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Bruner's Theory Constructivist Learning on the Ability to Understand Mathematical Concepts of Elementary School Students

Yunita Wildaniati*
*Department of Madrasah Ibtidaiyah Teacher Education, Faculty of Tarbiyah and Teacher Training, Institut Agama Islam Negeri Metro, Indonesia
*Department of Basic Education, Graduate School, Universitas Negeri Malang, Indonesia
E-mail: wildaniatiyunita3@gmail.com

Ummi Nur Rokhmah**
**Department of Madrasah Ibtidaiyah Teacher Education, Faculty of Tarbiyah and Teacher Training, Universitas Islam Negeri Siber Syekh Nurjati Cirebon, Indonesia
**Department of Basic Education, Graduate School, Universitas Negeri Malang, Indonesia
E-mail: umminurrokhmah@syekhnurjati.ac.id

Susana Eka Dewi***
***Department of Basic Education, Graduate School, Universitas Negeri Malang, Indonesia
E-mail: susana.eka.2321039@students.um.ac.id

Fattah Hanurawan****
****Department of Psychology Education, Faculty of Psychology, Universitas Negeri Malang, Indonesia
E-mail: fattah.hanurawan.fppsi@um.ac.id

Ade Eka Anggraini*****
*****Department of Basic Education, Graduate School, Universitas Negeri Malang, Indonesia
E-mail: ade.ekaanggraini.pasca@um.ac.id

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Abstract

Having the ability to understand concepts is fundamental to learning math, and it is important for students. This study is directed to examine the impact of Bruner's constructivist learning approach on elementary school students' ability to understand mathematical concepts. The type of research used is pre-experimental with a one group pre-test-post-test design. This study focuses on grade IV students from SDN 04 Ardirejo, Kepanjen Regency Malang. Data was collected using a written test in the form of a description of 5 points of pre-test questions and 5 points of post-test questions. Research data was analyzed using descriptive and inferential statistics with a paired sample t-test. The test results of the t test obtained that t_{count} is 20.065 while t_{table} is 2.059. Because 20,065 > 2,059, the $t_{count} > t_{table,}$ it can be concluded that there is a significant influence from the application of Bruner's theoretical constructivism learning on the ability to understand mathematical concepts of grade IV students of SDN 04 Ardirejo, Kepanjen Regency Malang.

Keywords: *bruner's theory of constructivism, understanding mathematical concepts.*

Abstrak

Memiliki kemampuan untuk memahami konsep adalah hal fundamental dalam belajar matematika, dan hal ini penting bagi siswa. Studi ini diarahkan untuk mengkaji dampak dari pendekatan pembelajaran konstruktivisme yang dikembangkan oleh Bruner, terhadap kemampuan siswa sekolah dasar dalam memahami konsep-konsep matematika. Jenis penelitian yang digunakan adalah pre eksperimental dengan desain one group pre-test-postest. Subjek dalam penelitian ini adalah siswa kelas IV SDN 04 Ardirejo Kepanjen Regency Malang. Pengumpulan data dilakukan dengan menggunakan tes tertulis bentuk uraian sebanyak 5 butir soal pretes dan 5 butir soal post-test. Analisi data penelitian dilakukan dengan menggunakan statistik deskriptif dan inferensial dengan uji paired sample t-test. Hasil pengujian uji t diperoleh bahwa t_{hitung} bernilai 20,065 sedangkan t_{tabel} sebesar 2,059. Karena 20,065 > 2,059 maka $t_{hitung} > t_{tabel}$ sehingga dapat disimpulkan bahwa terdapat pengaruh yang signifikan dari penerapan pembelajaran konstruktivisme teori Bruner terhadap kemampuan pemahman konsep matematis siswa kelas IV SDN 04 Ardirejo Kepanjen Regency Malang.

