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Learning Activities and Their Impact on Students' Understanding of Linear Equations in One Variable

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Abstract

Junior high school students often have difficulties in understanding linear equations in one variable (LEOV). Therefore, this research aimed to enhance junior high school students' understanding of LEOV by developing and implementing effective learning activities. The research was conducted as design research in three stages: preliminary design, teaching experiment, and retrospective analysis. The participants of the research were 50 seventh-grade students from two junior high schools in Bandung, Indonesia. The data collected from observations, interviews, and student worksheets were analyzed using triangulation to ensure the validity and reliability of the research. The research explored how the teacher explained LEOV in four meetings and how they contributed to students' understanding, where the first meeting dealt with open sentences, closed sentences, and the definition of LEOV from the context of distance and displacement, the second focused on solving LEOV from the context of two passing trains, and third focused on fractional LEOV from the context of jogging, and the fourth provided the students an opportunity to apply the LEOV concept from a dynamo-powered toy car simulation. The implication of the research is that teachers can significantly improve students' understanding of LEOV by implementing effective learning activities as identified here.

Keywords: Design Research, Learning Activities, Linear Equations in One Variable, STEM, Students' Understanding.

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INTRODUCTION

One of the mathematics materials studied by seventh-grade junior high school students is linear equations in one variable (LEOV). It is essential for students to master this material as it builds a strong foundation in algebra, enabling them to solve real-life problems and progress to more advanced mathematical concepts (Muhammad et al., 2025). In studying LEOV, students should have first studied algebra as a prerequisite. In this case, seventh graders are expected to be able to solve real-life problems using numerical and algebraic expressions and equations (Assadi & Hibi, 2022; Fauziah & Pandra, 2023). As students have already built familiarity with coefficients, variables, and constants through the algebra material, they can start learning LEOV from closed sentences, which are either true or false, and open sentences, which are sentences whose truth value is unknown. Introducing these two types of sentences at the beginning of LEOV learning will enable students to understand similarities and equations (Otten et al., 2020).

The researcher found several obstacles that seventh-grade junior high school students experience in learning LEOV. Students have difficulties finding solutions to LEOV problems as they lack sufficient understanding of the meaning of the LEOV form (Mengistie, 2020). They only remember the procedure for working on such problems as exemplified by the teacher. In other words, students' understanding

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of the LEOV material does not progress beyond the procedural level to the conceptual level (Rohimah et al., 2023). The teacher explains the material and gives examples of questions, while the students do exercises according to the procedure explained by the teacher. As a result, students only remember the procedure for solving questions that are provided as examples by the teacher (Kolar & Hodnik, 2021). It is this confinement of students' understanding only to the procedural level that leads to the obstacles or difficulties the students experience in solving LEOV problems (Birgin & Yazıcı, 2021). In addition, students' lack of understanding of variables and algebraic expressions leads to difficulties in completing mathematical operations related to algebra (Tafari et al., 2024; Yarman et al., 2024). To address this issue, the teacher should reorganize students' fundamental understanding of numbers and link it to students' algebraic understanding (Moyo & Machaba, 2021). Students should also be introduced to more diverse procedures that they can apply to develop problem-solving strategies (Putri et al., 2022).

Additionally, difficulties in solving LEOV word problems further complicate students' LEOV learning. These difficulties stem from students' lack of understanding of these story problems, making and completing mathematical models, and translating the variables obtained (Permaganti & Zanthy, 2023). This is because students do not understand the concept of variables, coefficients, and constants. Furthermore, the examples and practice questions provided by the teacher are limited in variety, preventing students from building a comprehensive understanding of the concept (Supianti et al., 2022). Likewise, the lack of knowledge of basic concepts and obstacles to bringing linear equations to real life add to factors inhibitory to learning and teaching algebra (Vollmuller et al., 2020; Namkung & Bricko, 2021).

Selecting relevant learning methods while considering the nature of the LEOV material is essential to building students' understanding in learning LEOV (Mengistie, 2020). Several studies have explored various teaching methods that teachers can use in teaching LEOV. One study used a balance scale to develop students' understanding (Otten et al., 2020), one combined a balance model and algebra tiles to improve learning achievement (Salifu, 2022), one made use of Android-based learning media to improve students' understanding (Prasetyo & Qohar, 2023), and one other utilized the Science, Technology, Engineering, and Mathematics (STEM) learning approach (Rohimah et al., 2022). The STEM approach, as explored by the last of the studies, is particularly advantageous for LEOV learning as it facilitates students' learning and helps students overcome learning barriers and apply the LEOV concept in everyday life (Rohimah et al., 2022).

