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Students' Cognitive Load in Understanding Linear Equation in One Variable

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ABSTRACT

Cognitive load is the mental effort made by students in their working memory to process information received. This study aims to describe the cognitive load of students in understanding linear equation in one variable material. The research method used is qualitative with a case study type of research. The research was conducted at a junior high school in Malang. The research subjects were two active students selected based on the recommendation of the mathematics teacher in the class. Data were collected through observation sheets, interviews, and student reflection sheets, then analyzed using data reduction, data presentation, and conclusion drawing techniques. The results showed that students experienced intrinsic, extraneous, and germane cognitive load. Intrinsic cognitive load occurred when faced with complex problems and story problems that required the processing of several concepts at once, such as equations, integer operations, distributive properties, and algebraic operations. Students experienced extraneous cognitive load because they did not have sufficient prerequisite knowledge due to the teacher providing apersepsi that did not help activate students' prior knowledge. Students misunderstood the definition of a linear equation in one variable and only memorized the rules for moving terms because the teacher used inappropriate terms in their explanation. Students were confused in understanding simple example questions because the teacher explained too quickly without giving students time to understand. Students' attention was divided because the teacher gave examples in the workbook, while the steps to solve the problems were written on the board. Students were unable to complete the exercises because the teacher did not pay attention to their understanding. Germane cognitive load occurred because students' understanding was procedural. This was because the teacher's learning strategy did not support the formation of knowledge schemas. These findings have implications for teachers to design learning that takes into account students' working memory capacity.

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A. INTRODUCTION

Cognitive load is the mental effort expended in working memory to process information received within a certain time interval (Chen et al., 2023; Sweller et al., 2019). Observing students' cognitive load is very important in learning because it is related to working memory capacity when processing information (Patel & Alismail, 2024). According to Ngu & Phan (2024) the adverse effects of high or excessive cognitive load on learning have been reported in various relatively complex cognitive domains such as mathematics. In line with the principles of cognitive load theory, which emphasizes the importance of managing the complexity of material according to students' abilities, reducing irrelevant cognitive load, and encouraging thinking activities that support the formation of knowledge schemas (Sweller et al., 2019). In this way, the learning process can take place more effectively and support students' deep conceptual understanding.

Cognitive load theory can be used to design learning based on knowledge of human cognitive architecture (Rahmawati et al., 2024). Cognitive load theory states that the strengths and limitations of human cognitive architecture originate from instructional design (Sweller, 2024). According to cognitive load theory, there are three types of cognitive load: intrinsic cognitive load, extraneous cognitive load, and germane cognitive load (Chen et al., 2023; Sweller et al., 2011). According to Artino (2008) intrinsic cognitive load is caused by the complexity of the material being studied and the students' expertise. According to Kalyuga (2011) extraneous cognitive load is caused by unnecessary instructional design by teachers. According to Plass et al. (2010) germane cognitive load is caused by students' cognitive resources to construct knowledge schemas. The quality of learning will improve if intrinsic cognitive load is managed effectively, extraneous cognitive load is minimized, and germane cognitive load is optimized (Chen et al., 2023; Sweller et al., 2011).

In mathematics learning, there is a thinking process, and in the thinking process, there is information processing. Information processing theory is a theory that explains the processing, storage, and retrieval of knowledge in a person's mind (Atkinson & Shiffrin, 1968). The components of information storage consist of sensory register, short-term memory, and long-term memory (Atkinson & Shiffrin, 1968). According to Kalyuga (2025) working memory is a cognitive workplace where information is consciously and deliberately processed and new knowledge is constructed. The processing of information in working memory is called cognitive load (Langerock et al., 2025).

In accordance with the independent curriculum, linear equation in one variable are one of the mathematics topics studied by students in junior high school, specifically in grade VII (Kemendikbudristek, 2022). A linear equation with one variable is a linear equation that only has one variable, which can be expressed in the form $ax = b$ wherea and $b \in \mathbb{R}, a \neq 0$. In the independent curriculum, the material on linear equations with one variable is included in the algebra category. According to Chen et al. (2023); Sweller et al. (2011) learning to solve algebraic equations is a task with a high level of interactivity because there are many elements that must be processed simultaneously. According to Ngu & Phan (2022) the complexity of an equation depends on the number of operational steps performed.

Previous research conducted by Zarkasyi et al. (2024) only described the general level of students' cognitive load based on the implementation of the Merdeka Curriculum, without exploring how each type of load arises in learning activities. Cognitive load research was also conducted by Pertiwi (2020) which only described students' cognitive load based on anxiety, without exploring the causes of cognitive load. Unlike these studies, this study examines in depth the sources and forms of students' cognitive load in learning. The novelty of this study lies in the analysis of the relationship between novice teachers' instructional design and students' cognitive load in understanding linear equation in one variable.

