Journal of Authentic Research on Mathematics Education
Volume 7, No. 2, July 2025
https://doi.org/10.37058/jarme.v7i2.9443 e-ISSN 2655-7762

# A REALISTIC APPROACH TO TEACHING ALGEBRAIC OPERATIONS TO JUNIOR HIGH SCHOOL STUDENTS

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**ARTICLE INFO**

**Article history**
Received: 12.16.2023
Revised: 01.02.2025
Accepted: 07.20.2025

**Keywords**
Operasi Aljabar, PMRI.

**ABSTRACT**

Operasi penjumlahan dan pengurangan bentuk aljabar merupakan salah satu materi penting dalam pembelajaran aljabar. Pada kenyataannya, masih banyak siswa mengalami kesulitan dalam belajar penjumlahan dan pengurangan aljabar disebabkan pembelajaran didominasi cara-cara formal sehingga hal ini tidak mendukung pemahaman siswa tentang konsep penjumlahan dan pengurangan bentuk aljabar. Oleh karena itu, diperlukan aktivitas belajar yang menekankan pada pemahaman konsep. Peneliti merancang aktivitas pembelajaran operasi penjumlahan dan pengurangan dengan menggunakan pendekatan PMRI. Penelitian ini bertujuan untuk memberikan kontribusi berupa hypothetical Learning Trajectory (HLT) tentang materi operasi penjumlahan dan pengurangan bentuk aljabar dengan menggunakan pendekatan PMRI. Subjek pada penelitian ini yaitu seluruh siswa kelas VIII SMP Negeri 29 Kerinci yang terdiri dari 15 siswa. Penelitian ini menggunakan metode penelitian desain research. Data dikumpulkan melalui lembar aktrivitas siswa (LAS), observasi, dokumentasi dan wawancara. Data yang telah dikumpulkan, dianalisis dengan cara yang meliputi mereduksi, menampilkan, dan menyimpulkan data. Hasil penelitian menunjukkan bahwa dengan adanya kontribusi berupa HLT tentang materi operasi penjumlahan dan pengurangan bentuk aljabar dengan menggunakan pendekatan PMRI dapat membantu siswa dalam memahami konsep operasi penjumlahan dan pengurangan bentuk aljabar melalui pembelajaran dunia nyata atau pengalaman siswa atau hal yang dapat dibayangkan oleh siswa menggunakan LAS yang diberikan.

The operations of addition and subtraction in algebraic forms are one of the important materials in learning algebra. In reality, many students still experience difficulties in learning algebraic addition and subtraction because learning is dominated by formal methods so this does not support students' understanding of the concept of algebraic addition and subtraction. Therefore, learning activities are needed that emphasize understanding concepts. Researchers designed learning activities for addition and subtraction operations using the PMRI approach. This research aims to provide a contribution in the form of a hypothetical Learning Trajectory (HLT) regarding material on algebraic addition and subtraction operations using the PMRI approach. The subjects in this research were all class VIII students at SMP Negeri 29 Kerinci, consisting of 15 students. This research uses a research design research method. Data was collected through student activity sheets (LAS), observation, documentation and interviews. The data that has been collected is analyzed in a way that includes reducing, displaying

and concluding the data. The results of the research show that with a contribution in the form of HLT regarding material on addition and subtraction operations in algebraic forms using the PMRI approach, it can help students understand the concept of addition and subtraction operations in algebraic forms through real world learning or student experience or things that students can imagine using LAS.

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**How to Cite:**

Norhaslina, Andiana, & Anggaini, R. S. (2025). A Realistic Approach to Teaching Algebraic Operations to Junior High School Students. *Journal of Authentic Research on Mathematics Education, 7*(2), 216-227. https://doi.org/10.37058/jarme.v7i2.9443

## 1. INTRODUCTION

Education is the process of teaching and learning in which students acquire knowledge and skills. It is a conscious effort to prepare or guide students for their future roles (Norhaslina & Erita, 2023). Education plays a crucial role in helping students develop strong character (Lucia Rengkung et al., 2022). Thus, education is more than just the transmission of knowledge; it enables students to realize their potential and enhance their character. Education is also a conscious effort to create a learning environment and process that allows students to develop their own potential.

