



Contents lists available at DJM

DESIMAL: JURNAL MATEMATIKA

p-ISSN: 2613-9073 (print), e-ISSN: 2613-9081 (online), DOI 10.24042/djm
<http://ejournal.radenintan.ac.id/index.php/desimal/index>



Scaffolding to reduce misconceptions: A case study of solving a two-variable linear equation system problem based on students' cognitive styles

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ARTICLE INFO

Article History

Received : 23-04-2024

Revised : 15-05-2024

Accepted : 15-06-2024

Published : 30-07-2024

Keywords:

Cognitive Style; Misconception;
Scaffolding; Two-Variable Linear
Equation System.

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Doi:

[10.24042/djm.v7i2.21957](https://doi.org/10.24042/djm.v7i2.21957)

ABSTRACT

This study aims to explain students' misconceptions in solving material problems of linear equations of two variables before and after scaffolding, the form of scaffolding given, and the effect of scaffolding. The research method used in this study is qualitative descriptive. This research was conducted at MTS Negeri Surakarta 1 with the subjects of 8th grade students who experienced misconceptions. The instrument used in this study is the Group Embedded Diagram Test to classify students based on their cognitive style. Students who experience misconceptions are given scaffolding level 2 (clarify, revise and restructure) and adapted to the needs of the students. Based on the research that has been done, students with a cognitive style of Field-dependent, as many as twelve students; intermediate field, as many as ten students; and depending on the field, as many as five students. Field-dependent students experience classification misconceptions in converting information into a system of two-variable linear equations and correlations in relating their knowledge to problem solving. Independent students experience classification misconceptions when determining the form of a system of linear equations in two variables. The result of this study is that the provision of scaffolding is an effective alternative in overcoming student misconceptions in solving the problem of a two-variable linear equation system.

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INTRODUCTION

Teaching mathematics is essential in training students' critical and logical thinking skills (Kurniawati & Ekayanti, 2020). Mathematics is a subject that is often considered difficult by most students (Maullina & Setyaningsih, 2023).

In research (Buhaerah et al., 2022), students have difficulty solving math problems. One of the topics that usually creates difficulties for students is understanding and solving systems of linear equations in two variables (Agustini & Pujiastuti, 2020). Materials Systems of

Linear Equations in Two Variables are often presented as story problems, so students need help solving the problems (Yustika et al., 2023). Because mathematical concepts are complex, students usually need explanations to understand and solve problems with systems of linear equations in two variables. This misconception stems from various factors such as differences in students' cognitive styles in understanding mathematical information. (Patingki et al., 2022).

Cognitive style refers to an individual's tendency to receive, process and remember information. Every student has a unique learning style, and an approach that works for one student may be challenging for another (Octaviana & Setyaningsih, 2022). A person who depends on the field of global thinking, accepts existing structures or information, has a social orientation, chooses a profession with social skills, tends to follow existing objectives and information, and prioritizes external motivation (Nirfayanti & Nurdiah, 2023). They accept things globally and have difficulty separating themselves from their surroundings or are more influenced by the environment and tend to identify themselves as part of a group. Field independent is an individual who has the characteristics of being able to analyze objects separate from their environment, organize objects, have an impersonal orientation, and choose a self-motivated profession. (Kamid et al., 2020). FI is not affected by the environment. They look at problems analytically, can analyze and isolate relevant details, detect patterns and critically evaluate problems. Other studies state that students who are field-independent (FI) and taught with a contextual approach have relatively higher mathematical reasoning skills than students who are field-dependent (FD). (Priastuti Mirlanda et al., 2020; Yunus et al., 2019).

Misunderstanding is a problem that must be addressed immediately because it can have a negative impact on Indonesian education. Students especially in mathematics still need clarification. Other studies mention that students experience analytical errors in solving math problems (Dj Pomalato et al., 2020). Meanwhile, other studies have found students who rely on cognitive style areas (Amalia et al., 2020). To overcome misconceptions and improve students' understanding of the material of systems of linear equations in two variables, scaffolding is the right strategy (Purwasih & Rahmadhani, 2022).