Cognitive load refers to the mental effort exerted by students to process and understand information during the learning process. This concept is related to the limitations of human working memory, which can affect students' understanding of the material. Based on this background, this study aims to describe the cognitive load experienced by students in understanding linear equation in one variable material. The focus of this study is on identifying the types of intrinsic, extraneous, and germane cognitive loads and the factors that cause them to arise during the learning process.

B. METHODS

This study uses a qualitative approach with a case study design. The purpose of this case study is to describe the cognitive load experienced by students in understanding linear equation in one Variable. This study was conducted at a junior high school in Malang with a total of 23 students. The subjects of this study were two active students selected based on the recommendation of the mathematics teacher in the class. Active students were chosen because they were easier to observe and tended to express their opinions and confusion, allowing the researcher to identify the cognitive load experienced by students. The two students were coded S1 and S2. In addition, this study also involved a novice teacher as a supporting informant to obtain data on instructional designs that could potentially cause cognitive load for students. The novice teacher had never participated in a teacher professional program (PPG), so they had limited teaching experience. This teacher was selected based on their limited teaching experience and suboptimal learning performance.

In this study, the researcher was the main instrument and data collector, assisted by one observer. The researcher observed mathematics learning in the classroom twice. In the first meeting, the teacher discussed the concept of equations, and in the second meeting, the teacher discussed mathematical modelling. The observation was conducted simultaneously by two observers who observed the learning activities at the same time. The results of the observations from both observers were then compared to see the level of conformity and consistency of the assessments. During the observation process, the researcher did not intervene or regulate the learning process, so that the results of the observations truly described the cognitive load of students in understanding the material on linear equation in one variable. The supporting instruments in this study included observation sheets, interview guidelines, and student reflection sheets provided by the teacher. The observation sheets and interview guidelines were validated by a mathematics lecturer at the State University of Malang. Data analysis refers to Miles et al. (2014) which includes data reduction, data presentation, and conclusion drawing. This study ensures data validity through triangulation techniques using data from observation sheets, student interviews, and student reflection results. The observation sheet was developed by referring to situations that have the potential to cause cognitive load during the learning process. The situations that cause cognitive load are presented in Table 1.

Table 1. Situations Causing Cognitive Load

Type of cognitive load	Situations causing cognitive load
Intrinsic	• Element interactivity
Extraneous	• Situations of inadequate prior knowledge • Redundancy situations • Transient situations • Split-attention situations • Advanced Learners Situations
Germane	• Imagination • Variable Example

Table 1 shows the situations that cause cognitive load in learning. Intrinsic cognitive load occurs when students process several concepts simultaneously, which is called element interactivity(Artino, 2008). Extraneous cognitive load is caused by the teacher's instructional design that burdens students in learning. These conditions are caused by several situations, such as inadequate prior knowledge situations, redundancy situations, transiency situations, split-attention situations, and advanced learner situations (Kalyuga, 2011). Germane cognitive load is related to students' efforts in constructing knowledge schemas through imagination and variable examples (Plass et al., 2010).

Each type of cognitive load is identified operationally through observation sheets developed based on situations that cause cognitive load. Intrinsic cognitive load is evident when students have difficulty understanding or connecting several concepts simultaneously. Extraneous cognitive load occurs as a result of inappropriate instructional design by teachers. Germane cognitive load is evident when students reflect, explain concepts, or connect ideas. The data from the observations, student interviews, and student reflections were then categorized into these three types of cognitive load according to the indicators that emerged.

C. RESULT AND DISCUSSION

During the learning process, the teacher used student worksheets (LKS) and PowerPoint (PPT) as supporting tools for learning activities. The learning process was carried out in three stages, namely introductory activities, core activities, and closing activities. During the research, the researcher obtained data on the cognitive load that arose in the learning of linear equation in one variable. The results of this study indicate the occurrence of intrinsic, extraneous, and germane cognitive load in the learning of linear equation in one variable.

The students' intrinsic cognitive load was evident in learning linear equations with one variable when students were faced with problems that required the integration of several concepts simultaneously, such as the concepts of equations, integer operations, distributive properties, and algebraic operations. This is in accordance with the element interactivity indicator, namely when solving complex problems in linear equations with one variable requires the processing of several elements of information simultaneously. Intrinsic cognitive load occurs when students must understand complex example problems given by the teacher. An example of this situation is shown in Figure 1.

$$-2(3x-5)+4=10-(x+6)$$

Figure 1. Example of a complex problem given by the teacher

In Figure 1, the problem is classified as complex because it involves more than one concept to solve it, requiring students to process several solution steps at once, which in cognitive load theory is referred to as element interactivity. Based on the observations, S1 appeared confused when faced with complex problems. When the teacher explained the problem on the board and described the steps to solve it, S1 stopped writing and stared at the problem for a long time. Meanwhile, S2 stared at his worksheet and then asked the teacher a question, as shown below.