The integration of STEM in LEOV learning is important to improve students' mathematical understanding and problem-solving abilities. STEM-based learning encourages students to explore mathematical concepts through real-world applications, thereby fostering deeper conceptual understanding than memorization does (Tonra et al., 2022). LEOV is a fundamental topic in algebra that plays an important role in various STEM fields, such as physics, engineering, and computer science, where equations are used to model and solve real-world problems (Nugroho & Septianisha, 2025). By utilizing the STEM approach, students can develop skills in mathematical modeling, critical thinking, and logical reasoning, which are important competencies in the 21st century (Suherman et al., 2021). Furthermore, hands-on STEM activities, such as engaging in technology-based simulations or engineering design challenges, can help students visualize abstract algebraic concepts and relate them to practical applications (Arlavinda & Anriani, 2022). This approach not only increases their engagement but also helps them overcome learning barriers by making mathematical concepts more real and relevant to their daily lives (Purniawan et al., 2022). Therefore, applying the STEM approach in LEOV learning can significantly improve students' understanding and application of algebraic principles, preparing them for more advanced mathematics learning and future STEM careers.

Based on the research background and previous research findings, the research questions posed in this study are:

1. How do teachers explain LEOV in junior high school classes?
2. How can learning activities with a STEM approach impact students' understanding of the LEOV concept?

Despite various studies addressing challenges in understanding linear equations in one variable (LEOV), notable gaps persist. Existing research often highlights students' procedural rather than conceptual understanding, impeding effective problem-solving (Chan et al., 2022). Although diverse methods like balance scales (Otten et al., 2020), a combination of a balance model and algebra tiles (Salifu, 2022), Android-based media (Prasetyo & Qohar, 2023), and STEM approaches have been proposed, comprehensive comparative analysis is scarce. Moreover, the application of the LEOV concept to real-life scenarios remains underexplored (Wicaksono et al., 2024). This research addresses these gaps by evaluating the impact of various learning activities on procedural and conceptual understanding, particularly within a single study framework. The novelty of this research lies in its holistic approach, combining multiple innovative learning activities and analyzing their comparative effectiveness on students' conceptual and procedural understanding of LEOV. The urgency of this study stems from the critical need to enhance mathematics education quality at the junior high school level, equipping students with robust problem-solving skills and a deeper understanding of fundamental mathematical concepts. Therefore, this study aimed to explain how learning activities on the LEOV material are to develop students' understanding abilities using the STEM learning approach.

METHODS

Research Type

This study was conducted as design research in three stages: preliminary design, teaching experiment, and retrospective analysis (Bakker, 2018). In the preliminary design stage, the researcher developed the initial design of a hypothetical learning trajectory (HLT) based on a literature review, discussions with experts, and teacher validation. In the teaching experiment stage, the researcher carried out teaching and learning activities in the classroom as well as observations during the learning process. In the retrospective analysis stage, the researcher reviewed how the learning process unfolded during the preceding stage and analyzed how teaching strategies and problem-solving approaches had contributed to students' understanding of LEOV.

Research Subjects

The subjects of this study consisted of 50 seventh-grade students from two junior high schools in Bandung, Indonesia. The indicators of students' understanding in this study comprised indicators of conceptual understanding and indicators of procedural understanding. The indicators of conceptual understanding in this study were 1) being able to describe mathematical situations in different ways and 2) being able to understand situations from different perspectives (Schoenfeld, 2007). Meanwhile, the indicators of procedural understanding in this study were 1) being able to remember, choose, and apply the correct formula, 2) being able to calculate accurately, and 3) being able to use algorithms accurately (McCallum, 2007).

Data Collection

The data in this study were collected from observations, interviews, and document review. Observations involved video recordings of the learning process in the classroom and the course of student small-group discussions, interviews were conducted with students to explore the extent to which they understood the subject matter, and document review was conducted on student worksheet answers (Morgan, 2022).

Data Analysis

Data was analyzed through several stages, including data reduction. Video analysis of the learning process and student interactions in the classroom focused on the structure of students' thinking and how it related to the concepts conveyed by the teacher. The results of this analysis are presented using a narrative method. Triangulation was carried out during the data analysis, that is by checking the data from observations, interviews, and document review to ensure the validity and reliability of the study (Khoa et al., 2023).

