

DEVELOPMENT OF STUDENT WORKSHEETS BASED ON A METAPHORICAL THINKING APPROACH WITH TUTOR FEEDBACK TO IMPROVE STUDENTS' MATHEMATICAL CONNECTION ABILITY

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ABSTRACT This study aims to develop student worksheets based on a metaphorical thinking approach with tutor feedback to improve students' mathematical connection ability in the topic of systems of linear equations in two variables. This research employed a development design based on the ADDIE model, which consists of analysis, design, development, implementation, and evaluation stages. The instruments used in this study included validation sheets, student and teacher response questionnaires, and mathematical connection ability tests. The validity assessment showed that the developed student worksheets obtained an average validity score of 93.06%, categorized as highly valid. The practicality test, based on student and teacher responses, obtained an average score of 84.5%, categorized as highly practical. The effectiveness of the worksheets was determined based on predefined criteria, namely the average achievement of students' mathematical connection ability, classical mastery, and the difference between pretest and posttest scores. The results showed that the average posttest score reached 68.83, with classical mastery of 83.33%. In addition, students' average score increased from 21.08 in the pretest to 68.83 in the posttest, and the paired sample t-test showed a significant difference with a sig. value of $0.000 < 0.05$. These findings indicate that student worksheets based on a metaphorical thinking approach with tutor feedback are valid, practical, and effective for improving students' mathematical connection ability.

Keywords: student worksheets, metaphorical thinking approach, tutor feedback, mathematical connection ability, ADDIE model

ABSTRAK Penelitian ini bertujuan untuk mengembangkan lembar kerja siswa berbasis pendekatan *metaphorical thinking* dengan *tutor feedback* untuk meningkatkan kemampuan koneksi matematis siswa pada materi sistem persamaan linear dua variabel. Penelitian ini menggunakan desain pengembangan berdasarkan model ADDIE yang terdiri atas tahap analisis, desain, pengembangan, implementasi, dan evaluasi. Instrumen yang digunakan dalam penelitian ini meliputi lembar validasi, angket respons siswa dan guru, serta tes kemampuan koneksi matematis. Hasil penilaian validitas menunjukkan bahwa lembar kerja

siswa yang dikembangkan memperoleh skor validitas rata-rata sebesar 93,06% dengan kategori sangat valid. Uji kepraktisan berdasarkan respons siswa dan guru memperoleh skor rata-rata sebesar 84,5% dengan kategori sangat praktis. Efektivitas lembar kerja siswa ditentukan berdasarkan kriteria yang telah ditetapkan, yaitu pencapaian rata-rata kemampuan koneksi matematis siswa, ketuntasan klasikal, dan perbedaan skor pretest dan posttest. Hasil penelitian menunjukkan bahwa rata-rata skor posttest siswa mencapai 68,83 dengan ketuntasan klasikal sebesar 83,33%. Selain itu, nilai rata-rata siswa meningkat dari 21,08 pada pretest menjadi 68,83 pada posttest, dan hasil uji *paired sample t-test* menunjukkan perbedaan yang signifikan dengan nilai $\text{sig. } 0,000 < 0,05$. Temuan ini menunjukkan bahwa lembar kerja siswa berbasis pendekatan *metaphorical thinking* dengan *tutor feedback* valid, praktis, dan efektif untuk meningkatkan kemampuan koneksi matematis siswa.

Kata-kata kunci: lembar kerja siswa, pendekatan *metaphorical thinking*, *tutor feedback*, kemampuan koneksi matematis, model ADDIE

INTRODUCTION

Mathematics is one of the compulsory subjects at every level of education because it plays an important role in various aspects of life, especially in developing students' thinking ability. According to NCTM (2000), several abilities need to be developed through mathematics learning, namely problem solving, reasoning and proof, communication, connection, and representation. Among these abilities, mathematical connection ability is an important competency because it helps students relate mathematical ideas to one another, apply mathematical concepts in other disciplines, and connect mathematics with real-life situations. Siregar and Surya (2017) stated that mathematical connection ability can improve students' cognitive ability, such as recalling previously learned material and understanding how mathematical concepts are applied in daily life.