Scaffolding is a form of support or guidance provided by others in a structured way to help students understand better (Lubis & Fauzi, 2022). Scaffolding can be adapted to each student's cognitive style so that the learning process becomes more effective. Scaffolding is effective in overcoming misconceptions and solving math problems. This is proven based on the results of previous studies. One of them is providing Scaffolding against student misconceptions in solving material set problems by (Intan & Masriyah, 2020). The results of the study show that providing scaffolding to students in the prescribed material reduces students' misconceptions about problem solving. Other studies explain that Scaffolding is supported by a supportive learning environment, direct interaction between teachers and students, and an emphasis on conceptual thinking. (Purwasih & Rahmadhani, 2022). This supportive environment can also be influenced by the facilities provided. Meanwhile, other studies explain Scaffolding as a bridge that connects the unknown with the new, with the lecturer as the main component of its implementation. (Rahayu et al., 2020).

In this study, the researcher aims to explore the effect of Scaffolding on students' understanding in solving two-

variable linear equation system problems, taking into account differences in their cognitive styles. This approach is expected to improve students' performance in solving complex mathematical problems and provide new insights on how to adapt scaffolding to students' cognitive styles to achieve optimal results. Through this research, it is hoped that more effective and personalized learning strategies can be found to overcome students' misconceptions when solving two-variable linear equation system problems. A comprehensive understanding of the relationship between scaffolding, students' cognitive styles, and understanding of mathematical concepts can provide a foundation for developing comprehensive, inclusive, and more adaptive learning approaches.

METHOD

This type of research is descriptive qualitative research. According to Sugiono (2018), descriptive qualitative research aims to understand or explain certain phenomena or problems in depth; it is naturalistic because the research is conducted on natural conditions cited (Sri Rahayu & Aldila Afriansyah, 2021). This research method focuses more on understanding the context, meaning, and characteristics of the phenomenon being studied. This research is focused on collecting and analyzing descriptive data to understand the phenomenon or problem in depth. The goal is to explain what happened, why, and how it happened. This study aims to find out how to provide Scaffolding to students with field-dependent and field-independent cognitive styles to overcome misconceptions related to linear equations of two variables. This study explains the misconceptions experienced by students based on students' cognitive styles and the appropriate framework to overcome them.

The subjects in this study are 8th grade students who experience misconceptions in solving two variable linear equation problems. This study aims to provide scaffolding to students based on their cognitive style. This research was carried out during the odd semester on the subject of linear equations of two variables at MTs Negeri Surakarta 1. The study was carried out on November 8-10, 2023, on Grade 8 Science 4 students. The instruments in this study include the GEFT Test, the test of linear equations of two variables and chat. The Group Embedded Figure Test (GEFT) is conducted on group research subjects based on cognitive style: Field dependent, field intermediate, or field independent. The GEFT test was developed by (Witkin et al., 1975).

This problem-solving ability test measures students' ability to solve two-variable linear equation problems. In this test, inappropriate decisions will be taken, and scaffolding will be provided according to the student's cognitive style. The questions given to students are as follows:

1. In conjunction with the anniversary of the City of Solo, a community activity is held, which is a traditional food festival. At the festival there are various types of traditional food such as sera, wet sausage, confectionary, rissole and various other delicacies. Novi and Diva went to celebrate on the third day. At the food festival, Novi bought 12 pieces of rissole and cake with a total price of Rp. 21,500,-. The price for one rissole is Rp. 2.000,- and one cake is Rp. 1,500,-. How much did Novi buy for each rissole and cake?
2. Gladys and Gita went to the mall one day to buy and resell bags. At Solo Paragon, there is an MSME festival, so many local product stalls are open. Many bags are sold from local brands with quality that is not inferior to foreign brands. Gladys is interested in products produced by the brand "Magnolia" which sells various bags

such as backpacks, sling bags, shoulder bags and tote bags. Gladys is interested in shoulder bags and backpacks. He bought about 15 bags of both types. The price of 1 pcs shoulder bag is Rp. 120,000,- and the price of 1 pc backpack is Rp. 180,000,-. Gladys' total expenses are Rp. 2,160,000,-. how many shoulder bags and backpacks did Gladys buy?

