The Role of Refutational Text as a Conceptual Change Effort to Fix the Misconception on Addition and Subtraction of Integers

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Abstract. There are conceptual difficulties in studying operations of integers from which a poor understanding of this concept could lead to misconceptions. One way that can be done to help the students' misconceptions was through the use of conceptual change techniques. There were four conditions in the conceptual change technique and the refutational text meets all conditions. The aim of this study was to describe the role of refutational text in conceptual changes that can fix misconceptions on addition and subtraction of integers. This research began with developing refutational text-aided learning media. Posttest pretest design was used. The pretest was given at 30 4th-grade students at the beginning of the lesson. In the teaching stage, the explanation of the concept through refutational text-aided learning media was presented. Posttest was conducted at the end of the study. Interviews were conducted twice, ie during pretest and posttest. Data analysis was done by comparing the result of answer and result of student interview at pretest and posttest. The result as a whole there is an increase in the average value ie $M_{\text{PRE}} = 43$ and $M_{\text{POST}} = 80.1$. In addition, there is an indication of a conceptual change of students in understanding the matter of addition and subtraction of integers.

1. Introduction

An integer is a part of a rational number, consisting of positive integers, zero and negative integers [1]. There is a conceptual difficulty to understand the concept of negative integers and operations using the set of integers [2,3]. Besides negative integers is a difficult subject to teach [4], one of the causes of students’ difficulties in understanding negative integers is the difficulty in understanding the use of a negative sign as a type of number or as a sign of subtraction operation. This is in accordance with the principles of Vygotsky, which defines the existence of a close relationship between signs such as language or symbols with cognitive development [5].

In several studies, found that there are still errors that students do in the matter of addition and subtraction of integers. One of the causes of errors in the matter of the addition and subtraction of integers is due to a misconception of the concept of arithmetic operations on integers [4,6,7,8,9]. Based on Makonye & Fakude’s research [4], it was found that 83.3% of 8th-grade students had misconceptions of the concept of addition and subtraction of integers caused by poor conceptual understanding [4]. Poor conceptual understanding can lead to errors in other parts, such as procedural errors (false in sign manipulation). This is reinforced by the finding that as many as 62.9% of students with poor conceptual understanding do procedural errors in performing addition and subtraction operations on integers [4].
Given that integers are one of the most important and challenging topics in the transition from arithmetic to algebra [10], there is an indication that student misconceptions about the matter of integers can cause difficulties in learning algebra [11]. Misconceptions about the concept of addition and subtraction on integers can have long-term effects, where adults who have been educated and taught over the years are found to have misconceptions about this concept, generally they assume that the sum of two numbers will always result in a larger number and a two-digit subtraction will always result in smaller numbers, including in the case of negative integers [12].

One method that can be used to fix misconceptions is by making conceptual changes [13,14]. The proposed teaching technique for conceptual change is teaching that can lead to cognitive conflict [15]. Cognitive conflict is a cognitive imbalance that can cause a person to discover or develop a new concept [15]. One way that can be used to achieve cognitive conflict in this research is by using refutational text [13], this is because the refutational text is the only way of teaching that aims to encourage conceptual change, where such conceptual changes can last a long time [16]. In addition, the refutational text also fulfills the four necessary steps for conceptual change can occur [17]. To achieve conceptual change, incorrect and correct concepts are presented in one text at the same time so two opposite concept can be activated in memory [18]. In the refutational text, incorrect concept (misconception) and correct concepts are very close to each other so it is quite possible that both can be activated simultaneously in working memory and make conceptual changes happen [19]. The aim of this study is to describe the role of refutational text in a conceptual change effort to fix the misconception of matter of addition and subtraction of integers. This research begins by developing ICT media that uses refutational text in it to make students easier to understand the refutational text and support the research being conducted.