Mathematics is one of the subjects that plays a very important role in education (Sugito & Aini, 2019). It is a fundamental branch of science due to its numerous applications, and every scientific field is closely related to mathematics. Mathematics serves to develop the ability to calculate, measure, and use mathematical formulas that can be applied in real life (Kartika, 2018). The aim of teaching mathematics is for students to understand the knowledge being taught (Anisa et al., 2021). Therefore, mathematics is taught at all levels of education, from elementary school to university. The objectives of mathematics education can be achieved if students learn with understanding and actively construct new knowledge based on their experiences and prior knowledge (Sari & Afriansyah, 2020).

Among the various topics in mathematics, one important topic to learn is algebra. Algebra plays a significant role in everyday life because it provides methods for solving equations and expressing formulas in a more concise way (for those who understand the concepts) than traditional methods, which rely on verbal descriptions (Ghea Hapshah Loemongga Puspasari et al., 2023). Many everyday problems can be solved using algebra, making it an essential area of study. Algebraic learning, especially in operations of addition and subtraction, is a critical aspect of mathematics education at the junior high school level. However, students often face difficulties in solving algebra problems. This is due to students struggling to understand the meaning of the problem and how to solve it (Dewi et al., 2023).

Based on observations at SMP Negeri 29 Kerinci, many students have difficulty understanding concepts, resulting in low scores. Interviews with the mathematics teacher revealed that students struggle to solve algebra problems, which stems from their limited ability to grasp concepts. This was also found by Nugraha et al. (2019), who

stated that 60% of seventh-grade students have difficulty solving algebra problems. This indicates a research gap that needs to be addressed, particularly in terms of the learning approach used.

One approach that can deepen students' conceptual understanding is the Indonesian Realistic Mathematics Education (PMRI) approach. PMRI, adapted from Realistic Mathematics Education (RME) in the Netherlands, emphasizes the importance of real-world contexts in learning mathematics (Rusnawati et al., 2013). PMRI is highly suitable and beneficial for students as it uses contextual problems as a starting point for learning. Additionally, PMRI focuses learning activities on the students and their environment (Izzabella & Amin, 2017), allowing students to develop their conceptual understanding. This is supported by Jaheman et al. (2019), who stated that students taught using the realistic mathematics approach demonstrated better conceptual understanding compared to those taught with conventional methods. Anggraini & Fauzan (2020) also found that students learning with the realistic mathematics approach achieved higher performance than those in conventional classes.

Many studies have been conducted on algebra over time, such as research on learning difficulties in algebra among seventh-grade students (Nugraha et al., 2019), analysis of difficulties in performing algebraic operations (Lestari & Suryadi, 2020), and analysis of students' mathematical conceptual understanding in algebra (Kartika, 2018), among others. These diverse studies have produced various findings. This study focuses on developing a Hypothetical Learning Trajectory (HLT) for the operations of addition and subtraction in algebra using the PMRI approach. The contribution of this research is to provide new insights into the effectiveness of PMRI in enhancing students' understanding of algebraic operations, as well as to formulate concrete steps for classroom implementation.

Based on the above, the researcher is interested in conducting a study on algebra learning using the PMRI approach with eighth-grade students at SMP Negeri 29 Kerinci. The objective of this research is to contribute a Hypothetical Learning Trajectory (HLT) on the topic of addition and subtraction operations in algebra using the PMRI approach.

## 2. METHOD

The research was conducted in Class VIII of SMP Negeri 29 Kerinci during the odd semester of the 2023/2024 academic year. The research subjects were all 15 students of Class VIII at SMP Negeri 29 Kerinci. In this study, the researcher employed a design research method. The objective of this research was to contribute a Hypothetical Learning Trajectory (HLT) on the topic of addition and subtraction operations in algebraic expressions. The HLT was developed using the Indonesian Realistic Mathematics Education (PMRI) approach.