RESULTS AND DISCUSSION

Overall, the learning process was conducted in four meetings. The first meeting introduced open sentences, closed sentences, and the definition of LEOV, the second and third meetings concerned solving LEOV and fractional LEOV problems, respectively, and the fourth meeting allowed the students to apply the concept of LEOV. Details of the development of the learning design in this study are explained by stage as follows.

Preliminary Design

The preliminary design took the form of an HLT, derived from a literature review and discussions with the teachers and experts. The HLT developed covered the learning objectives, learning activities, descriptions of the learning activities, and students' thinking conjectures in four meetings. On the grounds of structured pedagogical considerations, the instruction on LEOV was set to last for four meetings to ensure comprehensive understanding and retention of the material, aligning with recent research findings on effective mathematics instruction strategies (Kesumawati et al., 2024). The first meeting introduced foundational concepts such as open sentences, closed sentences, and the definition of LEOV, which are crucial for understanding more complex topics. The second meeting focused on solving basic LEOV problems, enabling students to develop essential problem-solving skills (Hikmah et al., 2021). The third meeting progressed to solving fractional LEOV problems, gradually increasing the complexity to reinforce students' abilities (Kranz et al., 2023). Finally, the fourth meeting involved the application of LEOV concepts in real-world contexts, helping students connect their mathematical knowledge to everyday situations, thereby enhancing their engagement and understanding (Nusantara et al., 2021; Duyen & Loc, 2022; Nusantara et al., 2024). The HLT developed was validated by the teachers and experts before being implemented in the teaching experiment stage.

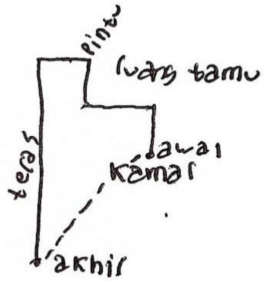
Teaching Experiment

At this stage, the learning activities designed in the HLT were integrated into the learning process. The researcher observed and analyzed the implementation of the learning activities according to the concept taught and how they impacted the students' understanding.

The 1st Meeting: Open Sentences, Closed Sentences, and the Definiton of LEOV

The learning objective of the first meeting was for students to be able to determine closed sentences and open sentences and write down the definitions of closed sentences, open sentences, and LEOV correctly following a simulation of the concept of motion at their homes respectively. The activities for this meeting are detailed in Table 1.

Table 1. The learning process on the introduction to LEOV

<table>
<tr><th>Activities</th><th>Concept</th><th>Impact</th></tr>
<tr>
<td>Students practiced measuring distances and displacements at home.

</td>
<td>Distinguishing examples of closed sentences and open sentences by context: distance and displacement.</td>
<td>Being able to understand situations from different perspectives</td>
</tr>
<tr>
<td>Students wrote down examples of open sentences and closed sentences based on the results of distance and closing measurements.
<table>
<tr><th>No. / Jenis Kalimat</th><th colspan="2">Kalimat Tertutup</th><th rowspan="2">Kalimat Terbuka</th></tr>
<tr><th></th><th>Kalimat Benar</th><th>Kalimat Salah</th></tr>
<tr><td>1</td><td>2 + 2 : 4</td><td>10 - 4 : 3</td><td>5y + 2 = 12</td></tr>
<tr><td>2</td><td>1 Kg : 1000 gram</td><td>8 × 3 : 12</td><td>3a + 2 : 11</td></tr>
<tr><td>3</td><td>1 + 1 : 2</td><td>1 Kg kapas lebih ringan dari 1 Kg batu</td><td>y - 4 : 6</td></tr>
</table>
English version:
<table>
<tr><th>No. / Type</th><th colspan="2">Closed sentence</th><th rowspan="2">Open sentence</th></tr>
<tr><th></th><th>True sentence</th><th>False sentence</th></tr>
<tr><td>1</td><td>$2 + 2 = 4$</td><td>$10 - 4 = 3$</td><td>$5y + 2 = 12$</td></tr>
<tr><td>2</td><td>1 kg = 1000 grams</td><td>$8 \times 3 = 12$</td><td>$3a + 2 = 11$</td></tr>
<tr><td>3</td><td></td><td>1 kg of cotton is lighter than 1 kg of stone</td><td>$y - 4 = 6$</td></tr>
</table></td>
<td>

Understanding the concept of open sentences and closed sentences based on the results of distance and displacement measurements.
Writing down the definitions of closed sentences and open sentences.