2. Refutational Text and Conceptual Change
Misconceptions can be fixed by a process called conceptual change [17]. The refutational text is aim to achieving conceptual change by explicitly stating, refuting and replacing an incorrect conception [18]. In the refutational text, two opposite concepts (incorrect and correct concepts) are presented in one text at the same time. In order to be referred to as a refutational text, the text must have two essential elements [13], ie: (i) the text must clearly indicate the wrong concept which will be refuted by the refutational text; (ii) the text must clearly state that this concept is not true and why (reason) by explaining the correct concept. Part of the refutational text always contains three components, ie: misconceptions, refutation cue and explicit disapproval (clear rejection) of the misunderstanding with an emphasis on currently accepted scientific explanations [13, 16]. Conceptual change is very likely to happen in learning. Conceptual change is a change in the structure of existing concepts or knowledge to be able to assimilate or accommodate to get new concepts or knowledge. In other words, to be able to make a conceptual change, one must rearrange the existing concept structure (existing knowledge) to be able to assimilate or accommodate new knowledge or concepts [13]. There are four steps in the conceptual change process, ie: (a) Dissatisfied, (b) Intelligible, (c) Plausible and (d) Fruitful [17].

3. Methods
This research is a research development and experimental research. Developmental research is done to develop learning media using refutational text. Learning media with refutational text is used to give students ease in understanding the refutational text, thus can supporting the research conducted. Development of learning media using the Plomp development model consisting of five stages [20], ie: (a) Preliminary Investigation, (b) Design, (c) Realization, (d) Test, Evaluation and Revision, (e) Implementation. Experimental research was conducted with one group sample pretest-posttest. This experimental research is the implementation of refutational text-aided learning media that has been developed.

3.1. Refutational Text-Aided Learning Media
An ICT media with refutational text in it, in this learning media there are parts of learning from apperception stage to evaluation. Refutational text in this learning media is emphasized at the time of
giving of materials. The given learning material is 8 addition and subtraction forms, consisting of 4 addition of integers and 4 of subtraction of integers. The addition and subtraction forms of integers are as follows: (i) \(a + b\), (ii) \(a + (-b)\), (iii) \(-a + b\), (iv) \(-a + (-b)\), (v) \(a - b\), (vi) \(a - (-b)\), (vii) \(-a - b\), and (viii) \(-a - (-b)\) in condition \(a < b\), \(a = b\), \(a > b\) with \(a, b \in \text{integers}\). In each of the materials taught will be given the conclusion of the concept. Then the students are asked to try some practice questions from each section studied, the exercise questions are in the form of multiple choice and when students make mistakes in the selection of answers then the refutational text will appear to guide the subject in correcting the error. One a part of the refutational text in media is as Figure 1.

**Figure 1.** Figure the use of refutational text in learning media.

In Figure 1 the blackboard is a place of refutational text, when students answer correctly then there will be an explanation of the concept and they can continue to the next page. However, when students answer wrong the refutational text will appear to direct the student’s mistake by telling them that the answer is wrong and explained the correct concept. The link between the conceptual change process and the use of refutational text appears, students will know that they are experiencing misconceptions that cause errors, (ii) in refutational text there is an explanation of the correct concept, so students are encouraged to be able to understand the new information, (iii) students are guided to be able to explain the new information in accordance with understanding that makes sense to him, (iv) by understanding refutational text, students are expected to be able to use the correct concept to solve different problems in the same material.

### 3.2. Pretest and Posttest

In this study pretest and posttest use the same problem, consisting of 4 questions of addition on integers and 4 problem of subtraction on integers, such: (i) \(a + b\), (ii) \(a + (-b)\), (iii) \(-a + b\), (iv) \(-a + (-b)\), (v) \(a - b\), (vi) \(a - (-b)\), (vii) \(-a - b\), and (viii) \(-a - (-b)\). Each question consists of 3 sub-items with condition \(a < b\), \(a = b\), \(a > b\) with \(a, b \in \text{integers}\). In addition, to determine whether there is or not misconceptions experienced by students on the addition and subtraction of integers, the question of pretest and posttest is given CRI (Certainty of Response Index) scale 0 – 5 to find out the level of confidence of students in providing answers [21].