The data collection techniques used in this study included direct observation, documentation during the teaching and learning process, student interviews, and Student Activity Sheets (LAS). The data collected were analyzed through data reduction, data display, and drawing conclusions.

This study adopted a design research approach aimed at developing and testing the HLT. The research steps included:

1. HLT Development: Developing the HLT based on PMRI theory and student needs.
2. HLT Validation: Validating the HLT through discussions with experts and limited trials.
3. Implementation: Implementing the HLT in the teaching process of Class VIII at SMP Negeri 29 Kerinci.
4. Data Collection: Using observation, interviews, and LAS to gather data

### 2.1 Participant Characteristics and Sampling Technique

The participants in this study were 15 eighth-grade students at SMP Negeri 29 Kerinci. The sampling technique used was purposive sampling, in which students were selected based on specific criteria, such as their initial ability in mathematics.

### 2.2 Development and Validation of Research Instruments

The research instruments, including the LAS, were developed based on the HLT and validated by mathematics education experts to ensure their relevance and effectiveness.

### 2.3 Data Collection Technique

Data were collected throughout one semester, with weekly observations and interviews conducted after each learning session. LAS was distributed to students to assess their understanding of the material.

### 2.4 Data Analysis Technique

The data were analyzed using both qualitative and quantitative approaches. Strategies to improve data reliability included triangulating data from multiple sources.

## 3. RESULTS AND DISCUSSION

The research results showed that the implementation of the HLT using the PMRI approach significantly improved students' understanding of addition and subtraction operations in algebra. These results align with previous studies demonstrating the effectiveness of PMRI in mathematics learning (Sari & Afriansyah, 2020). However, potential weaknesses of this approach include dependence on relevant contextual problems and students' readiness to comprehend these contextual issues.

The teaching and learning process was conducted using the PMRI approach. Initially, the teacher provided a stimulus to prepare students for the core learning activity. Then, students were given Student Activity Sheets (LAS), which consisted of two problems. Problem 1 was a contextual problem related to algebraic addition operations, while Problem 2 was a contextual problem involving both addition and subtraction operations in algebraic expressions.

***Initial Learning Activity***

At the beginning of the lesson, the teacher prepared the learning situation and gave an initial stimulus to get students ready for the core activities. The teacher asked students to recall previously learned material as a foundation for understanding addition and subtraction operations in algebraic expressions, as seen in Dialogue 1.

**Dialogue 1**

*Teacher* **:** *Have you ever learned about algebra before?*

*Students* : *Yes, we have.*
*Teacher* : *What do you know about algebra?*
*Students* : *Algebra is like the one that has x, y, z in it, ma'am.*
*Teacher* : *Like this? (writes on the board "2x + 3y – 3 = 0")*
*Students* : *Yes,ma'am*

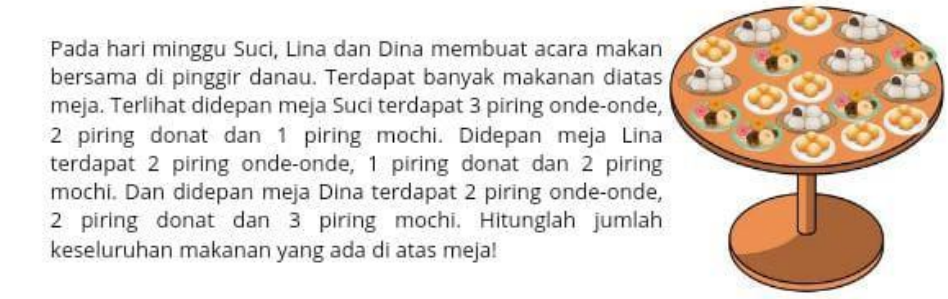


**Figure 1**. Contextual Questions

The teacher then presented a problem in the form of a contextual scenario, displaying both the question and an image of various foods placed on a table (Figure 1). To solve the problem, the teacher gave students time to imagine the steps needed to work through the problem. The students appeared confused, as they had never encountered story-based problems before, as illustrated in Dialogue 2.

