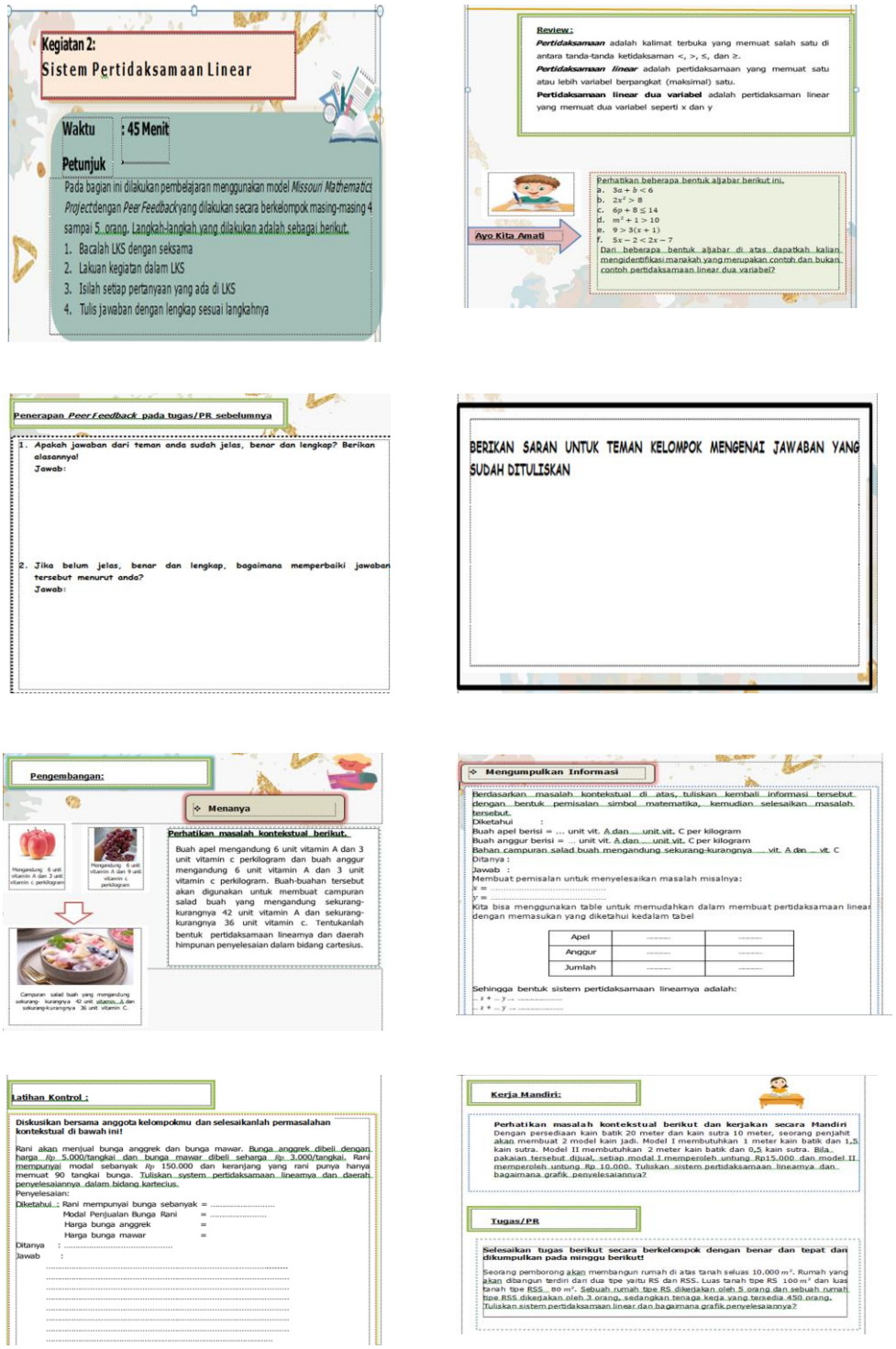

Figure 3. Missouri Mathematics Project Model Oriented Student Worksheet Design with Peer Feedback Learning Activities Section

3.3. Development Stage

3.3.1. Characteristics of student worksheet Development

The student workshet with the missouri mathematics project model with peer feedback contains things that can make students' time effective in learning, namely

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review of previous material, development of new ideas as an expansion of last mathematical concepts, provision of control exercises, assignments of independent assignments to students, and assignments of homework and assignments are corrected and assessed directly by the students themselves so that the remaining time is used with as effectively as possible to learn and engage directly in learning and assessment activities.

3.3.2. Validation of student worksheets

The assessment for the validation of the student workshet consisted of 2 validators, namely 1 media expert and 1 material expert. The media expert validation sheet consists of 10 indicators of assessment of student worksheet, consisting of aspects of appearance and accessibility. Based on the validation of media experts, the Missouri Mathematics Project Model-oriented Student Worksheet with Peer Feedback on Linear Program Materials obtained a validity score of 80%, with the category of Valid.