### 4. Results and Discussion

Participants as many as 30 students in 4th grade, consists of 15 male and 15 female students. Age between 10–11 years. All the students are physically normal. The selection of participants of 4th grade of primary school because the matter of addition and subtraction of integers involving negative integers begins to be taught at this level, so it is important to immediately correct the misconceptions that may occur in this material. This research design uses one group sample pretest-posttest. At the beginning of the study, the students were given a pretest consisting of 8 questions of the addition and subtraction of integers. After the pretest, an interview was conducted on the entire student to know the initial level of students’ understanding of the addition and subtraction of integers through the answers given by the
students at the time of pretest. At four subsequent meetings, students are asked to study the addition and subtraction materials of integers using refutational text-assisted learning media, students study independently. Then given the posttest by using the same test given at the time of pretest. The results of pretest and posttest are grouped into high, medium and low-value groups. The determination of high, medium and low score groups is based on the mean and standard deviation on each test.

The selection of interview subjects is based on the students who experience the change of the value group after being given the learning by using refutational text-aided instructional media. The change of value groups between the pretest and the posttest is a change in the low to moderate, low to high and moderate to high values group. If there is a decrease in the value group, one additional interview subject will be chosen for an interview. The results of the interview during the posttest will be compared with the results of the interview during the pretest to determine whether or not there is any conceptual change that occurs during the exposure of refutational text.

The aim of this study is to describe the role of refutational text in a conceptual change effort to fixing the misconception of matter of addition and subtraction of integers. Overall there is an increase in the results of pretest and posttest values, where the average pretest score is 43.0 and the average posttest score is 80.1. In the pretest still found a misconception, the existence of these misconceptions is indicated by the level of confidence of students at the time of reply, where students answer wrong with a high level of confidence [23], as in Table 1.

| Low CRI (< 2.5) | High CRI (> 2.5) |
|-----------------|------------------|
| Correct answer  | Correct answers and low CRI indicate "lack of knowledge" |
| Wrong answer    | Wrong answers and low CRI indicate "lack of knowledge" |
|                 | Correct answer and high CRI indicate "concept comprehension is correct" |
|                 | Wrong answer and high CRI indicate "misconception" |

When pretest it was found that in the matter of addition and subtraction of integers there are 4% of students are at the level of "lack of knowledge", 47% of students are at the "correct comprehension" and 49% of students experience "misconceptions". This is seen from the level of student confidence over the wrong answer or the correct answer given. Misconceptions rate tends to decrease at posttest, ie stay 8% after exposure with refutational text. One of the differences in student answers when pretest and posttest are presented in Figure 2.

In the matter of addition of positive integers with positive integers, there is no error and no misconception of all students. However, like that shown in Figure 2 in the matter of addition and subtraction materials that use negative integers, there is still a misconception. The selection of interview subjects is based on the range of scores on each test, at the time of pretest with M = 43.0 and SD = 21.18 there were 2 students with high score group, 3 medium score group students and 25 low score group

![Figure 2](image-url)
students. While at posttest with M = 80.1 and SD = 20.0 there are 16 students with high score group, 10 students of medium score group and 4 students with low score group. Comparing the results of pretest and posttest, there were 6 students experiencing a change in low to moderate value group, 9 students experienced a low to high group value change and 10 students experienced moderate to the high-value group. None experienced a decline in the value group, but there were 5 students who did not experience a change in the value group of pretest and posttest.

4.1. Student Task Analysis Results

There are differences in students' answers when pretest and posttest. Analysis of student task results will be described in Table 2 and Table 3.

### Table 2. Analyze the results data of the students' answers to the pretest and posttest

| Addition of Integers | Transcript of the answer from S₅ | Transcript of the answer from S₃ | Transcript of the answer from S₄ |
|----------------------|----------------------------------|----------------------------------|----------------------------------|
| Pretest              | Pretest                          | Pretest                          | Pretest                          |
| (a) 5 + (−7) = 2 √  | (a) −6 + 9 = −15 √               | (a) −3 + (−7) = 4 √              |
| (b) 8 + (−8) = 0 √  | (b) −7 + 7 = −14 √              | (b) −6 + (−6) = 0 √              |
| (c) 9 + (−3) = 6 √  | (c) −10 + 9 = −19 √             | (c) −8 + (−2) = 6 √              |
| Posttest             | Posttest                         | Posttest                         | Posttest                         |
| (a) 5 + (−7) = −2 √ | (a) −6 + 9 = 3 √                 | (a) −3 + (−7) = −10 √            |
| (b) 8 + (−8) = 0 √  | (b) −7 + 7 = 0 √                 | (b) −6 + (−6) = −12 √            |
| (c) 9 + (−3) = 6 √  | (c) −10 + 9 = −1 √               | (c) −8 + (−2) = −10 √            |