Teacher : *Pay attention, let's solve what's inside the brackets first,* -2 *multiplied by* $3x - 5$ *gives* $-6x + 10$*. So, the equation is* $-6x + 10 + 4 = 10 - x - 6$*.*

S2 : *Why does the right side become* $10 - x - 6$*, Miss?*

Teacher : *Because the negative sign in front is also multiplied. Then combine like terms, so* $-5x = -10$*, and the final result is* $x = 2$

The question asked by S2 shows that S2 does not yet understand the application of the distributive property when there is a negative sign in front of the parentheses. This condition indicates that S2's understanding of the concept of distributive operations is still limited. Based on this situation, intrinsic cognitive load occurs because complex problems involving linear equation in one variable have a high level of interconnection between their elements. In learning, it is evident that students have not fully mastered the concepts of algebraic operations and the properties of equations. This makes it difficult for students to follow each step of the solution. As a result, students have difficulty understanding the questions and only follow the teacher's steps without understanding the purpose of each step of the solution. The intrinsic cognitive load of students in understanding linear equation in one variable material is also caused by story problems that involve several elements to be processed simultaneously. An example of a story problem is presented in Figure 2.

Budi membeli 4 bolpoin dan 3 penghapus. Harga 1 bolpoin adalah Rp2.500. Total belanja Budi adalah Rp17.500. Tentukan harga 1 penghapus.	Translation Budi bought 4 ballpoint pens and 3 erasers. The price of 1 ballpoint pen is Rp2,500. Budi's total purchase is Rp17,500. Determine the price of 1 eraser.

Figure 2. Example of a story problem given by the teacher

In Figure 2, the problem requires students to understand the content of the story correctly, i.e., to distinguish the information in the problem, and students also need to transform it into a mathematical model. The process of translating from a contextual form to an algebraic form requires complex cognitive processing because students need to process a lot of information simultaneously in their working memory. The question is categorized as complex because it requires students to analyze information and represent it in a mathematical model. In cognitive load theory, this condition is referred to as element interactivity. Based on the observation results, the teacher explained to the students how to solve the question, as presented below.

Teacher : *We convert the information from the question into an equation. For example, we express the price of one eraser as x, so* $4x\ 2500 + 3x = 17.500$*. After multiplying and moving the terms, we obtain* $3x = 7.500$*, then divide* 3*, so we obtain* $x = 2.500$*.*

In this situation, S1 and S2 appear confused and unable to follow the teacher's explanation. When the teacher explains the steps to solve the problem, the students do not respond to the teacher's explanation because they are unable to connect the verbal information with the mathematical representation. The students are only able to copy the steps to solve the problem as explained by the teacher. This intrinsic cognitive load arises because the story problem has a high level of interactivity. The extraneous cognitive load in understanding the material on linear equation in one variable was caused by the teacher's instructional design in learning. The teacher provided an aperception that actually confused the students by connecting the linear equation in one variable with algebraic forms. The aperception provided by the teacher burdened the students because it was still procedural in nature. Based on the observation results, S1 appeared confused by the apersepsi provided by the teacher, as seen from S1's questions to the teacher presented below.

Teacher : *Do you still remember algebraic forms? There are coefficients, variable, and constants. Well, PLSV is almost the same, but PLSV only has one variable and one exponent, for example, from the algebraic form* $2x^2 + 6y + 10$*, if PLSV* $2x + 6 = 10$*.*

S1 : *So, the difference is in the exponent and the number of variables, right, Miss?*

Teacher : *Correct. I will explain further in the definition of PLSV.*

The question asked by S1 shows that S1 is trying to understand the difference between algebraic forms and linear equation in one Variable, but this actually causes confusion. Meanwhile, S2 seems confused in understanding the teacher's explanation linking the concepts of algebraic forms and linear equation in one Variable. When the teacher explains the example on the blackboard, S2 looks at his friend and discusses it while pointing to his notebook. Based on this situation, there was extraneous cognitive load due to the teacher's apersepsi. Students had difficulty understanding the apersepsi conveyed by the teacher. This situation was categorized as an inadequate prior knowledge situation because students did not have sufficient prerequisite knowledge to understand the basic concepts before learning new material.