Question 1 was given to students before scaffolding, and question 2 was given after scaffolding. Data analysis techniques in this study are data reduction, data presentation and conclusion. The test results of question 1

are subtracted to obtain the required results. The reduced test result data is then presented by identifying the misconceptions experienced by the students. Scaffolding that is given adjusts the misconceptions experienced so that it is effective in overcoming misconceptions that occur again. Question 2 is prepared to ensure that misconceptions do not occur to FD and FI students. The presentation of data is based on the results of tests and interviews conducted as a source of information that strengthens and confirms the researcher's findings. Draw conclusions based on the data presented in the previous step.

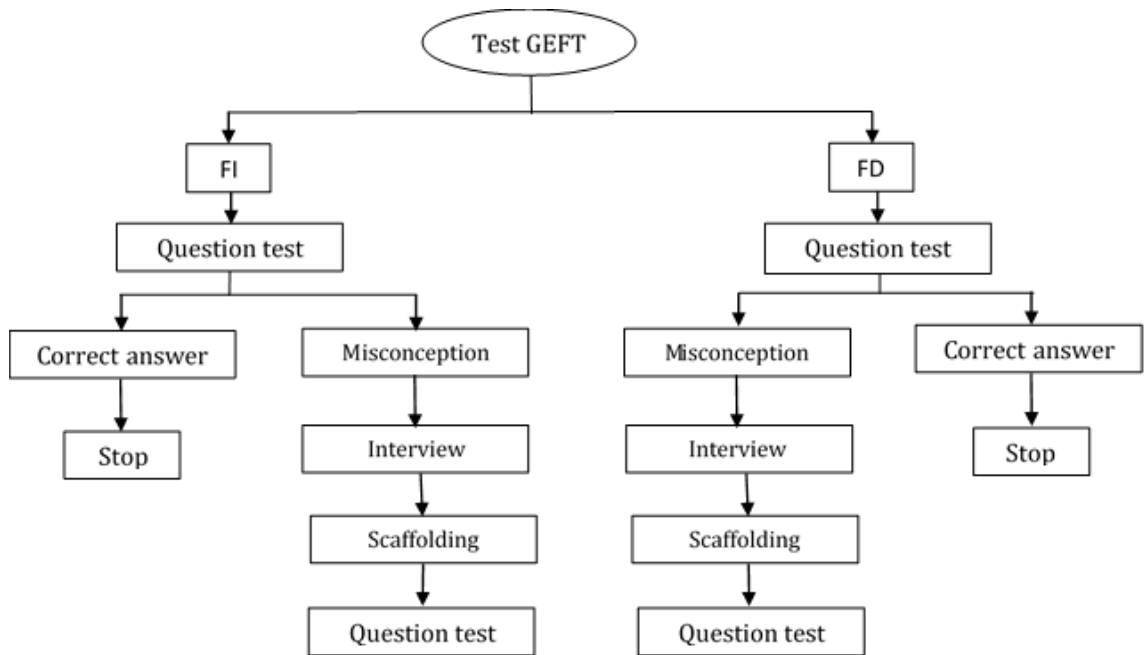


Figure 1. Research Design

RESULTS AND DISCUSSION

Based on a study that has been conducted on 27 students using the Group Embedded Figure Test (GEFT), students were obtained with a field-based cognitive style of twelve students, a mid-field cognitive style of ten students, field-independent cognitive style of five students. However, this study will only discuss students with field-based and field-independent cognitive styles.

Furthermore, field-dependent students will be called FD students, and field-independent students will be called FI students.

Then, a two-variable linear equation system test was conducted to determine which students had misconceptions. From question 1 presented, students experience many misconceptions in the solution process.