Based on preliminary observations at a public junior high school in Kota Baru, students' mathematical connection ability was still relatively low. Most students had difficulty connecting one mathematical topic with another and applying mathematical concepts to other subjects or everyday problems. This condition was also supported by the average pretest score of 30 students, which was only 21.08. In addition, the worksheets used in learning still contained conventional materials and routine questions, without being integrated with an innovative learning approach that could support student activity, motivation, and learning outcomes. Therefore, learning resources are needed that can guide students to actively construct mathematical connections.

Students with good mathematical connection ability are more likely to understand the purpose of learning mathematics and recognize its relevance in daily life. One approach that can support this ability is the metaphorical thinking approach. Metaphorical thinking is a learner-centered approach that encourages students to relate mathematical problems to familiar situations or experiences in everyday life (Sundry, 2020). Through metaphorical thinking, students are trained to connect

prior knowledge with new concepts and to understand the relationship between mathematical ideas. This is in line with Bernard and Senjayawati (2019), who stated that mathematical connection ability involves understanding relationships among mathematical topics and applying mathematics in other fields or real-life contexts.

In addition to an appropriate learning approach, feedback is also an important component in supporting students' learning process. Reinholz (2018) stated that feedback in learning provides students with greater insight into interpreting their work and supports mathematics learning. Feedback as part of formative assessment helps students identify the gap between their current understanding and the expected learning goals, as well as guides them to take the necessary steps to improve their learning. Misbah (2022) also emphasized that feedback can help students understand learning objectives and make the learning process more meaningful. In this context, tutor feedback is important because it can help students recognize misconceptions, revise their thinking, and understand the logic behind each step of problem solving.

The integration of metaphorical thinking and tutor feedback is relevant for developing students' mathematical connection ability. The metaphorical thinking approach guides students to build connections between mathematical concepts and real-life contexts, while tutor feedback provides reinforcement and guidance during the process of constructing these connections. Through worksheets designed with metaphorical thinking stages, students are encouraged to interpret problems, identify relationships among concepts, and apply mathematics in contextual situations. Tutor feedback can be inserted into the learning activities to help students evaluate their answers, correct mistakes, and strengthen their understanding. Thus, the combination of metaphorical thinking and tutor feedback provides a structured learning process that supports the development of mathematical connection ability.

One learning resource that can facilitate this process is student worksheets. Student worksheets can guide students' thinking patterns, support the discovery of new knowledge, and encourage students to be actively involved in solving problems (Juwita, 2019; Winda et al., 2020). A good student worksheet should be designed attractively, aligned with curriculum demands, and adapted to students' learning needs. In this study, the student worksheets were developed based on the metaphorical thinking approach with tutor feedback. The tasks and exercises were designed based on indicators of mathematical connection ability, namely applying mathematics in daily life, applying relationships between mathematical topics, and applying mathematical topics to other scientific fields.

Previous studies have examined metaphorical thinking, feedback, and the development of student worksheets in mathematics learning. However, studies that specifically develop student worksheets by integrating the metaphorical thinking approach with tutor feedback to improve students' mathematical connection ability

are still limited. Therefore, the novelty of this study lies in the development of structured student worksheets on systems of linear equations in two variables that explicitly combine metaphorical thinking stages and tutor feedback, and are tested based on validity, practicality, and effectiveness criteria. Based on this background, this study aims to develop student worksheets based on a metaphorical thinking approach with tutor feedback to improve students' mathematical connection ability.

METHODS

This study used a development research design based on the ADDIE model developed by Robert Maribe Branch. The ADDIE model consists of five stages: analysis, design, development, implementation, and evaluation (Cahyadi, 2019). This model was selected because it provides systematic stages for developing, revising, and evaluating learning products.

