Cognitive conflict strategy to minimize students’ misconception on the topic of addition of algebraic expression

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Abstract. Students’ misconception on algebra needs more attention. Implementation of cognitive conflict strategy is needed to minimize student misconception. Learning instruments on algebra operation using a cognitive conflict strategy have been developed using the ADDIE model. The learning instruments consist of a lesson plan, worksheet, and diagnostic test. This paper describes the test result on the addition and subtraction of algebraic expression based on the learning instruments developed. The subjects were 20 students of a junior high school in Lhokseumawe, Aceh, Indonesia. Research instruments used were teacher self-reflection sheet to see how relevant the lesson plan is with the learning implementation. The learning process began with motivating the students through the problems related to their daily activities followed by working on the cognitive conflict test, presenting the result, and discussing the answers. In this phase, the teacher ensured that the students’ concept was aligned with the scientific concept. In the next step, the students wrote a self-reflection to find out the differences between the initial concept and the new one. At the end of the learning, they did individual tasks related to the topic. Generally, conceptual changes found are quite good even though few students still faced misconception. However, it can be concluded that the cognitive conflict learning strategy could minimize student misconception on the topic of algebra.

1. Introduction
The misconception is an incorrect understanding of the concept occurring repeatedly and explicitly. The misconception of the mathematic concept raises the concern because it leads the false concept formation and generalization obstructing the learning process [1]. The misconception occurs because before learning the concept, the students have their understanding based on reasoning, intuition, culture, or others. The concept is maintained to explain the symptoms existing surrounding, but the concept is different from the actual concept. The misconception is difficult to be changed to the correct one; so, it can detain the learning process [2].

Many researchers have identified that the students in 6th to 8th-grade face misconception in algebra [3]. The students often merge the algebraic addition (conjoining) incorrectly. For example, the students simplify the algebra of 4 + 3x² become 7x². The students also simplify 4 + 3x become 7x [4]. Most students also incorrectly solve the fractional operation, e.g., \( \frac{x}{2} + \frac{x}{3} = \frac{x^2}{5} \) by multiplying the numerators and denominators. Those examples show that student misconception and misunderstanding are found in using algebraic concept [5].
Misconceptions on algebra are also faced by students in Grade 8 of a junior high school in Lhokseumawe, North Aceh. Based on the initial observation conducted by the researchers, out of 22 students, 17 students faced misconception even though the test was given after the students had just finished learning algebra. The misconception was found in solving the equation of $3x + 2y$. The students thought that $3x + 2y$ is equal to $5xy$. Another misconception was found in simplifying $\frac{4}{xy} + \frac{2x}{y}$; the students simplified it into $\frac{6x}{xy}$. They also made an error in solving $3(x-y)$; their answer was $3x - y$.

Generally, the misconceptions faced by the students could be a barrier for their learning. Therefore, it is required the efforts to deal with this problem. One of the efforts that can be undertaken is demonstrating the cognitive conflict [6]. In the learning using cognitive conflict strategy, students are challenged to show the concept they have understood. Thus, students having misconception will present the concept contrary to the actual concept.

Cognitive conflict is the condition in which the students find the contrary between cognitive structure they have and the surrounding condition [2]. The cognitive conflict strategy raises the students' dissatisfaction with the concept they have so that it helps students change their incorrect concept to correct one based on the scientific concept [7]. Cognitive conflict strategy presented by the teacher is expected to make the students more aware of the misconception they made, and finally, the students can construct the concept toward scientific conception. Thus, this article aims to describe algebra learning through cognitive conflict to minimize students’ misconception.

2. Method
The learning instruments of algebra using cognitive conflict strategy have been developed using ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development model [8]. The learning instruments used are a lesson plan, student worksheet, and diagnostic test. Those instruments have met the validity criteria based on the recommendation from the experts and practitioners. The data of this study was obtained from the pilot test of algebraic operation learning instruments in the implementation phase based on the ADDIE model. The pilot test aims to measure the practicality and the effectiveness of the instruments. This study involved 20 students of Grade 8 of a junior high school in Lhokseumawe, Aceh, Indonesia. The research instruments used were teacher self-reflection sheet. The reflection sheet was used to see the relevance between the lesson plan and learning implementation. The data were analyzed descriptively.

3. Result and discussion
The learning on algebraic operation using cognitive conflict strategy aims to minimize student misconceptions on algebra addition and subtraction. The learning began with the introduction phase, motivating students through daily problems related to algebraic addition and subtraction as shown in Figure 1. The teacher asked the students a question, “What do you understand about the picture?” Then, the teacher explained the objectives and the steps of the learning process. The learning implementation in this phase was relevant to the lesson plan.

In the core activity phase, the learning process began with students observe the contextual problems on the worksheet. The students were encouraged to ask questions related to the information
existing in the problems that they had not understood yet. For example, a student asked, “How to change this problem into the algebra equation? Can we define it with another symbol other than x?”

Furthermore, the students were asked to collect the information related to the algebra addition and subtraction on the textbooks. The information could assist the students in solving the problems. Then, the students were asked to solve questions on the worksheet that could reveal student cognitive conflict on algebraic addition and subtraction (see Figure 2). In this phase, the students completed those questions to find out their initial concepts.