**Dialogue 2**

*Teacher* : *Can anyone solve this problem?*
*Student* : *No, you haven't explained how to do it yet.*
*Teacher* : *This problem is related to algebraic expressions. Try to think about the steps needed to solve it using algebra*
*Student* : *I don't know, ma'am. Yesterday, we were only given problems with x, y, z — not story problems.*

The teacher then explained the steps needed to solve the problem. Students were asked to group similar foods, count the total number of items on the table, represent the items as algebraic variables such as a,b, c or x, y, *, and then solve the problem, as shown in Dialogue 3.

**Figure 2.** Teacher providing stimulus

**Dialogue 3**

Teacher : *Look at the picture of the food on the table. What kinds of food are there?*
Student : *There are onde-onde, donuts, and mochi, ma'am.*
Teacher : *How many plates of food are there on the table?*
Student : *On Suci's table, there are 3 plates of onde-onde, 2 plates of donuts, and 1 plate of mochi. On Lina's table, 2 plates of onde-onde, 1 plate of donuts, and 2 plates of mochi. On Dina's table, 2 plates of onde-onde, 2 plates of donuts, and 3 plates of mochi.*
Teacher : *Now, group the plates of onde-onde, donuts, and mochi, and add them up.Student:*
Student : *Onde-onde = 3 + 2 + 2 = 7 plates; Donuts = 2 + 1 + 2 = 5 plates; Mochi = 1 + 2 + 3 = 6 plates*
Teacher : *That's not yet in algebraic form. Now, let's connect it to algebra. Does anyone know how?*
Student : *No, ma'am.*

The teacher then guided students to represent the contextual problem in algebraic form. She explained that although each plate contained the same type of food, the exact number of items was unknown. Therefore, the plates could be represented using variables x, y, and z to denote the unknown quantities. The teacher also emphasized that unlike items cannot be added directly — for example, onde-onde plates cannot be directly added to donut or mochi plates. This was clarified in Dialogue 4.

**Dialogue 4**

Teacher : *Since we don't know how many items are in each plate, we can represent the plates of onde-onde, donuts, and mochi with variables **x**, **y**, and **z**. Try to represent each food with these variables.*
Student : *So onde-onde = x, donuts = y, and mochi = z. Like that, ma'am?*
Teacher : *Yes, now convert the food quantities on Suci's, Lina's, and Dina's tables into algebraic expressions.*
Student : *Suci's food = 3x + 2y + z — like that?*
Teacher : *Yes, continue.*
Student : *Lina's food = 2x + y + 2z; Dina's food = 2x + 2y + 3z*
Teacher : *Next, add all the food from Suci, Lina, and Dina.*
Student : *How do we add them, ma'am?*
Teacher : *Since the items are different types, you can't add them directly. First group like terms onde-onde with onde-onde, donuts with donuts, and mochi with mochi and then add them.*
Student : *Like this, ma'am?*
*3x + 2y + z + 2x + y + 2z + 2x + 2y + 3z =*
*(3x + 2x + 2x) + (2y + y + 2y) + (z + 2z + 3z) =*
*7x + 5y + 6z*
Teacher : *Exactly. That's the result.*

From Dialogues 3 and 4, it is evident that students were unable to solve the problem without teacher guidance. Through this contextual problem, students were led to understand algebraic concepts and solve addition operations in algebraic expressions.

***Core Learning Activity***

During the core activity, students were given a Student Activity Sheet (LAS) containing two problems to be solved in groups. The 15 students of Class VIII were divided into 5 groups of 3 students each. Problem 1 presented a contextual problem involving addition of algebraic expressions, and Problem 2 involved both addition and subtraction. Before students began, the teacher explained the steps for solving the problems.

**Figure 3.** Teacher distributing and explaining LAS

***Problem 1 on LAS***

The objective of Problem 1 was for students to convert contextual problems into algebraic form and solve them using algebraic addition, as illustrated in Figure 4.