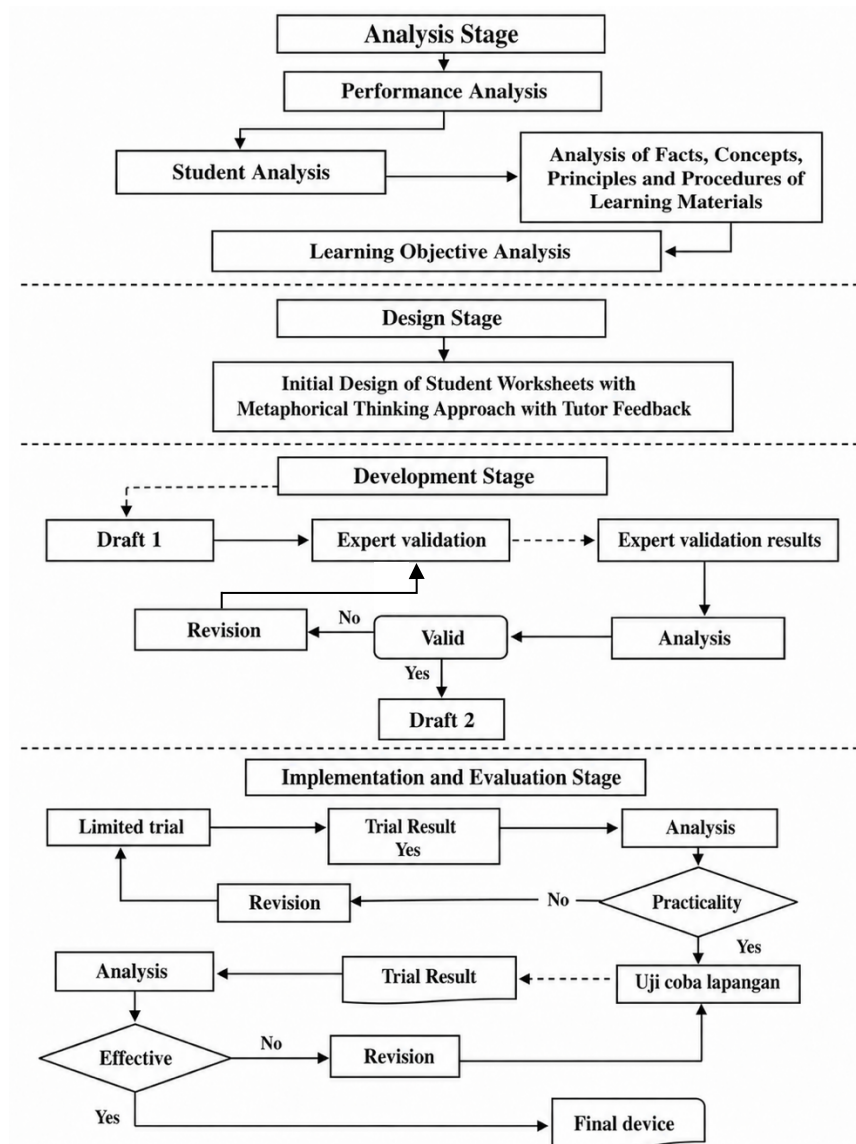


Figure 1. Stages of the ADDIE Development Model

The product developed in this study was a student worksheet based on a metaphorical thinking approach with tutor feedback on the topic of systems of linear equations in two variables. The worksheet was designed to improve students' mathematical connection ability. The research was conducted at Kota Baru State Junior High School in the 2025/2026 academic year.

The participants involved in this study were divided according to the development stages. The validation stage involved two expert validators, namely a media/design validator and a material validator. The small-scale trial involved 15 students from Class VIII-A and one mathematics teacher to assess the practicality of the developed worksheet. The field trial involved 30 students from Class VIII-B to examine the effectiveness of the worksheet in improving students' mathematical connection ability.

The instruments used in this study consisted of validation sheets, teacher and student response questionnaires, and mathematical connection ability tests. The validation sheets were used to assess the quality of the worksheet in terms of content, construction, language, presentation, media design, the suitability of the metaphorical thinking approach, tutor feedback, and mathematical connection indicators. The practicality questionnaires were used to obtain teacher and student responses regarding ease of use, clarity of instructions, attractiveness, time efficiency, usefulness, and suitability for classroom learning. Meanwhile, the mathematical connection ability test was used to measure students' ability to apply mathematics in daily life, connect relationships between mathematical topics, and apply mathematical concepts to other scientific fields.

The validity of the worksheet was analyzed using the percentage formula adapted from Riduwan (2018):

$$TV = \frac{\text{total score obtained}}{\text{maximum score}} \times 100\%$$

where *TV* represents the validity level. The interpretation of the validity score is presented in Table 1.

Table 1. Interpretation of Student Worksheet Validity

Interval	Criterion
81%–100%	Highly valid
61%–80%	Valid
41%–60%	Quite valid
21%–40%	Less valid
0%–20%	Invalid

The worksheet that had been validated by experts was then tested in a small-scale trial to determine its practicality. Practicality was analyzed based on student and teacher response questionnaire scores using the same percentage formula. The interpretation of practicality scores is presented in Table 2.