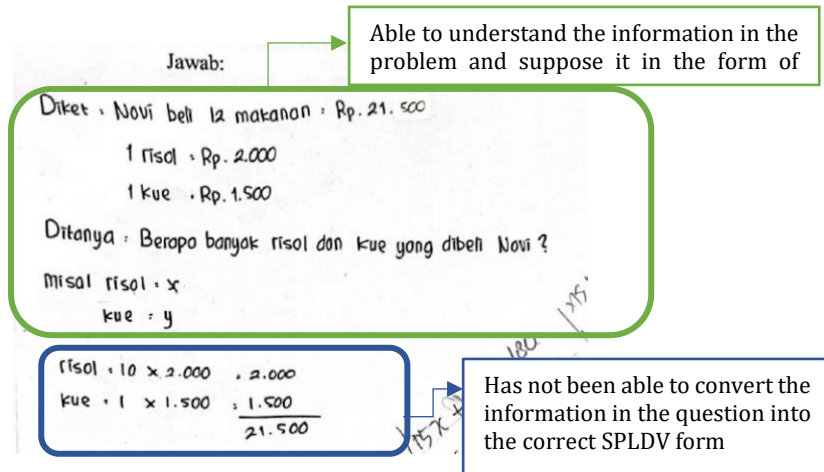


Figure 2. The answer result of question 1 FD student

Figure 2 shows that students with a field-dependent cognitive style identified as FD students can analyze the information from question 1 presented. However, they need help converting the information on the question into the correct form of a two-variable linear equation system. In solving question 1, FD students can analyze the problem contained in the question and express it in direct sentences. At the completion stage, the FD students assume rissole in x and cake in y . However, FD students need help in designing solutions in mathematical models.

P : If this is translated into mathematical form, what is the next step? Yesterday, I said this test uses a system of linear equations of two variables; now, what form would you use if you converted it to a model of a system of linear equations in two variables?

FD : This is not wrong, my friend.

P : Does this mean that there is confusion about the problem of changing the model of a system of linear equations of two variables?

FD : Yes Sister

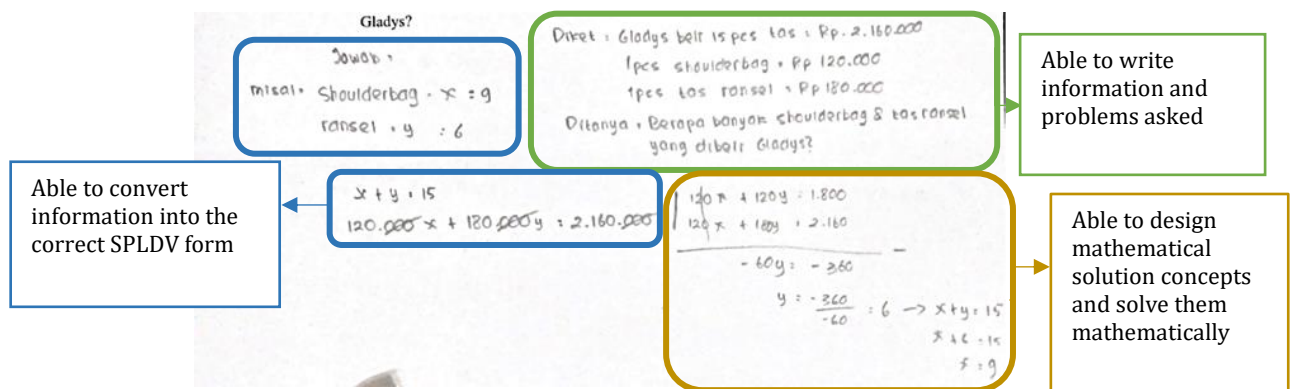


Figure 3. Results of FD students' answers after being given scaffolding

In interviews, FD students expressed difficulty in converting problems into mathematical form. Furthermore, scaffolding is given according to the students' needs, and question 2 is given.