Kalimat Tertutup adalah Kalimat yang sudah diketahui nilai benar atau salahnya (nilai Kebenarannya)
Kalimat benar adalah Kalimat yang bernilai benar
Kalimat salah adalah Kalimat yang bernilai Salah
Kalimat terbuka adalah Kalimat yang belum diketahui nilai Kebenarannya (benar atau salah)
English version:
A closed sentence is a sentence for which the truth value (true or false) is already known.
A true sentence is a sentence that has a true value.
A false sentence is a sentence that has a false value.
An open sentence is a sentence whose truth value (true or false) is not yet known.
</td>
<td>Being able to describe mathematical situations in different ways</td>
</tr>
<tr>
<td>Students chose one example of an open sentence with one variable of the first degree and related it with an equal sign.
Berdasarkan pengertian kalimat terbuka di atas, coba tuliskanlah dua kalimat terbuka yang memiliki satu variabel berpangkat satu dan dihubungkan dengan tanda sama dengan!
1. x + 5 : 8
2. 3a + 2 = 11</td>
<td>

Understanding the concept of LEOV from an open sentence that has one variable raised to the first power and is related with an equal sign.
Write down the definition of a linear equation in one variable.

</td>
<td></td>
</tr>
</table>

Activities	Concept	Impact
English version: Based on the definition of an open sentence above, try writing two open sentences that have one variable to the power of one and relate to an equal sign! 1. $x + 5 = 8$ 2. $3a + 2 = 11$	Persamaan linear satu variabel adalah Kalimat terbuka yang memuat tanda sama dengan (=) dan hanya memuat satu variabel dengan Pangkat satu. **English version:** A linear equation in one variable is an open sentence that contains an equal sign (=) and only contains one variable with a power of one.	

Table 1 shows the learning process in which LEOV was introduced to the students. The activity in this meeting involved measuring distances and displacements around each student's home. The paths that the students took could form a triangle, circle, or semicircle, resulting in a difference between the length of the distance traveled and the displacement. Students could also take a straight path in which case the length of distance and the displacement were the same. The teacher directed students to discuss various measurement results and express views to one another, leading to the conclusion that distance and displacement have different definitions. The difference in distance and displacement measurements served as the starting point for studying sentences in mathematics. Below is an excerpt from an interview with a student who created a triangular path in the distance and displacement simulation.

Teacher : *How did you determine the distance from the bedroom to the front yard?*
Student 1 : *I walked from the bedroom to the living room and turned toward the front yard.*
Teacher : *Then, how did you determine the displacement from the bedroom to the front yard?*
Student 1 : *I drew a path that goes from the starting point (bedroom) to the ending point (front yard). Then, I drew a straight line from the starting point to the ending point to measure the displacement.*

From the interview excerpt, it is evident that the student understood the distinction between distance and displacement. The student correctly identified that distance is measured along the actual path taken, while displacement is the straight-line measurement from the starting point to the endpoint. Furthermore, the student's response indicated an awareness that distance and displacement are not always different, as their relationship depends on the shape of the path taken.

Through these activities, students determined true and false sentences on distance and displacement. Furthermore, they connected the concept of variables with the open sentences they encountered in this material. They were able to explain the definitions of true sentences, false sentences, and open sentences, where both true sentences and false sentences are closed sentences. They wrote examples of closed sentences, including true sentences and false sentences, and open sentences from the simulation activity that they did in relation to distance, displacement, and travel time. Those who already understood the differences between these sentences were given examples of general sentences, not only based on their measurements or the simulation that they had carried out to ensure that they understood the material and could generalize it universally.

Students indicated their understanding of the definition of a linear equation in one variable by choosing an open sentence on the teacher's order. When there were no more open sentences they could choose, the students were directed by the teacher to conduct a class discussion to define a linear equation in one variable. At the end of the lesson, the students were given open sentences that they had to change into true sentences. This was to ensure whether the students understood the definition of an open sentence with a variable of the first degree, which is called a linear equation in one variable.

The 2nd Meeting: Solving LEOV Problems

The learning objective of the second meeting was for students to be able to solve LEOV problems correctly. In this meeting, students were given a problem in the context of trains passing each other. The activities for this meeting are detailed in Table 2.