Table 2. Interpretation of Student Worksheet Practicality

Interval	Criterion
81%–100%	Very practical
61%–80%	Practical
41%–60%	Fairly practical
21%–40%	Less practical
0%–20%	Not practical

The developed worksheet was considered feasible for use if it met at least the valid and practical categories (Isharyadi & Ario, 2018).

The effectiveness of the worksheet was examined using a one-group pretest-posttest design in the field trial. In this design, students were given a pretest before learning using the worksheet and a posttest after the learning process. The research design is presented in Table 3.

Table 3. One-Group Pretest-Posttest Design

Pretest	Treatment	Posttest
O_1	X	O_2

Description:

O_1 : Pretest of students' mathematical connection ability before treatment

X : Learning using student worksheets based on the metaphorical thinking approach with tutor feedback

O_2 : Posttest of students' mathematical connection ability after treatment

The effectiveness analysis was based on three criteria: (1) the average score of students' mathematical connection ability reached at least 60, (2) at least 75% of students achieved classical mastery, and (3) there was a significant difference between students' pretest and posttest scores. The mastery score of 60 was determined based on the initial ability score of the sample plus the standard deviation, following the procedure used by Fathonah (2019). In this study, the average initial ability score was 42.50 and the standard deviation was 17.89, resulting in a threshold of 60.39, which was rounded to 60 to make the criterion easier to apply in classroom assessment.

Before conducting the paired sample t-test, a normality test was carried out to ensure that the pretest and posttest data were normally distributed. The paired sample t-test was then used to determine whether there was a significant difference between students' mathematical connection ability before and after learning using the developed worksheet. Classical mastery was analyzed by calculating the proportion of students who achieved a score of at least 60. The worksheet was considered effective if all predefined effectiveness criteria were met.

FINDING AND DISCUSSION

Analysis Stage

The analysis stage was conducted to identify the initial needs for developing student worksheets based on a metaphorical thinking approach with tutor feedback. The results of interviews with mathematics teachers at Kota Baru State Junior High School showed several important findings. First, the mathematics curriculum used in the school still referred to the 2013 Curriculum. Second, students tended to depend heavily on teacher explanations during the learning process. Third, the learning resources used in class were mainly mathematics textbooks, which contained limited explanations and routine exercises. Fourth, teachers had not yet developed innovative student worksheets based on students' needs and learning characteristics.

Student analysis was also conducted to determine the characteristics of Grade VIII students. Based on classroom observations, students were not fully active in learning and tended to wait for the teacher's explanation before attempting to solve problems. Many students also lacked confidence in expressing their mathematical ideas. This condition indicated the need for learning materials that could guide students to be more independent, active, and confident in connecting mathematical concepts.

The material analysis focused on the topic of systems of linear equations in two variables. The worksheet tasks were designed based on indicators of mathematical connection ability, namely applying mathematics in everyday life, connecting relationships between mathematical topics, and applying mathematical concepts to other scientific topics. Based on the analysis of learning objectives, students were expected to learn actively, creatively, and independently through mathematics learning using student worksheets based on a metaphorical thinking approach with tutor feedback.

Design Stage

The design stage consisted of two main activities: selecting the worksheet format and preparing the initial draft of the student worksheets and research instruments. The student worksheets were designed based on the stages of the metaphorical thinking approach and were integrated with tutor feedback in the formative assessment sections. The worksheets were arranged with guided activities and blank

completion spaces so that students could construct their own answers and solution strategies.

The metaphorical thinking approach was integrated into the worksheets by presenting contextual problems that encouraged students to relate mathematical concepts to familiar situations. Through these activities, students were guided to understand problems, identify mathematical ideas, build connections between concepts, and apply mathematics in daily life. Tutor feedback was inserted to provide reinforcement, guide students in checking their answers, and help them correct misconceptions during the learning process. Therefore, the worksheet was not only designed as a collection of exercises, but also as a learning tool that supported students in developing mathematical connection ability.