**Figure 4.** Problem 1 on LAS

Students were asked to calculate the total number of fruit baskets harvested by Mr. Hasim and Mrs. Nana.

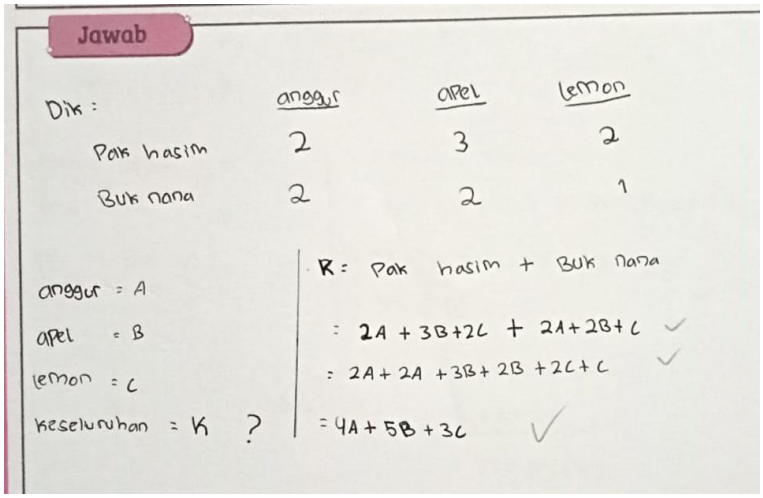


**Figure 5.** Group 1's answer to Problem 1

From Figure 5, students first identified known data, assigned variables a, b, c for each fruit basket, and K for the total. They then grouped like terms and added them, showing their understanding of algebraic addition.

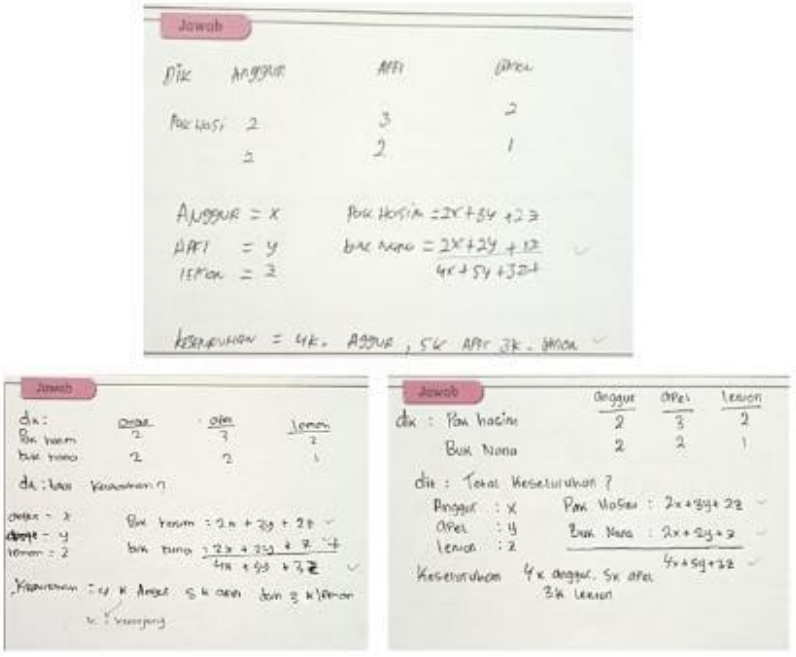


**Figure 6.** Group 2, 3, and 4's answers to Problem 1

These groups followed similar steps, initially identifying known and unknown information, assigning x, y, z, and using column addition to solve the problem. These groups demonstrated an understanding of algebraic concepts despite using basic addition methods.

