Students’ Understanding of Mathematical Concepts Using Manipulative Learning Media in Elementary Schools

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Abstract. This study aims to analyze students' understanding of mathematical concepts in the material of addition and subtraction of integers by using manipulative media in the form of colored paperboard designed into rectangular shapes. This research was conducted in class IV SDN 02 Koto Tangah. The subjects in this study are class IVB students with the total number of 25 students. The instrument used in this research was a subjective test that had fulfilled mathematical concept indicators and test indicators. Data analysis was carried out by using the N-Gain formula developed by Meltzer (2002 and then was interpreted based on the classification of the N-Gain index from Hake (1999). The results of this study reveal that mathematics learning by using manipulative media in the form of rectangular shape designed paperboard can improve students' understanding of mathematical concepts in the material of addition and subtraction of integers.

Keywords: Conceptual understanding, manipulative media, addition and subtraction of integers.

1. Introduction
Understanding of mathematical concepts is one of the mathematical understandings that students must acquire in learning mathematics. [1] defines concept understanding as the ability to explain concepts, use them in a variety of different situations, and develop their several cause-effect relations. In addition, understanding mathematical concepts can also be defined as the ability to formulate completion strategies, apply simple calculations, use symbols to present concepts, and change forms to other forms such as fractions in mathematics learning[2]. Therefore, understanding mathematical concepts is defined as the ability to understand definitions, symbols attached to concepts, interrelationship between several concepts, and transformation of simple concepts into more complex ones.

In learning mathematics, students are required to understanding mathematical concepts from the simple to the complex ones. [3] states that each concept in mathematics is related to other concepts, and a certain concept becomes a prerequisite to understand other concepts. [4] states that at the level of their deep understanding students are able to make connections among mathematical ideas and to generalize mathematical concepts, in [5]. Hence, understanding of mathematical concepts determines the success of students' mathematics learning[6]. It is a very important aspect of learning for students to absorb, master, and store in their long-term memory. Understanding of mathematical concepts is also an important basis for solving mathematical problems as well as everyday life problems [1]. Improving
students' understanding of mathematical concepts is one of the goals of implementing mathematics learning in schools. This is in accordance with the vision of mathematics learning development to meet the present needs of directing mathematics learning to conceptual understanding [7]. In this case, conceptual understanding is a required ability for students when learning mathematics from elementary to tertiary level.

Several studies reveal that students often have difficulty understanding mathematical concepts [8]. Furthermore, students’ understanding of mathematical concepts will influence their learning outcomes, [9]. Learning and working with concrete objects is a foundation for developing mathematical concepts, [10]. Therefore, the researcher believes that it is difficult for students to understand mathematical concepts because the learning process does not actively involve them to construct their knowledge by using concrete objects (media).

Using concrete objects (media) can be one of teachers’ efforts to improve students' understanding of mathematical concepts. In order to understand these concepts easily, the learning process must be arranged from the simple to complex ones and from the concrete to the abstract ones [8]. Moreover, the media can facilitate students in learning the concepts, [11]. The media is very instrumental in improving the quality of learning; they can be used to build understanding and to enhance understanding of abstract mathematical concepts and symbols [11]. Concrete media can provide an earlier introduction to mathematical concepts for students in accordance with the stages of their cognitive development [12]. The cognitive development of elementary school students is still bound by concrete objects (media) that can be captured by the five senses [13]. In other words, the use of concrete media can facilitate elementary school students in understanding mathematical concepts.

The media that teachers use in learning is called learning media. It is a tool that can help teachers to facilitate students in understanding the learning concepts. Students’ understanding of the concepts is an important factor in learning process. Learning can improve students’ learning outcomes and help them achieve the goals of mathematics learning [14]. Thus, the application of the learning media in mathematics learning increases students’ learning activities resulting in their increasing learning outcomes, [15][16]. Learning media used by teachers in mathematics learning should be able to stimulate students to learn. Therefore, the media used must be as engaging as possible. In light with this, [13] suggests that learning media that attracts students' attention to teaching and learning activities will further stimulate they learning activities. One of the media that can attract students’ attention is manipulative media. Manipulative media is those that can be seen, touched, heard, and manipulated, [17]. It is also defined as a tool to explain the subject matter, so students can easily understand the concepts of material taught through these objects. They are designed like the real ones close to students' daily lives such as fruits, animals, and transportation in the forms toys or beads that can be easily assembled or changed,[18]. Furthermore, according to[17], manipulative material in mathematics learning is a learning tool used primarily to explain mathematical concepts and procedures. In other words, learning by using manipulating media can improve students' understanding of mathematical concepts. [19]in her various research find manipulative objects in mathematics learning can help students understand abstract mathematical concepts. The use of manipulative learning media is very suitable for students of elementary school age who are in the concrete operational age,[20]. Another by research [21] concludes that learning mathematics by using manipulative objects significantly increases students' understanding of mathematical concepts, their understanding of spatial relation, and their positive attitudes towards mathematics learning.