UMPAN BALIK/FEEDBACK DARI TUTOR

Feedback from : *Feedback for :*

➔

Apakah jawaban dari siswa anda sudah jelas? Berikan alasannya!
Jawab:

Jika belum jelas, bagaimana memperbaiki jawaban tersebut menurut anda?
Jawab:

Apakah jawaban dari siswa anda sudah benar dan lengkap? Berikan alasannya
Jawab:

Jika belum benar dan lengkap, bagaimana memperbaiki jawaban tersebut menurut anda?
Jawab:

Figure 2. Excerpt from the Student Worksheet Based on the Metaphorical Thinking Approach with Tutor Feedback

Figure 2 should present only one representative excerpt from the developed worksheet. The selected excerpt should show the main characteristics of the product, especially the contextual problem, metaphorical thinking activity, and tutor feedback section. Other images, such as before–after revision pages or screenshots of statistical output, do not need to be displayed and can be summarized in tables.

Development Stage

The development stage involved expert validation of the student worksheets. The validation was conducted by two expert validators, namely a media/design expert and a material expert. Based on the media/design validation, which consisted of 27 assessment indicators, the student worksheets obtained a validity score of 88.88%, categorized as highly valid. The validator suggested improving the worksheet front page because it appeared too empty. Therefore, relevant images and motivational elements were added to make the worksheet more attractive.

The material validation consisted of 29 assessment indicators and obtained a validity score of 97.24%, categorized as highly valid. The suggestions from the material expert included improving the consistency of rupiah units in several problems, clarifying images in example problems, and adjusting the indicators and learning objectives in the tutor feedback section to align with the material presented. The summary of validator suggestions and revisions is presented in Table 4.

Table 4. Summary of Validator Suggestions and Revisions

Validator	Revised Section	Suggestion	Revision Made
Media/design expert	Worksheet front page	The front page was too empty and needed visual or motivational elements	Relevant images and motivational elements were added
Material expert	Example problems	The use of rupiah units needed to be consistent	The writing of rupiah units was revised consistently
Material expert	Images in example problems	Some images were unclear	The images were revised to improve visibility
Material expert	Tutor feedback sheet	Indicators and learning objectives needed to be aligned with the material	The indicators and learning objectives were adjusted according to the mathematical concepts presented

Based on the validation results, the average validity score of the developed student worksheets was 93.06%. This result indicates that the student worksheets based on the metaphorical thinking approach with tutor feedback met the highly valid criterion. Thus, the worksheets were considered appropriate in terms of media design, material content, language, presentation, and suitability with mathematical connection ability indicators.

Implementation Stage

The implementation stage was conducted through a small-scale trial involving 15 students from Class VIII-A and one mathematics teacher. This stage aimed to determine the practicality of the developed student worksheets based on teacher and student responses.

The practicality questionnaire results showed that students gave a positive response, with a score of 77%, categorized as practical. Meanwhile, the teacher response reached 92%, categorized as very practical. The average score of student and teacher responses was 84.5%, which was categorized as very practical. These results indicate that the developed student worksheets were easy to use, understandable, and suitable for classroom learning.

Table 5. Practicality Test Results

Respondent	Score (%)	Category
Students	77.00	Practical
Teacher	92.00	Very practical
Average	84.50	Very practical

The results of the practicality test show that the developed worksheets can be used in mathematics learning. The teacher response indicates that the worksheets are helpful as structured learning materials, while the student response shows that the worksheets can guide students in completing tasks and understanding the learning activities. Although the student response score was lower than the teacher response, it still met the practical criterion.

Evaluation Stage

The evaluation stage was conducted through a field trial involving 30 students from Class VIII-B. The effectiveness of the student worksheets was determined based on three criteria: the average mathematical connection ability score reached at least 60, classical mastery reached at least 75%, and there was a significant difference between pretest and posttest scores.

a. Initial Data Analysis

The mastery threshold for mathematical connection ability was determined based on the average initial ability score of the sample plus the standard deviation. Based on the calculation, the average initial ability score was 42.50 with a standard deviation of 17.89. Therefore, the threshold was 60.39 and was rounded to 60. Thus, students were considered to have achieved mastery if they obtained a score of at least 60.

Before conducting the paired sample t-test, a normality test was conducted. The Shapiro-Wilk test showed a significance value of 0.313 for the pretest data and 0.073

for the posttest data. Since both values were greater than 0.05, the pretest and posttest data were normally distributed.