The extraneous cognitive load on students in understanding linear equation in one variable is further exacerbated by the teacher's use of inappropriate or redundant information. Teachers provide inaccurate information when defining linear equation in one variable. Teachers define that "a linear equation in one variable is an equation that contains only one letter." This condition has the potential to cause misconceptions, because students focus more on the letters used than on understanding the algebraic properties and actual structure of the equation. Based on the observation results, S1 appeared confused by the explanation given by the teacher. This situation was evident when S1 asked the teacher about the definition of a linear equation in one variable, as presented below.

Teacher : *PLSV is an equation that only contains one letter, for example x.*
S1 : *Besides the letters x, isn't it still a PLSV, Miss?*
Teacher : *What I mean is, a PLSV is an equation with one variable and a power of one, the variable can be x or another letter.*

In this situation, the teacher's statement about the definition of a linear equation with one variable shows an error in definition. Based on the dialogue between S1 and the teacher during the lesson, it appears that the teacher still associates the concept of a linear equation with one variable only with the use of certain letters, not with the structure of the equation. Meanwhile, S2 remained silent without showing any understanding. It appears that S2 only focused on writing down the definition given by the teacher. This indicates that the student followed the solution process mechanically without elaborating on the concept being studied.

Based on this situation, it indicates that the teacher's instructional design is still procedural. As a result, students misunderstand the concept, as if a linear equation in one variable is only determined by the letters used, not its mathematical structure. Incorrect definitions cause redundancy situations because the information provided by the teacher burdens the students' working memory. In addition, the teacher also provided inaccurate information or created redundancy situations in teaching linear equation in one variable. The teacher explained the example of solving problems using the concept of "moving terms" without explaining the mathematical reasoning behind the procedure. The teacher's use of the term "moving terms" caused confusion, especially for students who did not yet understand the concept of algebraic operations.

Based on the observation results, S1 was seen copying the steps of the solution explained by the teacher in the PowerPoint (PPT) slide without showing any understanding of the reasons behind each procedure performed. When the teacher asked again why the sign changed, S1 only replied briefly, "Because the number was moved, Ma'am." Meanwhile, S2 looked confused and asked the teacher as follows.

Teacher : *To solve the problem* $3x - 5 = 10$*, the number* 5 *is moved to the right side to become* $3x = 15$*, resulting in the solution* $x = 3$
S2 : *Why is the* -5 *added, Miss?*
Teacher : *Because when you move it to the other side, the sign changes.*

The dialogue between the teacher and S2 shows that the teacher only emphasized the "move to the other side" procedure without providing an explanation of the underlying concept. This situation shows the occurrence of extraneous cognitive load, because the information presented by the teacher focused on procedural aspects without reinforcing understanding of the basic concepts. Based on this situation, students are only directed to memorize procedural rules without understanding the conceptual reason that this step is actually the application of inverse operations to maintain the balance of the equation. As a result, students only memorize the "move the term" rule without understanding the mathematical reasoning behind it. This condition leads to misconceptions, because students can solve simple problems by following these rules, but they will have difficulty when faced with more complex problems or different forms. Both situations create extraneous cognitive load on students, because they must try to adjust between the procedural rules taught by the teacher and the mathematical concepts that should be understood. The extraneous cognitive load on students in learning linear equations with one variable is further exacerbated by teachers moving too quickly through the material. Teachers give examples of simple problem solving and then move on to complex examples. An example of a simple problem given by teachers is shown in Figure 3.

$$3x - 5 = 10$$

Figure 3. Simple examples given by the teacher

Based on the results of observations, teachers did not give students the opportunity to practice with similar problems, but instead immediately gave examples of solutions to more complex problems. As a result, students did not have enough time to understand the basic concepts before moving on to complex problems. Students who do not understand the basic steps in simple problems find it difficult to follow the procedures in complex example problems. This situation is categorized as a transiency situation, because the teacher explains simple problems without giving students the opportunity to practice. The complex problems given by the teacher are presented in Figure 4.

$$-2(3x-5)+4=10-(x+6)$$

Figure 4. Examples of complex problems given by the teacher

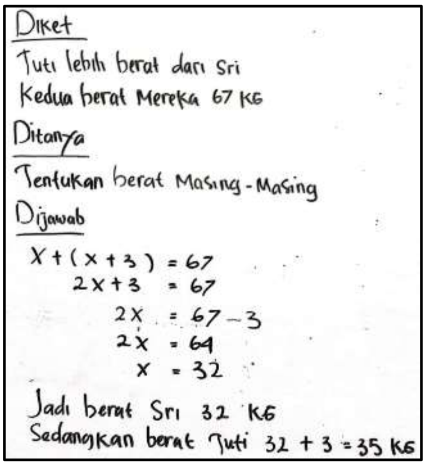
When the teacher explained the steps for solving complex problems, S1 looked at his friends and asked them about the steps for solving the complex example problem given by the teacher. S1 looked confused because he did not fully understand the steps for solving simple problems. Meanwhile, S2 was seen only copying the steps to solve the complex problem explained by the teacher without showing any understanding. S2 tended to only follow each step mechanically without understanding the meaning of each step. This condition occurred because the students did not have sufficient basic understanding to solve more complex problems. This situation showed that the learning strategy used by the teacher caused transiency situations, which occur when information is delivered too quickly before students understand the previous information.