In light of the use of manipulative objects (media) in learning, [22] mentions that the media used can be in the form of abacus, gravel, bottle caps, sticks, seeds, cuissenaire rods, and base ten blocks. In addition, [21] suggests that these manipulative objects do not have to be purchased; students can be assigned to create them as their homework. Teachers in using manipulative media must pay attention to the suitability of the media used with the learning objectives. In this study, the manipulative media is used to help students easily understand the concepts of addition and subtraction of integers through
rectangular shape designed paperboard with the color of light blue and yellow. Based on the above problems, the researcher is inspired to analyze the increase in students’ understanding of mathematical concepts by using manipulative media in elementary schools.

2. Research Methodology

This research is an experimental research with pre-experimental approach. The research design used in this study is a one-group pretest-posttest design [23] as in table 1.

![Table 1](https://example.com/table1.png)

**Description:**

- **T<sub>1</sub>**: Pretest, the test before using manipulative media
- **X**: Treatment, the learning process using manipulative media
- **T<sub>2</sub>**: Posttest, the test after using manipulative media

The population in this research are all sixth grade students of SDN 02 Koto Tangah, which consist of 2 classes, class IVA with 24 students and class IVB with 25 students. The class IVB was selected through random technique. Prior to this selection, the following steps were conducted: 1). Collecting data on students’ mathematics score in SDN 02 Koto Tangah, 2). Conducting population normality tests of students’ mathematics score, 3). Performing variance homogeneity test, 4). Conducting random selection after the population considered normal and homogeneous. The stages in this study include: 1) identifying problems and goals, 2) making learning media, 3) developing test instruments followed by validation of experts and empirical (field test trial), 4) conducting the pretest, 5) providing learning treatment using manipulative media, 6) conducting the post-test, 7) analyzing the test results, 8) drawing conclusions from the results of the study, 9) writing the research report. The data were collected by giving written tests through pretest and posttest to find out students' understanding of mathematical concepts related to addition and subtraction of integers. Students’ understanding of mathematical concepts is measured from their knowledge before and after the treatment through pre-test and post-test for the material addition and subtraction of integers. The test guidelines used to measure students' understanding of mathematical concepts are given in table 2 below.

![Table 2](https://example.com/table2.png)
The test instrument consists of 7 questions. Before this instrument was used in this research, it was validated by experts (3 Mathematics Education Lecturers and 1 Elementary School Teacher). The final validity obtained 7 valid questions with a slight improvement in terms of language use. After validity from the expert, the instrument was tested to IVA students to find out the empirical validity. The result of empirical validity on IVA graders was then processed to see what number of questions is valid. Based on the calculation of this validity, all questions are considered valid. After knowing the validity, the reliability, difficulty level, and discriminating power were also determined. The validity was tested by using Pearson Product Moment correlation formula [24] while the reliability was tested by using Alpha formula [25]. After obtaining the valid and reliable test instrument, the test was given to IVB graders to obtain the pretest and posttest results. Data obtained from the results of the pretest and posttest were then analyzed to see the improvement before and after the treatment with manipulative media for the addition and subtraction of integer materials. Quantitative data analysis was used to see the magnitude of the increase before and after the treatment by using normalized Gain formula developed by [26].

\[ N-Gain = \frac{Posttest Score - Pretest Score}{Maximal Score - Pretest Score} \]

Gain value obtained was interpreted based on the classification of the N-Gain index according to [27] as in table 3 below.

| N-Gain Index | Interpretation |
|--------------|----------------|
| \( N-Gain \geq 0.7 \) | High |
| \( 0.3 \leq N-Gain < 0.7 \) | Medium |
| \( N-Gain < 0.3 \) | Low |