Analysis:
- Students still misconception on the addition of the forms \( a + (−b) \) with \( a < b \). Students assume that \( 5 + (−7) = 7 − 5 = 2 \), but it is not. Addition of positive with negative integers equals reducing the number smaller than the larger number and the sign on the number follows the larger number.
- Students still misconception on the addition of the forms \( −a + b \) with \( a < b, a = b, a > b \). The student understands that the addition is equal to summing two numbers, since the sign at the beginning of the number is negative, so it will produce a larger negative number. This is not. This addition is equal to subtracting the smaller number from the larger number and the number sign following the larger number.
- Students still misconception on the addition of the forms \( −a + (−b) \) with \( a < b, a = b, a > b \). Students understand this addition is the same as reducing the number smaller than the larger number. This is not. This addition of negative numbers with negative numbers will result in larger negative numbers, so the result will be smaller and negative, not positive.
- Overall misconceptions that occur can be corrected at posttest.

### Table 3. Analyze the results data of the students' answers to the pretest and posttest

| Subtraction of Integers | Transcript of the answer from S₁ | Transcript of the answer from S₃ | Transcript of the answer from S₄ |
|-------------------------|----------------------------------|----------------------------------|----------------------------------|
| Pretest                 | Pretest                          | Pretest                          | Pretest                          |
| (a) 0 − 4 = 4 √        | (a) 8 − (−10) = 2 √              | (a) −5 − 8 = 13 √                |
| (b) 8 − 8 = 0 √        | (b) 3 − (−3) = 0 √               | (b) −6 − 12 = 4 √                |
| (c) 9 − 8 = 1 √        | (c) 9 − (−7) = 2 √               | (c) −10 − 7 = 17 √               |
| Posttest               | Posttest                         | Posttest                         | Posttest                         |
| (a) 0 − 4 = −4 √       | (a) 8 − (−10) = 18 √             | (d) −5 − 8 = −13 √               |
| (b) 8 − 8 = 0 √        | (b) 3 − (−3) = 6 √               | (e) −6 − 6 = −12 √               |
| (c) 9 − 8 = 1 √        | (c) 9 − (−7) = 16 √              | (f) −10 − 7 = −17 √              |

Ents experienced moderate to the high group.
Analysis:
- Students still misconception on the addition of the forms \(a - b\) with \(a < b\). Visible understanding of students stated that \(0 - 4 = 4 - 0 = 4\). This is not the case. Subtraction of positive numbers with a positive number form \(a - b\) with \(a < b\) is generating a negative number, ie \(0 - 4 = -4\).
- Students still misconception on the addition of the forms \(a - (b)\) with \(a < b, a = b, a > b\). The student understands only that the reduction means reducing the number smaller than the larger number regardless of the sign of the number. On the number line, it produces a positive integer, a larger positive number. So it can be stated that \(a - (b) = a + b\).
- Students still misconception on the addition of the forms \(-a - b\) with \(a < b, a = b, a > b\). Students do not yet understand that reducing negative numbers with negatives will result in larger negative numbers. Where \(-a - b = -(a + b)\).
- Students still misconception on the addition of the forms \(-a - (b)\) with \(a < b, a = b, a > b\). Students sum up smaller numbers with larger numbers. Whereas students should reduce the numbers smaller than larger numbers.
- Overall misconceptions that occur can be corrected at posttest.