The extraneous cognitive load in learning linear equation in one Variable is further caused by the way the teacher presents the problems and the steps for solving them in separate places. This situation is called split-attention situations. The load caused by the teacher forces students to shift their gaze, and they will rely on their short-term memory to remember the content of the problem when reading the steps to solve it. This creates an extraneous cognitive load that hinders students' understanding. When explaining, the teacher took an example question from the workbook, as shown in Figure 5.

2. Berat Tuti 3 kg lebih berat dari Sri. Jika jumlah berat mereka 67 kg, tentukan berat masing-masing.	Translation 2. Tuti weighs 3 kg more than Sri. If their combined weight is 67 kg, determine their individual weights.

Figure 5. Example of a problem in the workbook selected by the teacher

Then the teacher writes down the solution by looking at the question in the student workbook, but does not rewrite the question on the board. As shown in Figure 6.



Translation
Given
1. Tuti weighs more than Sri
2. Both weigh 67 kg
Question
Determine the weight of each person.
Answer
$x + (x + 3) = 67$
$2x + 3 = 67$
$2x = 67 - 3$
$2x = 64$
$x = 32$
So, Sri weighs 32 kg
While Tuti weighs $32 + 3 = 35$

Figure 6. Solution to the question worked out by the teacher on the blackboard

In this situation, S1 is seen going back and forth between looking at the workbook to remember the question and looking at the blackboard to see the solution steps. This shows that S1 is trying to connect the information from the question and the solution steps on the blackboard. Meanwhile, S2 focuses on copying the solution steps and does not look back at the question to understand the context of the calculation. This condition shows that S2 is not yet able to relate the solution steps to the meaning of the given problem.

This situation divided the students' attention because they had to shift their focus from the questions in the workbook to the solution steps on the blackboard. This situation shows that the teacher's instructional design was not efficient in presenting the questions and solution steps, so that students quickly forgot the details of the questions before understanding the solution steps. Extraneous cognitive load in the advanced learner situations aspect did not appear in the learning process because the teacher gave students a variety of practice questions. Students at the advanced learner level tended to feel challenged to solve various types of questions, so that they did not just repeat simple procedures but also tried to relate the concept of linear equation in one variable to more complex question contexts. The variety of questions given by the teacher is shown in Figure 7.

Translation

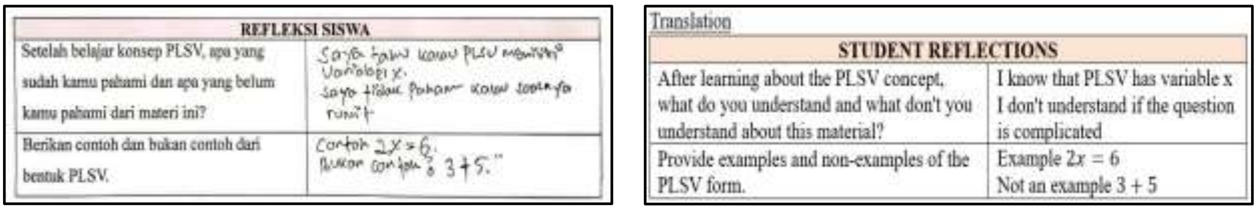
EXERCISE QUESTIONS

1. Determine the solution to the following equation.
   - $7 - 3x = -5$
   - $3(2x - 5) = 4x + 7$
2. If K is the solution to the equation $3(2x - 4) = 4(2x - 1) + 2$, What is the value $k + 3$?

Figure 7. Exercise questions given by the teacher

Based on classroom observations, S1 and S2 were unable to complete the questions given by the teacher. S1 and S2 only stared at the questions without attempting to answer them. This shows that S1 and S2 had difficulty understanding the questions and the concepts needed to complete them. The teacher then decided to assign the questions as homework. This situation shows that students do not yet have adequate cognitive readiness to solve more complex problems. The students are still accustomed to simple question patterns, so when faced with complex questions, they have difficulty determining the steps to solve them. This condition occurs because the teacher did not pay enough attention to the students' understanding when giving example questions. The teacher rushed to give examples of solving questions from simple to complex, so that the students could not gradually build their understanding to strengthen their knowledge schema.