Kata kunci: *konstruktivisme teori bruner, pemahaman konsep matematis.*

INTRODUCTION

Mathematics is compulsory for every elementary school student (Khoirunnisa & Soro, 2022; Rinaldi & Alfriansyah, 2019). NCTM states that in order to solve a problem, one must understand the concept of matter (Mayasari & Habeahan, 2021). Understanding concepts is one of the mathematics learning goals that must be owned by every student who learns mathematics (Diana et al., 2020; Etyarisky & Marsigit, 2022). Since elementary school, students must be educated to understand mathematical concepts (Radiusman, 2020). Understanding concepts is the foundation for understanding principles and theories, so students must first grasp the concepts that form these theories and principles. Failure to grasp mathematical concepts can be fatal (Diana et al., 2020). According to Sari (2018), understanding mathematical concepts is the ability of students to understand concepts and perform procedures flexibly, accurately, and precisely.

The indicator of the ability to understand mathematical concepts is the ability to reconvey a concept, the ability to categorize objects by their characteristics; the ability to give examples and not examples; the ability to present concepts in many forms of mathematical representation; the ability to develop the necessary or sufficiently solid conditions for a concept; the ability to use, utilize, and select specific procedures or operations; and the ability to use concepts in problem solving (Mayasari & Habeahan, 2021; Radiusman, 2020; Sumarmo et al., 2019). Students who have a good understanding of mathematical concepts will quickly remember, use, and rearrange the concepts they have learned, in addition to the ability to solve various types of math problems (Hadi & Umi Kasum, 2015). However, students' lack of understanding of mathematical concepts and low absorption rates are significant problems in mathematics learning.

Kusumadewi et al. (2020) said the cause of students' low understanding of concepts is difficulty in seeing and understanding the questions tested. In the learning process, students often experience confusion and do not understand the relationship between different topics in the subject. Students are not enthusiastic about asking questions and do not use objects around them to help them learn, and they lack using learning media that are interesting and fun.

Markovits & Forgasz, (2017) explained that most students do not like mathematics because it is considered complicated, complete with formulas that must be memorized, and complete with numbers. As a result, when teachers explain the material, most students are not actively involved in learning. (Buyung et al., 2022) also mentioned that the factors causing students to lack understanding of mathematics are students' attitudes and interests are shallow towards mathematics, students do not like mathematics, some students believe that mathematics is a complex and boring subject, and teachers ignore them during learning. As a result, students often experience discouragement during their learning process. Rinaldi & Alfriansyah (2019) Add that the teacher becomes the center of the learning process, so students are not given the opportunity to construct their understanding of the material being studied. This means conventional methods are still used to teach mathematics.

Based on the results of a pre-survey conducted in grade IV SDN 04 Ardirejo, Kepanjen Regency Malang, information was obtained that 85% of students are still constrained in restating a concept of multiplication and division material, only 12% of students can solve problems related to daily life. The class teacher informed me that mathematics is considered difficult by most students. Students face difficulties in mathematics lessons when they change concepts from abstract to concrete and vice versa. In addition, students continue to struggle with comprehending and implementing concepts in narrative problems. The teacher also mentioned that he faced challenges in presenting the mathematics material in a way that was easily understood by the students, despite his own enjoyment of the subject. The problem of low understanding of students' mathematical concepts cannot be ignored, considering that understanding concepts is a fundamental ability that students must have before having other mathematical abilities. Constructivist learning can help solve this problem.

Constructivism is an approach to learning that allows students to build, interpret, and reorganize what they know (Mbonane & Mavuru, 2022). The main principle of constructivist learning is when students are actively involved in the process of constructing their knowledge (Rababah, 2021). Constructivist theory emphasizes that learning is an active process in which individuals actively build knowledge and understanding from their experiences. In the context of constructivist learning, teachers act as facilitators who help students become active participants in their learning and make meaningful connections between previous and new knowledge (Olusegun, 2015). The constructivist learning theory used in this study is a school of cognitive psychology. Matsumoto (2017) states that cognitive theory centers on the learning process, giving students more opportunities to develop the rational abilities necessary to understand and recognize what they are learning. In other words, cognitive theory does not focus on learning outcomes, but rather on how the learning process unfolds based on students' perceptions of specific situations, enabling them to achieve meaningful and long-lasting changes. There are many types of perspectives regarding cognitive theory, one of which is Jerome S. Bruner. Jerome S. Bruner is known as one of the main figures in the modern constructivist theory of education (Metsämuuronen & Räsänen, 2018).