Suggestions and inputs from media expert validators are to pay attention to the page margins on the box containing sentences in the student worksheet. The following Figures 3 and 4 show the revision of the student workshet by media experts.

Figure 4. Student Worksheet View Before Validation

Figure 5. Student Worksheet View After Validation

The material expert validation sheet consists of 9 indicators for the assessment of of student worksheet, consisting of learning aspects and material content. The validity score for subject matter experts is 100% and is in the category of very valid. The suggestion and input from the material expert validator is to provide a place in the depiction of a graph in the form of a Cartesian diagram in the form of a grid so that the size on both coordinate axes is the same. The following figures 5 and 6 show the revision of the student worksheet from the subject matter expert.

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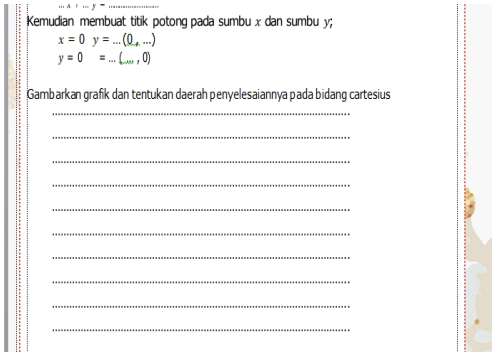

Figure 6. Student Worksheet View Before Validation

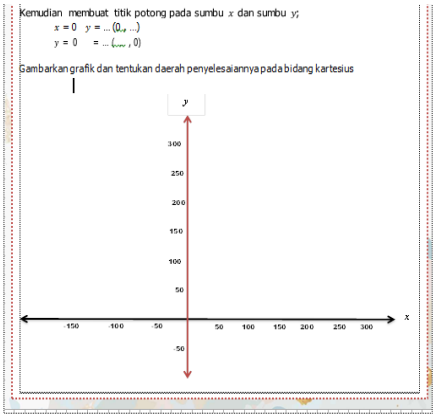

Figure 7. Student Worksheet View After Validation

The results of the validation activity show that the validator's assessment of the student worksheet is generally valid; however, there are still revisions related to the layout, graphics, symbols, and numerical errors as a result of typos. The results of the rational assessment by the validator provide the conclusion that the student worksheet is based on a strong theory, and the construction between its components consistently describes the learning model of the Missouri Mathematics Project, incorporating peer feedback. This is, by the opinion of (Sugiyono, 2017) that the validator's assessment of product design is carried out based on rational thinking, not facts in the field.

3.3.3. Practicality Test

The practical test of the development product was carried out in a small-scale (limited) trial, namely, 15 out of 24 students in grade XII MIPA 1 were selected as test subjects. For the 15 students, the researcher simulated the student worksheet, which were then asked to respond to the simulated student worksheet. In this simulation process, 1 mathematics teacher was also attended. Based on the results of the calculation of the small group test practicality questionnaire, a positive response from students to the student worksheet obtained a validity score of 82%, with a very practical category. And the teacher's positive response obtained a validity score of 88% with a very practical category.

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The average response of students and teachers reached 85%; If converted with the criteria of practical tools, the overall results of student and teacher responses are in the very practical category. The Missouri Mathematics Project's syntax, with its peer feedback, is very clear, making it very helpful for teachers in improving students' understanding of mathematical concepts. The steps students must take in this student worksheet to understand the concept are very clear. Learning does not feel boring. This is in line with the opinion of (Aufa et al., 2021) who found that students enjoyed the learning components through the Missouri Mathematics Project model. This is also supported by research (Febrian et al., 2023) demonstrated that the application of the Missouri Mathematics Project model, implemented through continuous practice, enabled students to gain experience in solving various problems.

3.3.4. Effectiveness Test

1. Thoroughness Test

The completeness test in this study consists of an average completeness test and a classical completeness test. The average completeness test was carried out to find out that learning outcomes oriented to the Missouri Mathematics Project model with peer feedback reached the minimum Completeness Criterion of 70. The hypothesis is as follows.

$H_0: \mu \leq 70$ (The average mathematics learning outcomes using the Missouri Mathematics Project model-oriented student worksheets with peer feedback are less than or equal to 70%.)

$H_1: \mu > 70$ (The average mathematics learning outcomes using the Missouri Mathematics Project model-oriented student worksheet with peer feedback of more than 70).

From the calculation using the t-test formula, a value is obtained for the price. Because it was rejected. So the results of this study can be concluded that the $t_{hitung} = 2{,}73 t_{tabel} = t_{(0,95)(23)} = 1{,}713 t_{hitung} > t_{tabel} H_0$ average mathematics learning outcomes using the student worksheet oriented to the Missouri Mathematics Project model, with peer feedback of more than 70, with an empirical average of 76.67

In this study, learning is said to be classically complete if at least 75% of all students taught using the Missouri Mathematics Project model-oriented with peer feedback reach a score of 70. The hypothesis used in this study is as follows.