Based on the results of the student's answers after being given the scaffolding, the student's answer's train of thought began to appear. Students write the information known from the question well, what was asked, and the answer. In the answer, the student assumes the

shoulder bag is x , and the backpack is y . Then, students use the mathematical concepts of elimination and substitution.

The calculations are good, so it can be concluded that the scaffolding given to the FD students is correct.

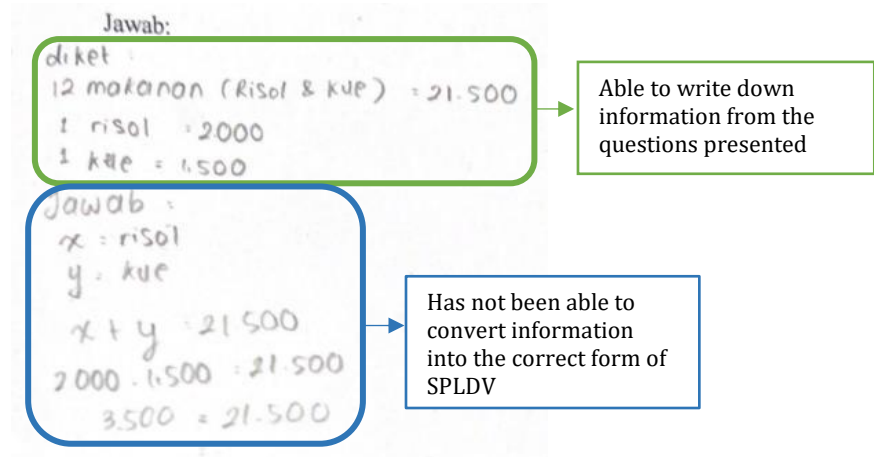


Figure 4. The answer results of question number 1 FI students

Based on the diagram of the answer to question number 1, the FI students had a misconception from the beginning that is the students stated the price of 12 meals for 21,500 in the known portion. Then, students express in the equation $x + y = 21,500$. Students who try to make the total of risol 6 and cake 6 equal to 21,500 are eliminated again with the total price of risol and cake equal to 3,500. Based on this analysis, students need clarification when converting sentences into mathematical forms. The following interview results support this:

P : What if the example was converted to mathematical form?

FI : i dont know

P : Are you confused by that part??

FI : yes

In interviews, students expressed difficulty in converting problems into mathematical models. So, students experience misconceptions about modeling in mathematical form. Furthermore, scaffolding will be provided according to the students' needs with the following results