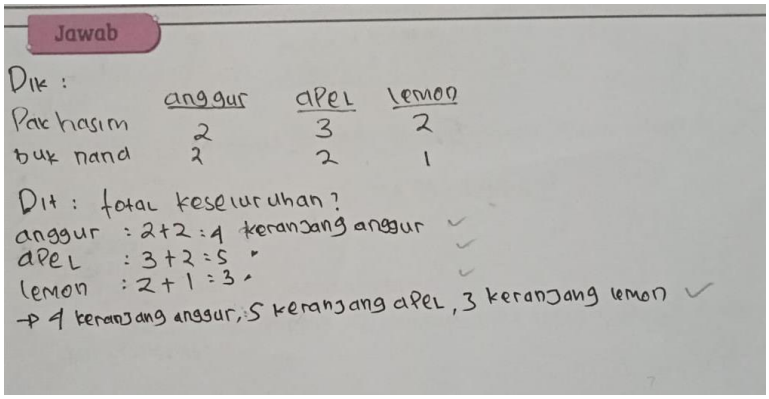


**Figure 7.** Group 5's answer to Problem 1

Group 5 identified and grouped similar baskets and added them without converting into algebraic form. This shows conceptual understanding but a lack of algebraic representation. The teacher guided them, as shown in Dialogue 5.

**Dialogue 5**

*Teacher : Your answer isn't yet in algebraic form. Let's convert it using variables x, y, z.*
*Student : Why do we need variables? Isn't our way correct? (shows answer)*
*Teacher : Your answer is correct, but since we are learning algebraic addition and subtraction, we need to solve it algebraically. Unknown values can be represented with letters like x, y, z. Let's solve it that way.*
*Student : Okay, ma'am.*

This shows Group 5 still lacked full understanding, highlighting the teacher's crucial role in guidance.

***Problem 2 on LAS***

The goal of Problem 2 was for students to convert contextual problems into algebra and solve them using both addition and subtraction, as shown in Figure 8.

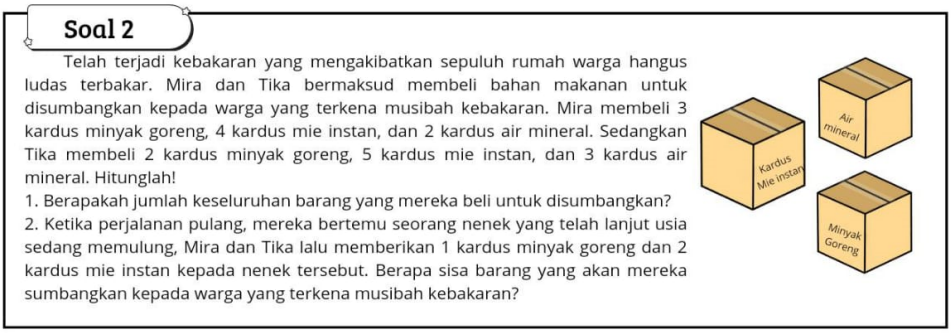


**Figure 8.** Problem 2 on LAS

Students were expected to apply algebraic addition and subtraction to solve the problem.

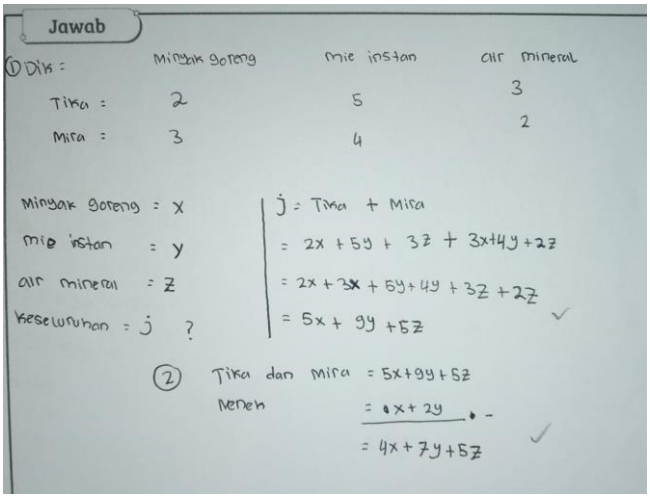


**Figure 9**. Group 1's answer to Problem 2

Group 1 followed similar steps as in Problem 1, grouping like terms and using subtraction. Their work showed correct understanding and use of algebraic operations.