Figure 2 presents an example of student answers related to the cognitive conflict. The students were asked to choose whether the simplified equations are correct or not and give reasons for their response. The options given for the simplified equations of \((2x + 5)\) are \(7x\), \(2x + 5\), and \(7\). The student chose \(7x\) as the correct answer because the student thought \(2x + 5 = 7x\). Then, the student considered \(2x + 5\) and \(7\) incorrect. The student reasoned that \(2x + 5\) is the question; it is not the simplified form, and \(7\) has no variable \(x\); thus, the simplified form is \(7x\).

Based on the reason given by several students, the students considered that \(2x + 5\) could be changed to \(7x\). It shows that the students still misunderstood the concept; they added together the unlike terms. The following excerpt shows the conversation between the teacher and the students on the problem.

Teacher: “Please, explain your answer.”
Student: “2 is added by 5. So, it becomes 7. Because there is the symbol “x” so it is added by x and finally it becomes 7x.”
Teacher: “Are you sure?”
Student: “Yes.”
Teacher: “Is it correct that 2x can be added by 7?”
Student: “Yes. So, it becomes 7x.”
Teacher: “How about 3x + 4y, what is the simplified form?”
Student: “It is 7xy.”
Teacher: “If x is apple and y is banana. How many are 3 apples added by 4 bananas?”
Student: (Silent and think)
Teacher: “What is the answer?”
Student: “3 apples and 4 bananas”
Teacher: “Is the answer 7 apples bananas?”
Student: “No”
Teacher: “So, how about 3x + 4y?”

Figure 2. The Cognitive Conflict Questions on algebraic addition and subtraction.
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Student: “3x + 4y”
Teacher: “and how about 2x + 5?”
Student: “it should be 2x + 5”

After the students finished the problems on the worksheet in their groups, each group was asked to present their answers, and other groups were given the opportunity to comment and share their ideas. This activity allowed the students to express and exchange their ideas. Through this phase, it was expected that the students raised the conflict in their minds so that the students encouraged to double check the initial concept they had with the scientific concept. The teacher guided the students to inquiry questions, such as questions started with why and how. These questions help students to correct their misconception.

The next learning phase is that the students summarized the materials they had learned. In this phase, the teacher gave feedbacks to strengthen students’ concept. The students were also asked to reflect on their answers to see the difference between the initial concept and the new concept made during the class discussion. Then, the students continued to complete their individual tasks.

The students’ answers on the individual tasks show that the students could determine the simplest form of \[7a+2b+4ab−4b+2ab+2a\]. The example of the correct answer is shown in Figure 3.

Based on the student’s answers (see Figure 3), the students no longer had performed misconception in simplifying the algebra equations. The students’ answer was confirmed through the interviews as presented in the following excerpt.

Researcher: “Please explain your answer (pointing to the selected answer).”
Student: “I choose the same variable, such as 7a, subtracted by 2a equal to 5a. 2b is subtracted by 4b equals -2b, and 4ab is added by 2ab equals 6ab.”
Researcher: “How about 2a + 2a^2?”
NT: “It cannot be calculated.”
Researcher: “Why?”
NT: “Because a is not the same as a^2.”
Researcher: “Do they use the same variable?”
NT: “Yes. But, the power is different.”
Researcher: “So, in your opinion, which formula can be operated?”
Student: “the same variable only.”

![Figure 3](image_url)

**Figure 3.** The student’s answer in the individual task.
Researcher : “What is the requirement to be the same variables?”
Student : “The same variables have the same power.”

Based on the students’ answers in the individual tasks and interviews, in general, cognitive conflict strategy can minimize the misconception on the algebraic addition and subtraction concept. Also, giving the additional task, i.e., homework strengthened this activity. Even though most of the students had improved their conceptual understanding, there was a small number of students who still needed additional time and supports from the teacher. The cognitive conflict questions could not help them realize their misconceptions.

The trial test shows that the learning process using the learning instruments could be implemented in the mathematics classroom. The implementation went well as the time allocated in the lesson plan, 90 minutes. Generally, it can be concluded that the learning objective was achieved. The findings show that the learning using cognitive conflict strategy can fix student misconceptions [7]. The cognitive conflict strategy is the conceptual alteration strategy that enables students to change their misconceptions into the concept aligned with the scientific concept. This change could improve the learning achievement of students [6].

Overall, the students’ conceptual alteration was quite good. The students could well develop the understanding of the learning concepts by the conceptual changes. The conceptual understanding includes expanding the concept they already had and fixing the inappropriate concepts.

Also, the test result indicates that some students have not changed their initial concepts as expected. This problem is not because of students’ learning weaknesses, but instead the resistant misconception. Therefore, the students need more challenging cognitive conflict tasks and longer time to realize the misconception they faced [9]. The students who made any changes to their concepts through the cognitive conflict tasks will have a strong concept, and the concept will stay longer in the students’ mind. [10]. That means that the misconception can be fixed if the right strategy in the longer period is implemented. Thus, it is reasonable when there were several students in this study who still faced misconceptions even though the cognitive conflict strategy had been implemented. This problem happens because it is not easy to change students’ misconception due to the resistance.

4. Conclusion
Based on the trial test of the learning instruments using cognitive conflict strategy on the concept of algebra addition and subtraction shows that the learning instruments have been well implemented. The learning process was implemented well as the lesson planned. Generally, students performed conceptual changes through the cognitive conflict task as expected in this study. The task helps students minimize their misconceptions on algebra. Thus, the learning instruments have met the learning objectives.

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