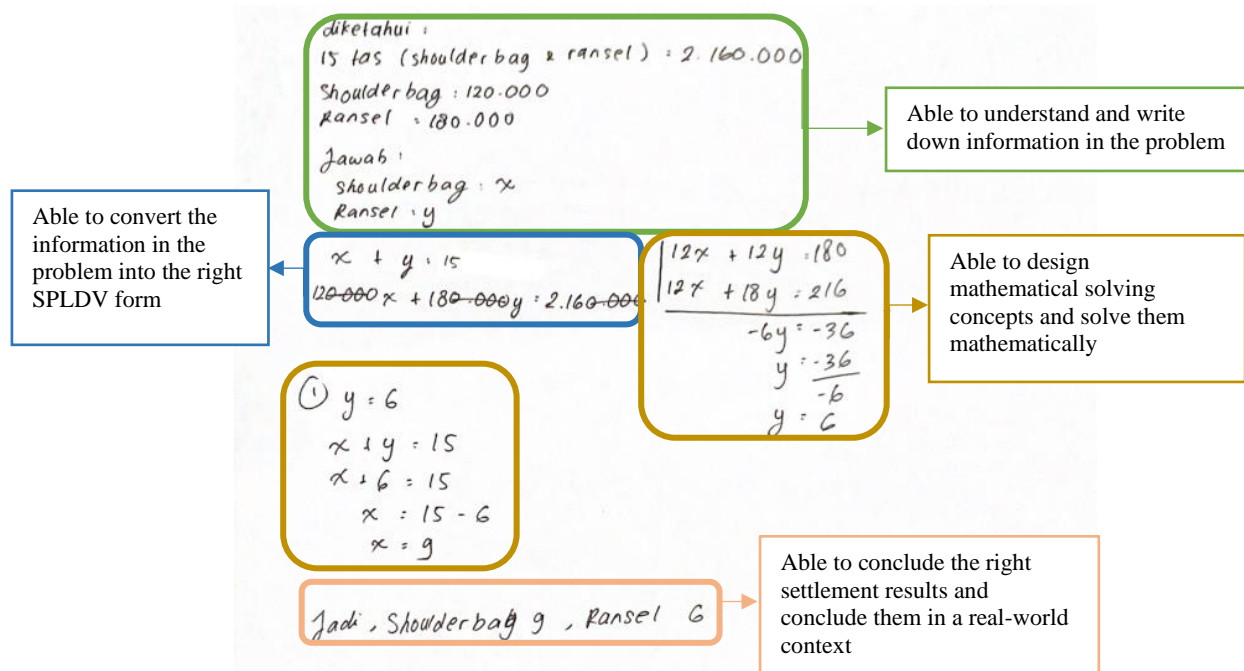


Figure 5. The results of FI students' answers after being given scaffolding

Based on Figure 5, FI students solve the questions well and correctly. FI students write information completely and correctly. The misunderstanding experienced before no longer occurs when solving this problem. Students use the method of elimination and substitution to solve the problem in the question. The calculations carried out are also correct. Students also give conclusions from the solutions they have obtained.

Based on the results of the students' answers after they were given Scaffolding, the students answered with a structure that was easier to understand than before. Students write the information from the problem completely; then, students convert the information into a mathematical model correctly. From the mathematical model obtained, students use the method of elimination and substitution. The calculations made by the students were also correct, so the Scaffolding provided to the FI students was accurate.

FD students need help converting information into the correct form of a system of linear equations in two

variables. FD students confirmed this during the interview. FD students experience classification misconceptions when determining the form of a system of linear equations in two variables and its solution. Students are unable to correctly classify algebraic variables. Similarly, in research (Intan & Masriyah, 2020), students experienced a misperception of classification, where students were asked to group sets and non-sets. However, some students express statements as sets that should not be sets and express statements as non-sets that should be sets. In this case, correlation misconceptions also occur in FD students: students cannot correlate their knowledge and relate it to problem solving. The cause of FD students' misconceptions is a preconception that is difficult to abandon. This is due to the previous learning process, the incorrect use of learned concepts, instability in relating concepts to each other and misinterpretation of student problems.

FD students have limitations in analyzing, which causes indicators to be unfulfilled when interpreting problems. Similarly, in the study of students with a

cognitive style, (Rahmasari & Setyaningsih, 2023) field-dependent shows good mathematical literacy skills but needs guidance to interpret the results and find appropriate and effective solution strategies. This is evident in the answers of FD students in the known section, where they write the type of food and its price; in addition, students also use variables to symbolize each food. However, in the answer, students need help to solve the problem thoroughly. In other words, students have not yet been able to develop an effective strategy to solve the problem of a system of linear equations of two variables.

Scaffolding is done with the level 2 method (explaining, reviewing, and restructuring) (Anghileri, 2006) with the following steps: The researcher asks the student to explain the information obtained by the student from the questions presented (seeing, touching and saying verbally). Then, ask the students to explain how the material of the system of linear equations of two variables has been given and then ask how if the material is used in the questions presented (prompting and probing). Furthermore, ask the students to explain and justify their answers (students explain and justify). Prepare a question that discusses question 1 and is related to a system of linear equations of two variables (context means), explain the problem in a simpler form (simplify the problem), discuss the meaning of a system of linear equations of two variables and its effective solution (negotiate meaning).