Lestari & Yudhanegara (2018) Bruner's theory is a practical and creative learning process in which teachers allow students to discover ideas, theories, rules, or understandings through real examples. This process is called discovery learning. Ardana et al. (2017) argue that Bruner's theory can be used as an alternative to teaching mathematics, especially to teach easy to understand concepts. Bruner states that three stages in students' cognitive development

are determined by how they perceive the world: the enactive stage is when students manipulate (tinker) objects with concrete objects. The next stage is iconic, where students show their knowledge in the form of pictures or graphics, and the last stage is symbolic, where students show their knowledge in mathematical symbols (Gningue et al., 2014; Lee & Kim, 2012). Therefore, Bruner's theory can be used as an alternative in mathematics learning to improve students' concept comprehension ability.

Previous research conducted by Lumbanbatu et al. (2023) mentions that students learn through active involvement in practice. Teachers encourage students to participate in activities that allow them to discover concepts and principles independently so that they can discover and understand concepts independently. The study's results were strengthened by research conducted by Wibowo et al. (2023), which states that applying Bruner's theory can activate students' learning so that the final learning results are obtained; as many as 92% of students experience improved learning outcomes. In addition, research from (Mutaqin et al., 2021; Nashiru et al., 2018) states that applying Bruner's theory in the learning process can increase student interest and achievement. The results showed that applying Bruner's theory helps students in learning mathematics (Rusdi et al., 2020).

Although the results show that the application of constructivist learning based on Bruner's theory contributes positively to students' understanding of mathematics, there are still some schools where the application of Bruner's theory has not fully occurred. One aspect that can be the focus of improvement is the application of Bruner's theory to the concept of the smallest common multiple and the largest common factor. Although the potential application of Bruner's theory to the material is recognized, the lack of implementation at the teacher level can hinder the development of students' ability to use the concept. Therefore, further efforts are needed to improve the application of Bruner's theory in the context of mathematics learning in elementary schools, especially on the material of the Smallest Common Multiple and Largest Common Factor.

Based on the description above, this research aims to see the effect of applying Bruner's constructivist learning theory on the ability to understand the concepts of Least Common Multiple and Greatest Common Factor in grade IV SDN 04 Ardirejo, Kepanjen Regency Malang. It is hoped that by implementing this learning, students will not feel bored with learning mathematics, can improve their understanding of mathematical concepts, and positively impact their learning outcomes.

METHODS

This research uses a type of quantitative research with *pre-experimental design research methods. Pre-experimental design* is a study that involves one group of students as an experimental group without a control group, and the sample is not randomly selected (Ahyar et al., 2020). This method is used based on the purpose of the study, which is to determine the influence of Bruner's constructivism learning theory on students' ability to understand students' mathematical concepts in grade IV SDN 04 Ardirejo Kepanjaen, Malang Regency with a total of 26 subjects for the 2023/2024 academic year. Researchers ran tests twice before and after applying Bruner's constructivism learning to achieve the study's objectives. This study used a pre-test-post-test group design, which has three stages, namely (1) pre-test is given to measure dependent variables before treatment; (2) experiments are given to all

subjects; and (3) post-tests are given to measure dependent variables after treatment (Hikmawati, 2020). The design drawings are as follows:

Table 1. One Group Pre-test – Post-test Research Design

Pretes	Treatment	Post-test
O_1	X	O_2

Information:

O_1 = The pre-test is carried out before the application of Bruner's constructivist theory of learning.

X = Bruner's constructivist learning theory

O_2 = Post-test is carried out after applying Bruner's constructivist learning theory.

The instrument used in this study was a description form test of 5 pre-test questions and 5 post-test questions. The questions have been arranged according to indicators to measure students' ability to understand mathematical concepts. Researchers use holistic assessment rubrics to guide the scoring of students' answers on pre-tests and post-tests (Becker, 2016).

The following is the scoring rubric for the students' mathematical concept comprehension ability test.