Table 2. The learning process on solving LEOV problems

Activities	Concept	Impact
Students solve simple LEOV problems by substitution. Tentukanlah nilai dari variabel-variabel di bawah ini! 1. $8+4=x+5$ 2. $7-y=6-4$ 3. $20=a-5$ 4. $73+56=71+b$ 5. $534+175=174+c$ Jawaban : 1. $x=7$ 2. $y=5$ 3. $a=25$ 4. $b=58$ 5. $c=535$	Solving LEOV problems by substitution to keep a balance between the left and right sides of the equations.	Being able to remember, choose, and apply the correct formula.
Students understood how to solve a LEOV problem using the velocity formula. $Jarak = Kecepatan\ relatif \times waktu$ $180\ km = 200\ km/Jam \times t$ $t = \frac{180}{200}$ $t = 0{,}9$ Jam 0,9 Jam × 60 Menit = 54 menit Waktu berpapasan = 07.15 + 54 Menit = 08.09 **English version:** $\text{Distance} = \text{relative velocity} \times \text{time}$ $180\ \text{km} = 200\frac{\text{km}}{\text{h}} \times \text{t}$ $\text{t} = \frac{180}{200}$ $\text{t} = 0.9\ \text{h}$ $0.9\ \text{h} \times 60\ \text{minutes} = 54\ \text{minutes}$ $\text{Time ofmeeting} = 07{:}15 + 54\ \text{minutes} = 08.09$	Introducing the solution to a LEOV problem in the context of two trains passing each other	• Being able to calculate accurately • Being able to use algorithms accurately

Activities	Concept	Impact
Students solved a LEOV problem by adding or subtracting both sides with the same number and/or multiplying or dividing both sides with the same number. $345 + 576 = 342 + 574 + d$ $921 = 916 + d$ $-d = 916 - 921$ $-d = -5$ $d = 5$	Solving a LEOV problem by performing arithmetic operations on both sides to keep the equation balanced.	

Table 2 provides details on the learning process in the second meeting, which focuses on solving LEOV problems. The first activity was solving simple LEOV problems by substitution, with the aim for the students to be able to remember, choose, and apply the correct formula. The next activity was aimed for students' understanding of how to solve a LEOV problem in the context of two passing trains. Students wrote down their observations based on the data available in the question. Students could also watch videos of trains passing each other at the links listed on their worksheet. This assignment formed the basis for students to create mathematical models from questions given by the teacher. An interview with one student revealed that the problem was closely related to his own personal experience seeing two trains passing each other.

Teacher : *Do you know how to calculate the time the trains would meet?*
Student 2 : *Sure, ma'am. We calculate using (the) relative velocity (formula).*

The interview excerpt above demonstrates that the student could connect his real-world experience with a mathematical concept, in this case the concept of relative velocity and its application to LEOV problem-solving. The student initially relied on intuition to determine the factors that should be included in calculating the time of meeting of the two passing trains, showing an understanding of velocity and distance. Through guided questioning, the student recognized the role of relative velocity and successfully used the correct approach to solve the problem.

The process of writing observations and constructing a mathematical model further reinforced students' comprehension. Students wrote down their observations and calculated the relative velocity of the two trains. They could generate a mathematical model of the LEOV problem using the formula for relative velocity, distance, and time. They could determine the time of meeting of the two trains by dividing the distance by the relative velocity. Some students solved the problem formally, while some others informally. During the class discussion, it was found that the solutions of some students could serve as examples of formal problem-solving.

The 3rd Meeting: Solving Fractional LEOV Problems

The learning objective of the third meeting was for students to solve fractional LEOV problems correctly using jogging as context. The meeting started with the teacher asking students to recall how to solve LEOV problems in the previous meeting as solving fractional LEOV problems is not much different from it, with a little more emphasis on solving operations in fractional forms in algebra. The activities involved in achieving this learning objective in this meeting are detailed in Table 3.