Table 6. Normality Test Results

Data	Shapiro-Wilk Statistic	df	Sig.
Pretest	0.960	30	0.313
Posttest	0.937	30	0.073

b. Final Data Analysis

The average posttest score of students' mathematical connection ability was 68.83. This score exceeded the predetermined mastery threshold of 60. The average completion test also showed that the calculated t-value was 3.342, while the t-table value was 2.7564. Since the calculated t-value was greater than the t-table value, it can be concluded that the average mathematical connection ability of students taught using the developed worksheets was higher than the mastery criterion.

The classical mastery test showed that 25 out of 30 students achieved a score of at least 60. This means that the percentage of classical mastery reached 83.33%, exceeding the minimum criterion of 75%. These results indicate that the developed worksheets met the classical mastery criterion.

Table 7. Effectiveness Results Based on Mastery Criteria

Effectiveness Indicator	Result	Criterion	Description
Average posttest score	68.83	≥ 60	Achieved
Students achieving mastery	25 of 30 students	—	Achieved
Classical mastery	83.33%	$\geq 75\%$	Achieved

The paired sample t-test was used to determine whether there was a significant difference between students' mathematical connection ability before and after learning using the developed worksheets. The results showed that the average pretest score was 21.08, while the average posttest score increased to 68.83. The paired sample t-test produced a sig. value of 0.000, which was less than 0.05. Therefore, there was a significant difference between students' mathematical connection ability before and after learning using the student worksheets.

Table 8. Paired Sample t-Test Results

Data Pair	Mean Difference	SD	SE Mean	t	df	Sig. (2-tailed)
Pretest- Posttest	-42.167	7.032	1.284	-32.842	29	0.000

These results indicate that the student worksheets based on the metaphorical thinking approach with tutor feedback met the effectiveness criteria in this development study. The effectiveness was shown by the average score exceeding the mastery threshold, the classical mastery percentage exceeding 75%, and the significant difference between pretest and posttest scores.

The improvement in students' mathematical connection ability can be related to the structure of the developed worksheets. The metaphorical thinking approach helped students connect abstract mathematical concepts with familiar contexts, while tutor feedback guided students in checking their thinking, correcting errors, and strengthening their understanding. This process supported students in applying mathematics in everyday life, connecting mathematical topics, and applying mathematical concepts to other scientific topics.

These findings are in line with Hendriana et al. (2017), who stated that metaphorical thinking can support students in understanding, explaining, and presenting mathematical concepts. The findings also support Wahid et al. (2024), who reported that students who learned through a metaphorical thinking approach showed better mathematical connection ability than those who learned through conventional learning. In addition, the use of tutor feedback in the worksheets functioned as formative support that helped students improve their learning process, consistent with Reinholz (2018) and Schoenfeld (2014), who emphasized the importance of feedback and formative assessment in mathematics learning.

Overall, the results show that the developed student worksheets are valid, practical, and effective. The worksheets are valid based on expert validation, practical based on teacher and student responses, and effective based on the predefined criteria of average achievement, classical mastery, and pretest–posttest difference. Therefore, student worksheets based on the metaphorical thinking approach with tutor feedback can be used as an alternative learning resource to improve students' mathematical connection ability on the topic of systems of linear equations in two variables.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this study, it can be concluded that the student worksheets based on the metaphorical thinking approach with tutor feedback developed using the ADDIE model meet the criteria of validity, practicality, and effectiveness. In terms of validity, the worksheets obtained an average validation score of 93.06%, which is categorized as highly valid. This result indicates that the worksheets are appropriate in terms of content, presentation, design, language, and alignment with the indicators of students' mathematical connection ability.

In terms of practicality, the small-scale trial involving 15 students from Class VIII-A and one mathematics teacher showed that the worksheets were practical to use in mathematics learning. The average response score from students and the teacher

reached 84.5%, which is categorized as very practical. This indicates that the worksheets are easy to use, understandable, and suitable for supporting classroom learning activities.

In terms of effectiveness, the field trial involving 30 students from Class VIII-B showed that the worksheets met the predefined effectiveness criteria. The average score of students' mathematical connection ability reached 68.83, exceeding the mastery threshold of 60. In addition, 25 out of 30 students achieved mastery, with a classical mastery percentage of 83.33%, which exceeded the minimum criterion of 75%. The paired sample t-test also showed a significant difference between pretest and posttest scores, with a sig. value of $0.000 < 0.05$. Therefore, the student worksheets based on the metaphorical thinking approach with tutor feedback are feasible and effective as learning materials to improve students' mathematical connection ability on the topic of systems of linear equations in two variables.

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