$H_0: \pi \leq 75\%$ (The proportion of completeness of students taught using the Missouri Mathematics Project model-oriented worksheet with peer feedback is less than or equal to 75%)

$H_1: \pi > 75\%$ (The proportion of completeness of students taught using the Missouri Mathematics Project model-oriented student worksheet with peer feedback is more than 75%)

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From the calculation using the z-test formula, a value is obtained for the price. Because it was rejected. This means that the proportion of completeness of students taught using the student worksheet is oriented to the $z_{hitung} = 5{,}71;\ z_{tabel} = 1{,}64\ z_{hitung} > z_{tabel}\ H_0$ Iowa mathematics project model with peer feedback of more than 75%.

2. Average Difference test (Paired Sample t-test)

The average difference test in this study was carried out with the help of the SPSS application using a paired sample t-test with a real level of 5%. The hypothesis testing criteria are H_0 acceptable if the output sig value > is 5%. The hypotheses used in this study are:

$H_0: \mu_1 = \mu_2$ (Ere is no average difference between mathematics learning outcomes in Pre test and Post test data.
$H_1: \mu_1 \neq \mu_2$ (Ere is an average difference between the mathematics learning outcomes in the pre test and post test data

The prerequisite test that is carried out before the paired sample t-test is a normality test. The results of the normality test output can be seen in the following SPSS output.

Table 4. Output of Pre test and Post test Data Normality

One-Sample Kolmogorov-Smirnov Test		
		Unstandardized Residual
N		24
Normal Paremeters[a, b]	Mean	.0000000
	Std. Deviation	5.06492646
Most Extreme Differences	Absolute	.244
	Positive	.208
	Negative	-.244
Kolmogorov-Smirnov Z		1.194
Asymp. Sig. (2-tailed)		.116

a. Test distribution is Normal; b. Calculated from data

Based on the tests of normality output table above, in the Kolmogorov-Smirnov test section, a sig value for the pre test value and a post test value of 0.116 were obtained. Because the sig value of the two tests is greater than 5%, it can be concluded that the pre test and post test data are normally distributed and can be used for the paired sample t-test.

Table 5. Paired Sample T-Test Output

		Paired Differences					**t**	**df**	**Sig. (2-tailed)**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of The Difference**				
					Lower	**Upper**			
Pair 1	Pre test - Post test	-43.125	5.067	1.034	-45.265	-40.985	-41.691	23	.000

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The SPSS output result above was obtained with a sig (2-tailed) value of 0.000, then $H_0 < 0{,}05_0$ Was rejected, and H_1 was accepted, meaning that there was a real difference between the mathematics learning results in the Pre test and Post test data. Based on the results of the data tests that have been carried out, it can be said that the mathematics learning outcomes using the LKS oriented to the Missouri Mathematics Project model with peer feedback were developed to achieve learning completeness. This is because the Missouri Mathematics Project model with peer feedback provides a learning experience for students to learn through problems given by the teacher, where, through these problem-solving activities, students build new knowledge by relating the knowledge they have before. This is also supported by research by (Hidayah & Ningsih, 2021) that student worksheets using the Missouri Mathematics Project learning model are effective in the learning process. According to Ausubel's theory of learning that it is important for students to associate experiences, phenomena, and new facts with the knowledge they already have.

The use of peer feedback in the MMP model trains students to express themselves understandably. Students take part in giving feedback on the problems solved, students are trained to read their peers' work, reflect on its quality, and formulate constructive and useful feedback, so that students can think critically about what they read. This is by Piaget's theory that to help cognitive development, learning conditions need to be made as optimal as possible to allow students to conduct experiments, ask questions, answer, and compare their discoveries with those of friends. This is in line with (Patchan & Schunn, 2015) research, stating that students are involved in assessment and peer feedback, not to become experts like teachers, but to be involved in tasks so that they can be active in learning activities. This is supported by research by (Naimnule et al., 2020) saying that Peer feedback has the most important influence on student learning achievement.

4. Conclusions

The characteristic of this Student Worksheet is that its development is adjusted to the Missouri Mathematics Project Model with Peer Feedback, which is cooperative learning among others to construct students' knowledge in finding problem-solving solutions and helping students to be actively involved in assessing and providing feedback on assignments independently. The LKS of the Linear Program material developed was declared valid with an average percentage of validators reaching 80% and through the simulation of the LKS developed oriented to the Missouri Mathematics Project Model with Peer Feedback on 15 students of grade XII MIPA-1 of Noemuti State High School and attended by 1 mathematics teacher, the response and response of teachers and students to the LKS and the process was declared very good (very practical) with the average response of the teacher and students reached 85%. From the research carried out, it can be seen that there are real differences. This is seen from the value of Sig. (2-tailed) is 0.001 < 5%. So that the use of the LKS developed is oriented towards the Missouri Mathematics Project Model with Peer Feedback in learning mathematics of linear programming materials effectively.

Author Contributions

The first author researches the implementation of activities, collects and processes

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data, and compiles them in an article manuscript. The second and third authors helped research the implementation of activities and made significant contributions to the process of writing and developing the research

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Declaration of Competing Interest
The authors declare that there are no conflicts of interest.

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