The cognitive load was evident when the teacher asked students to fill out a reflection form after the lesson. The purpose of the reflection was to identify the extent to which S1 and S2 understood the material on linear equation in one variable. The results of the reflection in the first and second meetings showed that S1 and S2 were still limited to procedural aspects and did not yet demonstrate conceptual understanding. The results of the students' reflections in the first meeting are presented in Figure 8 and Figure 9.

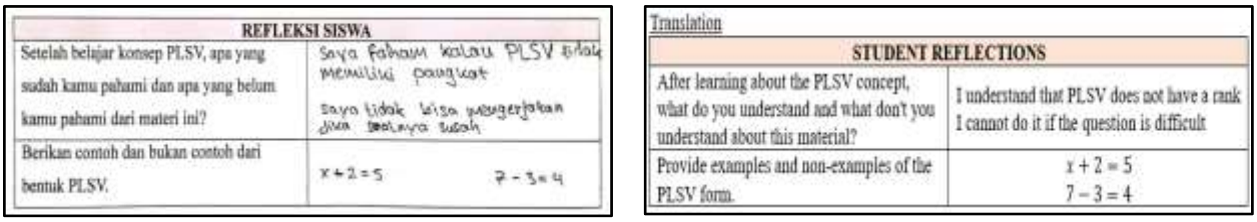


REFLEKSI SISWA	
Setelah belajar konsep PLSV, apa yang sudah kamu pahami dan apa yang belum kamu pahami dari materi ini?	Saya tahu kalau PLSV memiliki variabel x. Saya tidak paham kalau soalnya rumit
Berikan contoh dan bukan contoh dari bentuk PLSV.	Contoh 2x = 6. Bukan contoh : 3 + 5.

Translation

STUDENT REFLECTIONS	
After learning about the PLSV concept, what do you understand and what don't you understand about this material?	I know that PLSV has variable x I don't understand if the question is complicated
Provide examples and non-examples of the PLSV form.	Example $2x = 6$ Not an example $3 + 5$

Figure 8. Learning reflection results of S1 in meeting 1



REFLEKSI SISWA	
Setelah belajar konsep PLSV, apa yang sudah kamu pahami dan apa yang belum kamu pahami dari materi ini?	Saya faham kalau PLSV tidak memiliki pangkat Saya tidak bisa mengerjakan jika soalnya susah
Berikan contoh dan bukan contoh dari bentuk PLSV.	x + 2 = 5 7 − 3 = 4

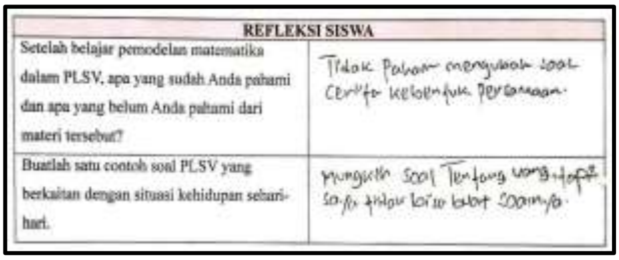
Translation

STUDENT REFLECTIONS	
After learning about the PLSV concept, what do you understand and what don't you understand about this material?	I understand that PLSV does not have a rank I cannot do it if the question is difficult
Provide examples and non-examples of the PLSV form.	$x + 2 = 5$ $7 - 3 = 4$

Figure 9. Learning reflection results of S2 in meeting 1

Based on the results of student reflections in the first meeting, S1 and S2's understanding of linear equation in one variable is still procedural. This procedural understanding can be seen from the way S1 and S2 answered the learning reflections in the first meeting. This can also be seen from the way the teacher presented the material and the steps for solving problems, which tended to emphasize procedure without providing conceptual understanding to students. As a result, S1 and S2 will focus more on following the sequence of steps mechanically and are not yet able to relate the concepts of linear equations with one variable.

This situation illustrates that the students' germane cognitive load is not developing optimally. In cognitive load theory, germane cognitive load is related to students' mental efforts to form new knowledge schemas. When learning only emphasizes procedures without giving students the opportunity to understand concepts, the schema construction process does not occur effectively. As a result, students are only able to understand the steps procedurally without building a deep conceptual understanding. The results of the S1 and S2 learning reflections in the second meeting are presented in Figure 10 and Figure 11.