Table 2. Scoring Rubric Ability to Understand Mathematical Concepts

Indicator	Conditions	Score
Restating a concept	Not answer	0
	Restating a concept but being wrong	1
	Restating a concept is incomplete	2
	Restating a concept correctly	3
Classify objects based on specific properties that correspond to a concept	Not answering	0
	Classify objects based on specific properties but do not fit their concept	1
	Classify objects based on specific but less complete properties	2
	Classify objects based on specific properties according to their concept	3
Give examples rather than examples of a concept	Not answering	0
	Giving examples and not examples but wrong	1
	Gives examples and no examples but is less complete	2
	Give examples instead of examples correctly	3
Apply a concept or algorithm to problem solving	Not answering	0
	Unable to apply formulas according to procedures in solving problems	1
	Can apply formulas according to the procedure in solving problems, but there are still many errors	2
	Can apply formulas according to procedures in solving problems but not yet appropriate	3
	Can apply formulas according to procedures in solving problems correctly	4

(Sumarmo et al., 2019)

The data obtained from the results of the study were processed using descriptive and inferential statistics. Descriptive analysis is used to see a picture of students' ability to understand mathematical concepts. In contrast, statistical analysis of inference is used to see the influence of Bruner's theory of constructivism learning on the ability to understand mathematical concepts of elementary school students. The results of the mathematical concept comprehension ability test that students have done are analyzed to determine the percentage of achievement of the student's mathematical concept comprehension ability indicator. The formula used is as follows (Afridiani et al., 2020):

$$P_n = \frac{\sum Achievment\ score\ item\ indicator}{\sum total\ score} \times 100\%$$

Based on the acquisition of percentage data, the ability to understand mathematical concepts of students is classified based on the following criteria (Alzanatul Umam & Zulkarnaen, 2022):

Tabel 3. Level of Understanding

Percentage	Level of Understanding
$0\% - 20\%$	Less Than Occasionally
$21\% - 40\%$	Less
$41\% - 60\%$	Enough
$61\% - 80\%$	Good
$81\% - 100\%$	Excellent

The instrument before being used to measure the ability to understand students' mathematical concepts, the instrument has been tested, and the instrument has met the criteria of valid, realistic, and meets the criteria of difficulty level and discriminating power of the problem. The results of the validity test of each question item are said to be valid if the $r_{xy} > r_{tabel}$have a significance of 5% (0.05). The trial of this instrument was given to 26 grade V students at SDN 04 Ardirejo, Kepanjen, Malang Regency. From the results of the pre-test validity calculation, it is obtained that each item of the question item is a valid question but has a different valid category. The first question item($r_{xy} = 0{,}83$) has a very high category. The second Question Point ($r_{xy} = 0{,}71$)has a high level of validity, the third question item ($r_{xy} = 0{,}63$) has a high level of validity. The fourth question point ($r_{xy} = 0{,}65$) has a high degree of validity, and the fifth question item ($r_{xy} = 0{,}43$) has a high level of validity.

The results of the post-test validity calculation are obtained that all questions are valid questions but have different validity categories. The first question item($r_{xy} = 0{,}53$) has a freasonably high category, the second question item ($r_{xy} = 0{,}67$) has a high level of validity, the third question item ($r_{xy} = 0{,}63$) has a high level of validity, the fourth question item (has a high level of validity), and the fifth question item $r_{xy} = 0{,}73$)($r_{xy} = 0{,}81$) has a very high level of validity. As for the value of $r_{tabel} = 0{,}404$. For reliability, pre-test questions are obtained $r_{11} = 0{,}68$ With the category of high reliability and for post-test questions, scores are obtained $r_{11} = 0{,}69$ With the category of high reliability, it can be concluded that the question is a reliable problem.

For the level of difficulty of the pre-test questions, it was found that they were neither too difficult nor too easy. From the calculation of the level of difficulty, it is obtained that the first question item (0.65) has a medium category, the second question item (0.91) has an easy category, the third question item (0.52) has a medium category, the fourth question item (0.39) has a medium category, and the fifth question item (0.93) has an easy category. At the same time, the results of calculating the difficulty level of the post-test questions were obtained that the first question (0.62), the second question point (0.53), the third question point (0.48), the fourth question point (0.7) and the fifth question point (0.65). The five post-test questions have a moderate level of difficulty.