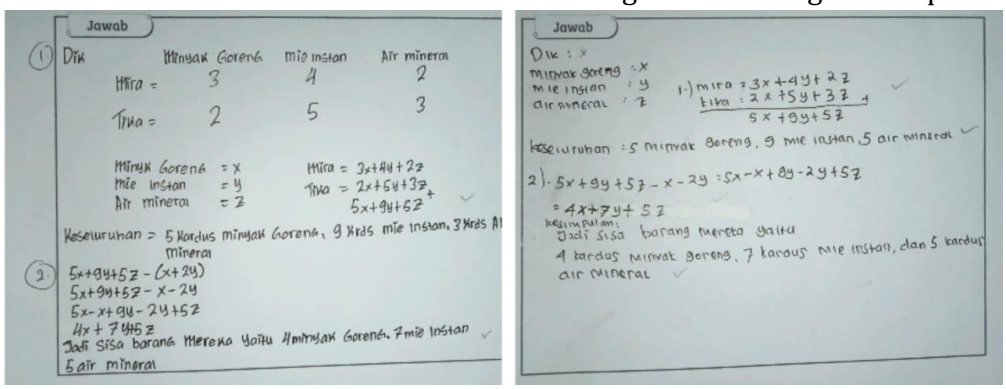


**Figure 10.** Group 2 and 5's answers to Problem 2

Groups 2 and 5 used column addition and grouped terms before subtraction. Group 5 improved from Problem 1, now correctly representing algebraic expressions.

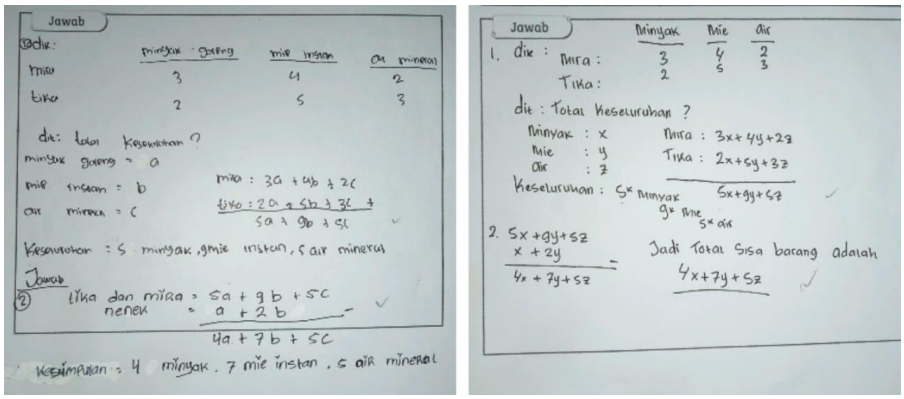


**Figure 11.** Group 3 and 4's answers to Problem 2

These groups used column addition and subtraction, showing improved understanding and ability to apply algebraic operations.Based on students' answers in both problems, most demonstrated conceptual understanding. Even though Group 5 struggled initially, they improved. This proves that the Hypothetical Learning Trajectory

(HLT) for algebraic addition and subtraction using PMRI helped students grasp these concepts. This aligns with Agusta (2023) and Surgandini et al. (2019), who found PMRI enhances conceptual understanding. Kamsurya (2019) also showed that PMRI improves student engagement and understanding. PMRI links real life to learning, making it easier for students to understand math concepts and improve outcomes (Wantinem, 2022).

## 4. CONCLUSION

The results showed that the Hypothetical Learning Trajectory (HLT) on algebraic addition and subtraction using the PMRI approach through Student Activity Sheets (LAS) helped students understand these operations. LAS contained problems designed to guide students in discovering these concepts. The PMRI approach supported student understanding by connecting real-life experiences or relatable scenarios to algebra. This research concludes that PMRI can be an effective alternative for teachers. Initially, students could not interpret contextual problems algebraically, but after PMRI-based learning, they began to do so. Thus, PMRI can serve as a bridge from concrete to abstract thinking for students.

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