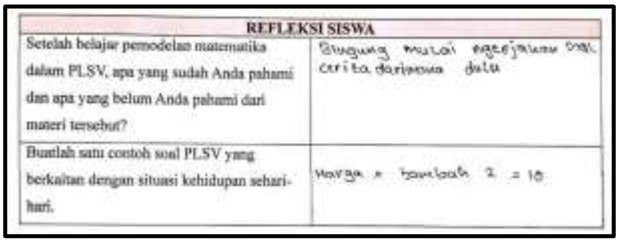


REFLEKSI SISWA	
Setelah belajar pemodelan matematika dalam PLSV, apa yang sudah Anda pahami dan apa yang belum Anda pahami dari materi tersebut?	Tidak paham mengubah soal cerita ke bentuk persamaan.
Buatlah satu contoh soal PLSV yang berkaitan dengan situasi kehidupan sehari-hari.	Mungkin soal tentang uang, tapi saya tidak bisa buat soalnya.

Translation

STUDENT REFLECTIONS	
After learning mathematical modeling in PLSV, what do you understand and what do you not understand from the material?	Don't understand how to convert the story into an equation
Create an example of a PLSV question related to everyday situations.	It might be about money, but I can't make the question

Figure 10. Learning reflection results of S1 in meeting 2



REFLEKSI SISWA	
Setelah belajar pemodelan matematika dalam PLSV, apa yang sudah Anda pahami dan apa yang belum Anda pahami dari materi tersebut?	Bingung mulai mengerjakan soal cerita darimana dulu
Buatlah satu contoh soal PLSV yang berkaitan dengan situasi kehidupan sehari-hari.	harga x tambah 2 = 10

Translation

STUDENT REFLECTIONS	
After learning mathematical modeling in PLSV, what do you understand and what do you not understand from the material?	Confused about where to start working on the story questions
Create an example of a PLSV question related to everyday situations.	Price x + 2 = 10

Figure 11. Learning reflection results of S2 in meeting 2

Based on the results of student reflections in the second meeting, S1 and S2's understanding of mathematical modelling in the form of linear equation in one variable was still very limited. S1 students had difficulty converting story problems into mathematical models, while S2 students had difficulty with the first step in solving story problems. In addition, S1 and S2 were also unable to provide examples of PLSV story problems. These difficulties indicate that the learning conducted by teachers is still procedural in nature, where students only follow the steps to solve problems without truly understanding the meaning of each process.

This situation illustrates that learning that emphasizes procedural aspects without reinforcing concepts cannot effectively build students' knowledge schemas. In cognitive load theory, this condition indicates that the germane cognitive load has not developed optimally, because S1 and S2 only copy and follow the teacher's steps without imagining how to understand the concept of linear equation in one variable. Based on the above explanation, students experience intrinsic cognitive load due to the complexity of the material being studied, extrinsic cognitive load due to learning designs that burden the learning process, and germane cognitive load that is not yet optimal because students are not yet able to build a deep conceptual understanding.

The students' intrinsic cognitive load occurs because the teacher provides complex example questions. According to Pharmer et al. (2021) task complexity affects intrinsic load; the more complex the task, the higher the load felt. Solving mathematical problems is a complex task that involves several different abilities that are essential in everyday situations (Kliziene et al., 2022). The lack of prior knowledge of S1 and S2 on prerequisite concepts causes intrinsic cognitive load in learning. This is in line with the findings of Endres et al. (2023) which explain that strong prior knowledge can reduce intrinsic cognitive load through established schemas.

Students with limited prerequisite knowledge must integrate several elements of information simultaneously. This condition increases the element of interactivity, which is a key feature of intrinsic cognitive load.

Students' intrinsic cognitive load occurs because teachers present example questions in the form of stories that require complex concept processing. Questions in the form of stories or contextual questions require analysis between pieces of information. These results are consistent with the research by Gupta & Zheng (2020) which confirms that story problems cause intrinsic cognitive load because they contain elements of information that interact with each other. Solving them requires several stages, so many elements are processed simultaneously in working memory. This representation process demands complex cognitive abilities, as S1 and S2 not only perform arithmetic calculations but also need to abstract from real-world contexts to mathematical symbols. According to Chen et al. (2023) intrinsic cognitive load is related to the complexity of the subject matter. The complexity of the material depends on students' prior knowledge.

Extraneous cognitive load occurs in learning due to the instructional design used by teachers in teaching. In learning linear equation in one variable, extraneous load occurs when teachers provide inappropriate apperception, so that the prior knowledge of S1 and S2 is not activated. Students with poor prior knowledge will have difficulty understanding new material (Dong et al., 2020). This extraneous cognitive load is evident when teachers directly provide apperception that actually burdens S1 and S2 in learning. This forces S1 and S2 to work hard to interpret information independently, which ultimately creates additional cognitive load that is not in line with the learning objectives. According to Alreshidi, (2023) teachers who provide inappropriate apperception will hinder the formation of students' knowledge schemas.