For the level of discriminating power, questions are carried out to determine the ability of the questions to distinguish between high-ability students and low-ability students. Based on the calculation of the distinguishing power of the pre-test questions, it is obtained that the first question item (0.35), the second question item (0.39), the third question item (0.21), the fourth question item (0.25), the fifth question item (0.22). The results of the calculation of the distinguishing power of the post-test questions were obtained that the first question item (0.25), the second question item (0.22), the third question item (0.26), and the fourth question item (0.34), the fifth question item (0.32). The distinguishing power category of the five pre-test and post-test questions is with sufficient categories.

A normality test is carried out before conducting data analysis and hypothesis testing. The normality test result shows that the significant value obtained is 0.200 greater than the actual level value $\alpha = 5\%$, so the data is normally distributed. Next, the hypothesis test is carried out using the paired sample t-test.

RESULTS AND DISCUSSION

This study sought to examine the impact of Bruner's constructivism theory on the comprehension of mathematical concepts among grade IV students at SDN IV Ardirejo, Kepanjen Regency Malang. This study utilized the Smallest Federal Multiple (KPK) and the Largest Federal Factor (FPB), teaching four lessons to a total of 26 students. To see the effect of Bruner theory constructivism learning on the ability to understand mathematical concepts, students were given an initial ability test (pre-test) before applying Bruner's theory constructivism learning treatment and a final ability test (post-test) after being given Bruner's theory constructivism learning approach. The recapitulation of the results of the test of students' mathematical concept comprehension ability after being given pre-tests and post-tests is as follows:

Table 4. Description of the Ability to Understand Mathematical Concepts of Class IV Students of SDN IV Ardirejo, Kepanjen Regency Malang

Tes	Number of Students	Top Rated	Lowest Value	Sum	Average	Standard Deviasi
Pre-tes	26	47	24	842	32,38	6,2
Post-test	26	100	59	2123	81, 65	11,5

Based on Table 4 above, it can be seen that there is an increase in students' ability to understand mathematical concepts before and after being given Bruner's theoretical constructivism learning. In the pre-test, the average score of students' mathematical concept

understanding ability was 32.38, and at the time of the post-test, it was 81.65. The constructivist approach has an important role in mathematics education today.

The constructivist approach makes students more active, and students' grades increase day by day. Students can build concepts according to their previous knowledge and learning style (Tan et al., 2022; Tezer & Cumhur, 2016). The constructivist approach of Bruner's theory emphasizes the active role of students in organizing information and using existing conceptual frameworks or structures to build their knowledge according to their learning styles. This approach shows that learning is not simply the receptivity of information but involves students' active participation in shaping their meaning and understanding (Lee & Kim, 2012; Matsumoto, 2017).

In addition, the test results of students' ability to understand mathematical concepts can be seen from how many students answered correctly on each test question item. Here is a summary of the number of students who correctly answered during the pre-test and post-test, among other factors:

Table 5. Students Answer Appropriately

Question items	Pre-test		Post-test	
	Multiple Students	Percentage	Multiple Students	Percentage
1	1	3,80%	10	3,80%
2	0	0%	13	38,50%
3	0	0%	20	50%
4	0	0%	5	76,90%
5	0	0%	13	50%

Based on Table 5 above, it can be seen that many students can answer correctly on the test items of students' mathematical concept comprehension ability during the post-test more than during the pre-test. This proves that there is an increase in students' ability to understand mathematical concepts during pre-test and post-test. Furthermore, from the pre-test and post-test value data, an analysis of the achievement of the concept understanding indicator was carried out. The following is a recapitulation of the achievement of indicators of students' ability to understand mathematical concepts:

Table 6. Recapitulation of Achievement of Indicators of Ability to Understand Mathematical Concepts

Indicator	Pre-test			Post-test	
		Percentage	Description	Percentage	Description
Restate a concept	47	60,3%	Good	83,3%	Excellent
Classify objects based on specific properties that correspond to a concept.	28	35,9%	Less	85,9%	Excellent
Give examples rather than examples of concepts.	34	43,6%	sufficient	100%	Excellent

Apply a concept or algorithm to problem solving	67	32,2%	Less	87,9%	Excellent
Average		43%	Sufficient	89,3%	Excellent