After being given Scaffolding, FD students can solve previously related problems. FD students can write information from questions correctly. Then, in the problem-solving section, use a sequential and easy-to-understand strategy. Using the method of elimination and substitution, the student correctly solves the problem of a system of linear equations in two variables. However,

students do not write conclusions. This is because FD students receive existing information, unlike FI students who are more analytical in dealing with a problem. Therefore, the scaffolding effectively overcomes the misconceptions of FD students when solving two-variable linear equation system problems. This is in line with the study (Nurul Meilisa Putri et al., 2022), which states that the application of scaffolding has a positive impact on increasing the algebraic operation ability of grade VII students in doing assignments. In Rusdianti's study, it was stated that after being given help or scaffolding, students who have a cognitive style depending on the field can solve the questions presented and student misconceptions can be reduced (Rusdianti & Masriyah, 2021).

FI students need help converting the information received from the questions into the correct form of a system of two-variable linear equations. Students convert the information they receive into a system of two-variable linear equations by representing each food in variable form. However, he sums up the quantity of the two foods so that the result is the total price. Students do not enter the cost of each variable as a coefficient of that variable. Students assume the variable represents price, which should represent the quantity of each food item. From this analysis, FI students experience classification misconceptions when determining the form of a two-variable linear equation system. This is in line with research (Tri Aldianisa et al., 2021). Students need to be more precise when understanding the steps of classifying fractions based on their order from smallest to largest.

During problem solving, FI students can describe the components of the problem and respond to the problem with various strategies. Research has also made it clear that students with a domain-independent cognitive style respond well

to problems by explaining the problem and responding and relating mathematical concepts. In the answer to question number 1, FI students are good at problem solving strategies. However, FI students need help to convert the information into mathematical form, so the solution results are not very accurate.

Scaffolding preparation to classify the misconceptions of FI students is carried out with Scaffolding method level 2 (clarify, review and restructure) (Anghileri, 2006) with the following steps: The researcher asks the student to explain the information the student obtained from the questions presented. (seeing, touching and saying verbally), asking about the material of the system of linear equations of two variables that has been studied before, and then asking FI students to distinguish between one variable and another variable (prompting and probing), asking FI students to explain and give justification answer. (students explain and justify). Provide deeper understanding and other examples with the aim that students can distinguish each variable (meaningful context), explain the limitations of the problem to make it easier (problem simplification), and discuss systems of linear equations of two variables and practical solutions (negotiate meaning).

After being given Scaffolding, FI students were able to solve questions better than before. When solving problems, FI students can describe the components of the problem, respond to them with different strategies. FI students can set up a good solution strategy by converting the information into a system of two-variable linear equations and then using the elimination and substitution method to solve it. This shows that Scaffolding is effective in overcoming the misconceptions experienced by FI students. This is in line with several studies entitled (Syahnur & Tasman, 2023) Scaffolding Against Student Errors

in solving Mathematical Critical Thinking Problems" summarizes that scaffolding can help students eliminate mistakes made, improve understanding, and provoke students to think critically about the topic being tested. Then, a study (Nursanti, 2022) states that the application of scaffolding methods can improve learning outcomes and student understanding in learning Mathematics.

CONCLUSIONS AND SUGGESTIONS

Based on the research that has been done, classification misconceptions in problem-solving strategies occur among field-dependent students. Then, there is a classification misconception in determining the variables that arise in field-independent students. Level 2 Scaffolding (clarifying, revising and restructuring) is provided by paying attention to each of the misconceptions in the field-dependent and field-independent students. Based on the test results of the two-variable linear equation system after Scaffolding, the misconception can be overcome. Field-dependent students solve problems correctly but need to make inferences. Meanwhile, field-independent students solve the questions correctly and completely.

For teachers, it is better to plan lessons that emphasize understanding concepts first. In order to minimize the occurrence of misconceptions, teachers should provide training to understand a material so that students can understand the concept, not just memorize it. Researchers who want to conduct a study on Scaffolding to overcome misconceptions about cognitive style should be more careful in conducting cognitive style tests and provide scaffolding treatment to misconceptions and students' needs.

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