3. Research Findings

From the pretest and posttest, the data of students’ maximum score and minimum score, average score (\( \bar{X} \)), and standard deviation (S) are obtained as follows. These data can be seen in table 4 below.

| Class | N | Max. Score | Min. Score | \( \bar{X} \) | S |
|-------|---|------------|------------|-------------|---|
| Pretest | 25 | 83.3 | 45.8 | 61.2 | 11.60 |
| Posttest | 25 | 95.8 | 50 | 78.3 | 12.03 |

The table 4. show the difference in the average score of students’ understanding of mathematical concepts. To find out the improvement of each sample N-Gain formula was. The results of the N-Gain formula value on students’ understanding of mathematical concepts can be seen in table 5. below.

| Sample Code | Pretest | Posttest | \( N-Gain \) | Criteria |
|-------------|---------|----------|--------------|----------|
| S1 | 45.8 | 50 | 0.0834 | Low |
From the table 5. above, it can be seen that the improvement occurred in 25 students, 3 with low criteria, 17 with medium criteria, and 5 students with high criteria. The average value of students’ improvement can be seen in table 6 below.

Table 6. The Average Value Of Students Improvement Based On N-Gain

| N   | Minimum Score | Maximum Score | Mean     | Criteria |
|-----|---------------|---------------|----------|----------|
| 25  | 0,08          | 1             | 0,54892  | Medium   |

From table 6. Above, it can be seen that the average value of N-Gain learning outcomes of 25 students is 0.54892. This value is in medium criteria. Pretest was given before the treatment was conducted. This test aims to find out the student's initial knowledge related to their ability to understand mathematical concepts for addition and subtraction of integers. The learning process was carried out by using manipulative media in the form of rectangular shape paperboard with light blue and yellow color. The use of this media aims to introduce students to the concepts of addition and subtraction of integers concretely.

Figure 1. Students are learning with manipulative media in.

Through the use of manipulative media, the researcher directed students to learn the concepts of addition and subtraction of integers. They were also asked to demonstrate the media in group, so they can obtain direct learning experience and discover their own concepts of addition and subtraction of
integers as well as compare them with the results obtained by their friends. After students knew the concepts of addition and subtraction of integers, the researcher then directed them to find the concepts of addition and subtraction of two integers (positive numbers with positive numbers, positive numbers with negative numbers, and negative numbers with negative numbers).

By using manipulative media in the form of paperboard, the researcher directed students to find out the concepts of addition and subtraction of integers. After using manipulative media, the researcher asked students about what they had found from the learning activities using this media. From the students' answers, the researcher then reexplained the material without using manipulative media pieces about the addition and subtraction of integers with the aim to lead students to abstract concept. Next, the researcher gave a quiz about the addition and subtraction of integers as a form of evaluation to find out the extent of students’ understanding of concepts. After get four meeting learning with manipulative media, the researcher gave them the posttest.

From the analysis of pretest and posttest data (table 4), the researcher obtained the minimum score of the pretest is 45.8, the maximum score is 83.3, and the average score is 61.2. As for the posttest, the minimum score obtained is 50, the maximum score is 95.8, the average score is 78.3. To find out each student’s understanding of mathematical concepts, N-gain test was conducted. From this calculation, there are 3 students with low criteria, 17 with medium criteria, and 5 with high criteria. Furthermore, to find out the improvement of all students average N-gain test was conducted. From this test, the average value obtained is 0.54892, which belongs to medium criteria. The findings of this study confirms the results of previous studies that reveal that the application of media in mathematics learning increases students’ learning activities and learning outcomes, [15][14]. This study also confirms the results of previous study which concludes mathematics learning by using manipulative objects significantly increases students’ understanding of mathematical concepts[21].

4. Conclusion
Based on the findings of the research, it can be concluded that mathematics learning using manipulative media can improve students' understanding of mathematical concepts. It can be seen from the large number of students who experience improvement on their understanding. 5 with high criteria, 17 with medium criteria and 3 with low criteria. It can also be seen from the average value of N-Gain obtained i.e 0.54892. This value is in the medium criteria. Based on the above conclusion, the researcher suggests that prospective teachers or experienced teachers can use the media in mathematics learning, especially in instilling mathematical concepts. One of the media is manipulative media in the form of colored paperboard designed into rectangular shapes. In addition, related to further research should be conducted on other manipulative media in mathematics learning to increase learning motivation, learning interest, and learning significance.

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