Table 3. The learning process on solving fractional LEOV problems

Activities	Concept	Impact
Students used the concept of velocity to calculate the distance travelled along a jogging track. $\frac{19-x}{8} + \frac{x}{11} = 2$ $\left(\frac{19-x}{8} + \frac{x}{11}\right) \times 88 = (2) \times 88$ $(19-x)\,11 + (x)\,8 = 176$ $209 - 11x + 8x = 176$ $-3x = 176 - 209$ $-3x = -33$ $x = \frac{33}{-3} = x = 11$ Jadi, Jarak yang ditempuh Andi Pada bagian kedua joggingnya adalah 11 km	Introducing fractional LEOV using jogging as context.	• Being able to calculate accurately • Being able to use algorithms accurately
Students solved the LEOV problem by adding or subtracting the two sides with the same fraction and/or multiplying or dividing the two sides with the same fraction. $\frac{2a+1}{3} - \frac{3a+4}{2} = 5$ $6 \times \left(\frac{2a+1}{3} - \frac{3a+4}{2}\right) = 5 \times 6$ $2(2a+1) - 3(3a+4) = 30$ $4a + 2 - 9a - 12 = 30$ $4a - 9a = 30 + 12 - 2$ $-5a = 40$ $a = \frac{40}{-5}$ $a = -8$	Solving fractional LEOV by performing arithmetic operations on both sides to keep the equation balanced.	

Table 3 provides details on the learning process in the third meeting, which focused on solving fractional LEOV. The first activity involved calculating the distance travelled along a jogging track to establish a fractional LEOV model. The students' thinking process is illustrated by the following interview excerpt with a student.

Teacher : *How did you get the equation* $\frac{(19-x)}{8}+\frac{x}{11}=2$?

Student 3 : *Let's say the length of the second track is x, so the first track is the total distance minus x. Each distance is divided by the velocity. The result is the total jogging time.*

The interview excerpt illustrates the student's structured thinking process in solving a LEOV with fractions. The student began by identifying and organizing the known values, such as velocity, distance, and total jogging time, which served as the basis for constructing a mathematical model. By defining a variable and setting up fractional expressions, the student demonstrated an understanding of how to represent real-world situations mathematically. To solve the equation, the student applied the least common multiple (LCM) to eliminate fractions, showing proficiency in algebraic manipulation.

Different students approached the problem in different ways, such as by operating on algebraic fractions first. This diversity fostered the class discussion that was facilitated by the teacher. Through this discussion, students explored multiple formal strategies for solving fractional LEOV problems, reinforcing both conceptual understanding and procedural fluency. The teacher directed students to find several formal ways to solve the fractional LEOV problems.

The 4th Meeting: Application of the LEOV Concept

The learning objective of the fourth meeting was for students to be able to apply the LEOV concept in combination with the concept of uniform, straight motion through a simulation using a dynamo-powered toy car. Students were expected to be able to use the LEOV concept to solve problems related to everyday events. At the outset of the meeting, the teacher reminded students about the definition of LEOV and how to solve LEOV and fractional LEOV to connect their previous knowledge, which they would apply in this meeting. The learning activities to achieve the learning objective of the fourth meeting are detailed in Table 4.

Table 4. The learning process with the application of the LEOV concept

Activities	Concept	Impact
• Students performed a simulation using a dynamo-powered toy car.  • Students wrote down the simulation results, including the distance, time, and velocity.	Applying LEOV in context: uniform, straight motion in a dynamo-powered toy car simulation.	Being able to describe mathematical situations in different ways.

Activities	Concept	Impact

Tabel Pengamatan Hasil Percobaan *Dynamo-Powered Toy Car*

Titik ke-	Jarak	Waktu	Kecepatan
1	0,6 m	1,1 detik	0,5
2	1,2 m	2,4 detik	0,5
3	1,8 m	3,6 detik	0,5
4	2,4 m	4,1 detik	0,5
5	3 m	5,3 detik	0,5

In this activity, students were expected to understand the problem by analyzing the relationship between distance, time, and velocity using the fundamental formula:

$$\boldsymbol{v = \frac{s}{t}}$$

Where:

$\boldsymbol{v = velocity}$
$\boldsymbol{s = distance}$
$\boldsymbol{t = time}$

Based on the table, students could verify the velocity by dividing the given distance by the corresponding time at each observation point. For example, at Point 1 the velocity was calculated as

$$\boldsymbol{v = \frac{0,6\ m}{1,1\ s} \approx 0,5\ m/s}$$

The calculated velocity after applying this formula to all data points remains approximately 0.5 m/s, showing uniform motion. By solving this problem, students could understand that if an object moves with a constant velocity, the ratio of distance to time remains the same. The students concluded that the dynamo-powered toy car moved with a constant velocity, underscoring their understanding of the linear relationship between distance, time, and velocity.

- Students discovered the LEOV concept from the results of a dynamo-powered toy car simulation.