Students' extraneous cognitive load in learning linear equation in one variable arises due to redundancy situations, which occur when teachers present inappropriate information. The presentation of inappropriate material or unnecessary information actually reduces student learning outcomes (Gorbunova et al., 2023). The information presented by teachers in defining linear equation in one variable and the use of the concept of transposition causes extraneous cognitive load for S1 and S2 and does not support the formation of knowledge schemas. S1 and S2 only processed mechanical rules without understanding the mathematical meaning behind them. According to Ncube & Luneta (2025) learning that relies on solution procedures will result in superficial understanding.

Extraneous cognitive load in learning linear equation in one variable occurs due to transiency situations, which are conditions where teachers move on to new material too quickly without ensuring that S1 and S2 have understood the previous material. Excessive speed and a lack of gradual explanation by teachers will burden students (Zhu et al., 2024). From observations, this situation occurs when teachers only provide simple example questions and then immediately move on to more complex questions. This causes working memory capacity to be overloaded by ineffective dual processing. Information that is delivered quickly and only briefly tends to disappear before students have time to integrate it, thus overloading their working memory (Lin et al., 2022).

The extraneous cognitive load of students in learning linear equation in one variable material also arises when teachers present example questions and their solutions in separate places. This situation causes a divided attention effect, a condition in which S1 and S2 must divide their attention to connect two sources of information that are interrelated but presented separately. In line with the research by Guzmán & Zambrano (2024); Rafi'ah & Retnowati (2023) students' attention becomes divided when example problems and solution steps are presented in separate text and image formats, because they have to shift their focus from one source to another while remembering the previous information. This situation burdens working memory because S1 and S2 not only try to understand the concepts and solution procedures, but also have to integrate information from two different places. According to Lespiau & Tricot (2024) the extraneous cognitive load arising from the separate display format between questions and solutions will hinder the development of students' knowledge schemas.

The extraneous cognitive load experienced by students occurs in the learning of linear equation in one variable because S1 and S2 are unable to solve the problems given by the teacher. The teacher has tried to provide varied problems aimed at encouraging S1 and S2 to practice connecting the concept of linear equations with one variable in complex forms. However, the situation in the classroom was reversed, with S1 and S2 unable to solve the complex questions given by the teacher. The inability of S1 and S2 was influenced by the teacher's learning strategy, which was too fast in delivering the material. The results of this study are in line with the findings of Costley et al. (2021) which state that instructions that are unclear or not tailored to the students' pace result in an increase in extraneous cognitive load due to irrelevant or complex elements. According to Wang et al. (2022) the provision of complex questions must be balanced with a delivery method that takes into account student understanding.

The germane cognitive load of students in learning linear equation in one variable material is still not optimal because students' understanding is still procedural. This is due to the way teachers explain, which still emphasizes procedures without providing conceptual understanding. According to teachers directly provide procedures or problems with high complexity without first building basic concepts, students' conceptual understanding will be less than optimal. S1 and S2's understanding of linear equation in one Variable is limited to recognizing the form of the equation and following the steps provided by the teacher. S1 and S2 are still unable to connect the concept of equations to real-life situations, so students' cognitive efforts in building knowledge schemas have not developed optimally. According to Lenz et al. (2024) students may be able to complete procedures correctly, but this does not necessarily mean they have a deep conceptual understanding.

D. CONCLUSION AND SUGGESTIONS

This study aims to describe the cognitive load experienced by students in understanding linear equation in one variable material, which includes intrinsic, extraneous, and germane cognitive load. The findings of this study indicate that students experience intrinsic cognitive load when faced with complex problems that require S1 and S2 to process several concepts simultaneously, such as the concepts of equations, integer operations, distributive properties, and algebraic operations. Students' extraneous cognitive load is caused by instructional designs that burden S1 and S2 in learning, such as inappropriate apersepsi, use of inappropriate terms, too fast explanation tempo, separation of questions and solutions, and lack of attention to student understanding, including S1 and S2. Students' germane cognitive load occurs because the teacher's learning emphasizes procedures without reinforcing concepts, so that S1 and S2's understanding is procedural. These findings imply that teachers need to design instructional designs that support the formation of students' knowledge schemas. This study only describes the cognitive load of students in understanding linear equation in one variable material. For further research, the researcher suggests focusing on the application of learning based on cognitive load theory. Thus, subsequent research will not only describe the phenomenon but also offer practical solutions to improve the effectiveness of mathematics learning, especially in linear equation in one variable material.

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