Based on Table 6 above, it can be concluded that the average achievement of students' mathematical concept understanding ability during the pre-test is in the sufficient category, while during the post-test, the average achievement of students' mathematical concept understanding ability is in the outstanding category. In terms of the final average percentage gain, the pre-test and post-test scores were 43% and 89.3% of the maximum percentage score of 100%. The students' ability to understand mathematical concepts has significantly improved both after and before the implementation of Bruner's theoretical constructivism learning. This can be seen from the indicator of classifying objects based on specific properties that correspond to a concept, providing examples and not examples of a concept, and applying concepts or algorithms into problem solvingDuring the pre-test, the scores fell into the less, sufficient, and less categories, whereas during the post-test, they were in the outstanding category. This is in accordance with research from A. Nashiru et al. (2018), which shows that students have difficulty understanding mathematical concepts both conceptually and procedurally during the pre-test. However, after intervention using teaching and learning strategies based on Bruner's developmental theory, there was a significant improvement in understanding of concepts.

Furthermore, we collected data on the student's ability to understand mathematical concepts prior to the hypothesis test, and then conducted a data normality test. Based on the data normality test conducted using SPSS 22 software, it is then seen whether the sample is normally distributed or not. As for the normality test results, the significant value is 0,200, and $\alpha = 5\%$ (0,05). The data is normally distributed because it is significantly or equal to alpha equals 0,05. Then, proceed to the hypothesis test using the paired sample t-test with the help of SPSS 22 software, and the acceptance criterion is if the significance $< \alpha$. The results obtained after the hypothesis test is that the value of the significance of the data is as high as $(0{,}00)$ and α $(0{,}05)$. So it can be concluded that there is an influence of Bruner's theoretical constructivism learning on the ability to understand mathematical concepts of grade IV students of SDN 04 Ardirejo, Kepanjen Regency Malang.

According to Zuliana et al. (2019), the application of Bruner's theory in learning has improved students' mathematics learning outcomes and activity levels. Students learn through active engagement with concepts and principles, and teachers encourage students to gain experience by doing activities that allow them to discover concepts (Tampubolon, 2018; Wen, 2018). Bruner's theory-based teaching can also help improve students' skills in solving math problems by reducing misunderstandings that occur in solving these problems (Tupamahu et al., 2023).

Based on the results of the analysis of research data conducted, the fact was obtained that students' ability to understand mathematical concepts showed an increase in each indicator. A significant improvement occurred in the indicator classifying objects based on properties that correspond to their concept and the indicator applying the concept or algorithm

into problem solving before learning in the category "less" became "excellent", followed by indicators giving examples and not examples that when pre-test in the category "sufficient" and when post-test became "Excellent". Overall, students' achievement of mathematical concept comprehension ability also achieved an improvement which during the pre-test in the "sufficient" category became "Excellent".

Enhancing students' comprehension of mathematical concepts from the pre-test to the post-test indicates a significant impact from the implementation of Bruner's theoretical constructivism learning, thereby contributing to the achievement of optimal student learning outcomes. Febrianti & Purwaningrum (2021) stated that the use of learning models based on Bruner's theory can help students become more active in thinking and more easily understand the problems faced. Using Bruner's approach, students can discover new ideas through observation and combine them with old pictures so as to produce extraordinary ideas.

Bruner's theory provides a solid theoretical basis for investigating how students' own contextual experiences can help them understand the subject matter (Sherwood & Makar, 2022). Bruner's theory introduces the concept of "Discovery Learning," in which students actively build their knowledge. This process occurs by means of students organizing and categorizing information using coding systems so that they not only passively receive information but are also actively involved in the formation of their understanding. Thus, through exploratory and participatory learning actions, students become more involved in the construction of knowledge and the development of their cognitive skills (Jiang & Perkins, 2013; Metsämuuronen & Räsänen, 2018)

CONCLUSION

Based on the results of the research that has been done, it is concluded that Bruner's constructivism theory of learning can positively affect students' ability to understand mathematical concepts. This is shown by increasing the ability to understand students' mathematical concepts before and after the application of learning.

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