Apakah persamaan pada grafik di atas merupakan persamaan linear satu variabel? Mengapa?

x – 0,5 = 0 / karena terdapat satu variabel yaitu x dan berpangkat 1, juga dihubungkan dengan tanda sama dengan (=)

English version:

Is the equation in the graph above a linear equation in one variable? Why?
$x - 0.5 = 0$ / Because there is one variable, namely x, and it is of the first degree. It is also connected with an equal sign (=).

Students solved other LEOV problems.	Applying the LEOV concept in solving other problems.	Being able to use algorithms accurately.

Activities	Concept	Impact
X = banyak finalis terbaik banyak finalis sisanya $= 63 - x$ Persamaan linearnya berarti: $100.000\ x + 25.000\ (63 - x) = 3.000.000$ $100.000\ x + 1.575.000 - 25.000x = 3.000.000$ $75.000\ x + 1.575.000 = 3.000.000$ $75.000\ x + 1.575.000 - 1.575.000 = 3.000.000 - 1.575.000$ $75.000\ x = 1.425.000$ $75.000\ x : 75.000 = 1.425.000 : 75.000$ $x = 19$ Jadi akan ada 19 finalis yang akan mendapatkan uang Rp. 100.000		

Table 4 provides details on the learning process in the fourth meeting, which involved the application of the LEOV concept. In this meeting, students conducted a simulation with a dynamo-powered toy car to understand the application of the LEOV concept, including elements such as velocity, distance, and time. Below is an excerpt of an interview with one of the students regarding the activity in the fourth meeting.

Teacher : *How did you prepare this dynamo-powered toy car experiment?*
Student 4 : *My friends and I first assembled the dynamo-powered toy car, ma'am. Then, we started to try it out.*
Teacher : *How did you divide the tasks in doing the experiment?*
Student 4 : *I operated the stopwatch to record the time. My friend held a dynamo-powered toy car. My other friend observed the distance. Then, we wrote the results on the worksheet.*
Teacher : *How could your friend observe the distance traveled by the dynamo-powered toy car?*
Student 4 : *We stretched out a meter and marked it at the same distance along the dynamo-powered toy car track, so that the distance traveled could be seen from the meter.*

The interview excerpt highlights the structured approach the students took in conducting the dynamo-powered car experiment and their ability to apply mathematical concepts to real-world scenarios. Through teamwork, they efficiently divided tasks among themselves, ensuring accurate data collection on time and distance. By systematically recording observations in an observation table, marking distances, and measuring time, students built a strong foundation for analyzing motion. They then translated their experimental results into coordinate points, plotted them on a Cartesian diagram, and derived the equation of a linear graph. Students They discovered can find that the graph that they created is a form of a linear equation of in one variable. Therefore, they concluded that the dynamo-powered toy car experiment is one of the applications of the LEOV concept can be found in the dynamo powered car experiment that students have conducted.

Retrospective Analysis

The data of teaching and learning activities obtained from observations during the teaching experiment were analyzed to be adjusted to the assumptions and learning trajectories that had been developed and to figure out the contribution of the teaching and learning activities to student understanding. The results of the analysis showed that student responses were in accordance with the assumptions and learning trajectories that had been developed and that each activity contributed to student understanding. These results are described in more detail as follows.

In the first meeting, based on previous research and teachers' experiences in schools, the researcher expected that when students were involved in an activity, in this case measuring the distance traveled and displacement made during a walk, they would gain a stronger understanding of the material (Vollmuller et al., 2020). Students took a walk, drew the walking route they took, and wrote down the distance, displacement, and travel time of the walk, which were then described as the results of the teaching experiment. These activities were found to have an impact on students' understanding, as shown by the achievement of the indicators "*being able to describe mathematical situations in different ways*" and "*being able to understand situations from different perspectives*".

The second meeting began with the teacher posing a problem that makes sense in a real-world context to enable students to calculate and estimate in authentic situations (Muhammad et al., 2025; Nusantara et al., 2024). In this case, students worked on a problem of two trains passing one another and then recorded the velocity of each train, the distance, and the departure time of each train. After that, students determined the time at which the two trains pass one another using the relative velocity formula. Some students solve LEOV problems formally, and some others informally. When faced with real-world LEOV problems, students, using their experiences, will find various ways to solve them (Fauziah & Pandra, 2023; Hikmah et al., 2021). The problem-solving methods used will bridge students' thinking processes from arithmetic to algebra (Supianti et al., 2022). Developing students' understanding from the informal to the formal will make learning meaningful for students (Duyen & Loc, 2022). In the second meeting, students were posed with a problem related to contextual algebra to facilitate their math processes (Tafari et al., 2024). The activities involved in the second meeting were found to have an impact on students' procedural understanding, as shown by the achievement of the indicators "*being able to remember, choose, and apply the correct formula*", "*being able to calculate accurately*", and "*being able to use algorithms accurately*".