4.2. Analysis of Student Interview Results
Results of student interviews are described in Table 4.

| Interview Data                                      | Analysis                                                                 |
|----------------------------------------------------|--------------------------------------------------------------------------|
| Interview Transcript with S₂                         | Overall students who experienced an increase in the value group gave an answer indicating that there is a change in students' understanding of the addition and subtraction of integers before and after exposure to refutational text in the form of learning media. Students tend to assume that they have obtained reasonable and useful information in correcting their former misconceptions. |
| Change of low to moderate value group.               |                                                                          |
| R : On the task number 3 (c), when pretest you answer \(-10 + 9 = 1\), while at posttest \(-10 + 9 = -1\). Do you think that is true when pretest or posttest? |                                                                          |
| S₂ : When posttest.                                  |                                                                          |
| R : Why? What do you think is bigger \(-10\) or \(9\)? |                                                                          |
| S₂ : The greater one \(9\). I'm just convinced of that now. |                                                                          |
| R : Sure what cause?                                 |                                                                          |
| S₂ : Because earlier on the computer indicated that on the number line -10 less than 9. And there are sentences that explain also. |                                                                          |
| R : So according to you, you get important information from the text that is in the learning media? |                                                                          |
| S₂ : Yes. Of course. (Smiling)                       |                                                                          |
| Interview Transcript with S₁₅                        |                                                                          |
| Change the low to high-value group.                  |                                                                          |
| R : When pretest you state that \(0 - 4 = 4\). Because 4 is bigger than 0 so the results are positive 4. |                                                                          |
| S₁₅ : No, its wrong.                                |                                                                          |
| R : Why wrong?                                      |                                                                          |
| S₁₅ : On the computer described if the smaller number minus the larger number the result will be negative. So the result \(-4\). |                                                                          |
| R : When you answer all the question, are you all right or wrong? |                                                                          |
| S₁₅ : No, there is wrong. But there are texts that help to fix. |                                                                          |
| Interview Transcript with S₂₁                        |                                                                          |
| Change of moderate to the high-value group.         |                                                                          |
| R : According to you \(-5 - 8\) is how much?        |                                                                          |
| S₂₁ : \(-13\)                                       |                                                                          |
| R : Okay. But your answer at pretest is positive 13? |                                                                          |
| S₂₁ : Yes. Previously I thought if negative meeting negative would produce positive. So I answer 13. |                                                                          |
| R : What do you think now about that answer?         |                                                                          |
| S₂₁ : Yes, the answer is wrong.                     |                                                                          |
R : How can you know that it's wrong?
S2 : When on the computer there is an animated rabbit that jumps showing that if the negative subtraction with positive it will produce a negative number whose value is greater.

From the result of the analysis of student's task and students interview that was shown in Table 2 and Table 3, it can be seen that there is the difference between student's understanding during pretest and posttest. Students generally get information that is reasonable and interesting in fixing mistakes made before, this is in accordance with the conditions that must be met for conceptual changes [17]. Where conceptual change can occur in the presence of cognitive conflict that can be activated by presenting two opposite concepts at one time on a single text [18]. According to the four conditions expressed by Posner [17], ie: (a) Dissatisfied, (b) Intelligible, (c) Plausible dan (d) Fruitful has been fulfilled.

Dissatisfied, students know that they are experiencing misconceptions. This is given when the student answers the question wrong, then the student will know where the misconception is owned. By trying to answer again, students have a desire to correct misconceptions that occur. Intelligible, students are given new information or correct knowledge of the misconceptions that are being encountered, and from the results of interviews students simply understand the explanation of the given text. Plausible, new information provided to students makes sense. This is evident from the results of work and student interviews where students have the ability to improve the answers given. Fruitful, new information is helpful for solving future problems, this is seen when students have used the correct concept while working on posttest [17].

To further reassure the effect of refutational text in the conceptual changes of students, Effect Size calculation is done which states that $E_z = 1.8$, if $E_z < 1.00$ it can be asserted that the refutational text is strongly influencing in the conceptual changes experienced by the students [22]. Calculation of Effect Size uses a comparison of the pretest and posttest values, although there will still be other factors that cannot be measured in this study which also influence the results. However, the results given are refutational text enough give a strong role in the conceptual change effort to fix misconceptions of addition and subtraction of integers.

5. Conclusion
Refutational text plays a powerful and effective role in the effort of conceptual change to fix misconception on the matter of addition and subtraction of integers. This is seen from the Effect Size test which states that if an action is given influence more than 1 then the action gives a strong influence, wherein this study the influence of refutational text-aided learning media is $E_z = 1.8$ [22]. In addition, refutational text can also improve students' understanding matter of the addition and subtraction of integers because if there is a wrong concept will be given a signal that the concept is wrong and given the correct concept so that students can minimize the misconception in learning this material [17,18].

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