The learning objective of the third meeting was achieved by presenting a narrative of a real-life problem that arises naturally as an opportunity for students to solve a substandard problem in the context of a written procedure (Kolar & Hodnik, 2021). In this meeting students worked on a jogging problem presented through the student worksheet, in which they were asked to write down the velocity, distance traveled, and total travel time and then determine the length of the jogging track using the velocity formula. The conclusion from student activities in the third meeting was that students solved a fractional

LEOV problem by multiplying by the least common multiple (LCM) or completing the fractional operations first. The difficulties in solving this kind of a problem were in performing the fractional operations and discerning the fractional LEOV structure. The activities in the third meeting were found to have an impact on procedural understanding, as shown by the achievement of the indicators "*being able to calculate accurately*" and "*being able to use algorithms accurately*".

In the fourth meeting, the learning objective was for students to be able to apply the LEOV concept to everyday life through a simulation using a dynamo-powered toy car. This activity was carried out to develop an informal activity model through local changes to a more formal activity model (Putri et al., 2022). Students applied the LEOV concept through the dynamo-powered toy car experiment, writing down the distance travel, travel time, and velocity of the toy car during the simulation. Next, students drew a linear graph of the relationship between distance and velocity. As the graph that they drew was a linear graph with one variable, students could conclude that the simulation that they had been working on was one of the applications of the LEOV concept. The activities in the fourth meeting were found to have an impact on conceptual understanding, as shown by the achievement of the indicator "*being able to describe mathematical situations in different ways*", and on procedural understanding, as shown by the achievement of the indicator "*being able to use algorithm accurately*".

The limitation of this research is its focus on a specific classroom setting, which may have limited the generalizability of the findings to other learning environments with different student backgrounds, teaching styles, and school resources. The use of real-world activities to facilitate student understanding was beneficial, but individual differences in prior knowledge and problem-solving abilities may have affected how students engaged with and benefited from these activities. Finally, while the study highlights students' problem-solving processes, it does not fully explore the role of factors such as peer influence, teacher intervention, or students' personal motivation, which could significantly impact students' learning experiences.

CONCLUSION

Based on the analysis of the learning process in the classroom, the teacher was able to teach the LEOV concept clearly during four meetings. In the first meeting, students were learning about open sentences, closed sentences, and the definition of LEOV. The first activity in the first meeting was measuring distance and displacement, which impacted on the students' ability to understand situations from different perspectives. The next activity was writing examples of open sentences and closed sentences and choosing one example of an open sentence with one variable of the first degree and relating it with an equal sign. This activity had an impact on the students' ability to describe mathematical situations in different ways. Finally, students engaged in an activity where they solved simple LEOV problems by substitution, which impacted their ability to remember, choose, and apply the correct formula. In the second and third meetings, students focused on solving LEOV and fractional

LEOV problems in context, by adding or subtracting or by multiplying or dividing both sides of the equations by the same number or fraction. These activities had an impact on the students’ ability to calculate and use algorithms accurately. In the fourth meeting, students engaged in a simulation with a dynamo-powered toy car. This activity impacted on their ability to describe mathematical situations in different ways. Students also solved additional LEOV problems, which reinforced their ability to use algorithms accurately. Conveying the LEOV concept using a real-world context with the STEM approach, as was the case in this study, could significantly affect students' comprehensive understanding.

This study was limited by its focus on a specific classroom setting, which might have affected the generalizability of the findings to different learning environments. Variations in students' prior knowledge and problem-solving abilities could also influence how they engaged with real-world activities. Additionally, factors such as peer influence, teacher intervention, and student motivation were not fully explored, although they might significantly impact the learning outcomes. Future research is suggested to use larger populations with different school characteristics. It is also suggested for future research to consider diverse classroom settings, account for individual learning differences, and examine the role of external influences in shaping students' understanding of mathematical concepts.

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