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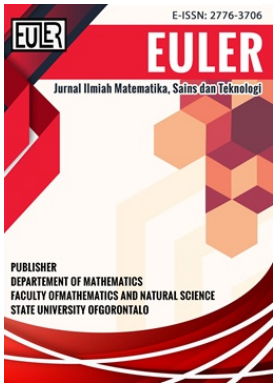

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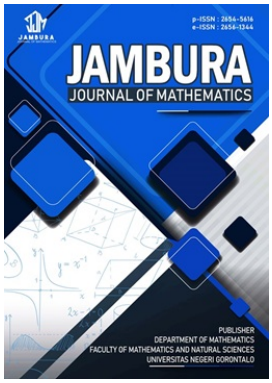

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Research Article

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Mathematics Education Students' Understanding of Exponent Concepts Based on Cognitive Style

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ABSTRACT. *This study aims to explore the understanding of the concept of exponents of mathematics education students in terms of cognitive style. This type of research is qualitative with a case study approach. The subjects in this study were 2 mathematics education students consisting of 1 student with reflective cognitive style and 1 student with impulsive cognitive style. The instruments used in this study were 2 items of exponent problem solving and interview guidelines. The results showed that Reflective Cognitive Style Subjects were able to fulfill all indicators of understanding the concept of exponents, namely indicators of exponent problem solving, identifying positive, negative, and zero exponents, using exponent rules, understanding roots and fractions as exponents, and identifying and correcting exponent misconceptions. Meanwhile, Impulsive Cognitive Style Subjects were only able to fulfill 4 indicators of understanding the concept of exponents. Impulsive Cognitive Style Subjects were not able to fulfill the indicators of identifying and correcting exponent misconceptions. The advantage in this study is to fill the gap in the literature by connecting the understanding of the concept of exponents and cognitive style variations. Furthermore, making mathematics education students as research targets. It offers novelty because their understanding of exponents has direct implications on how they teach the concept in the future.*

1. Introduction

Mathematics is one of the important subjects related to the development of science and technology [1]. In addition, the National Research Council (1989) as cited in Hikmahturrahman [2] stated that mathematics is the basis of science and technology. Therefore, mathematics has become a very important in the national education curriculum taught, starting from elementary school to college level.

One of the concepts in mathematics that needs to be understood deeply is exponents. Understanding the concept of exponents is a very fundamental aspect of learning mathematics. For mathematics education students, understanding the concept of exponents is very important because they are not only required to master the concept, but also to be able to teach it effectively to students. However, previous research shows that students' understanding of the concept of exponents often has difficulties, especially in applying the concept to contextual situations or solving complex problems. The findings in the research conducted by Ridho'i & Agustin [3] showed that some types of student concept errors were unable to restate the concept of the problem in mathematical representation, which resulted in the subject experiencing difficulties and errors in using the problem solving algorithm which resulted in the subject's answer being wrong. Then the subject is unable to group similar terms which is one of the basic concepts that must be understood in solving exponent problems.

In addition, the findings in the research conducted by Junengsih & Sutirna [4] showed that the subject had difficulty in applying the properties of exponents to the problem and also did not understand the meaning of the problem of power numbers. The subject also made mistakes in operating the answer which should have used the properties of exponents in solving the problem. While the research findings by Imelda & Indrie [5] show that students tend to be constrained by their inability to understand the problem and find the right concept in solving the problem so that they are less careful in the problem solving steps.

Cognitive style is a characteristic that each individual has in receiving, storing, processing, and using information to achieve a goal [6]. While in the context of learning, cognitive style is a typical student's way of learning, both with regard to the way of receiving and managing information, attitudes towards information, and habits related to the learning environment [7]. Each student has differences in how to acquire, store, and apply a certain amount of knowledge. The difference in these ways can be seen in the way students process their understanding regarding what students see, remember, and think about [8].

In the context of mathematics education, cognitive factors often determine how a person understands mathematical concepts, including exponents. This is in line with the opinion of Kurniasari & Sritresna [9] which states that cognitive style affects students in understanding mathematical materials and problems

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because students have their own way of solving given problems. This is also reinforced by some findings in previous studies. Wijayanti et al. [10] showed that subjects with auditory and kinesthetic learning styles have a better understanding of the concept of exponents compared to subjects with visual learning styles.

With regard to cognitive style, Septiani & Pujiastuti [11] showed that the ability to understand the mathematical concepts of students have similarities and differences. Students in the Field Independent (FI) cognitive style group have similarities that they are able to achieve all indicators of understanding mathematical concepts. Students in the cognitive style group Field Intermediate (FID) have differences in ability that is only one student who can achieve all indicators and other students only achieve some indicators, while students in the cognitive style group Field Dependent (FD) only a few indicators that can be achieved by students in understanding mathematical concepts. Reflective cognitive style and impulsive cognitive style is a cognitive style that has been widely studied [12]. According to Rismen et al. [13], reflective and impulsive cognitive style is a cognitive style that shows conceptual tempo or speed of thinking. Tempo or speed in question is the time used to respond to information received [14].

Previous research shows that there is a correlation between cognitive style and success in learning mathematics. However, research that explores or connects understanding of exponent concepts with cognitive styles, especially in mathematics education students is still very limited. Existing research tends to focus more on understanding mathematics in general or other basic mathematical concepts such as arithmetic or geometry, without giving special attention to exponents. In addition, the majority of studies that have been conducted at the higher education level have not integrated cognitive style as the main variable in exploring the understanding of mathematical concepts, including understanding the concept of exponents. Given the importance of this, more specific research is needed to explore how cognitive style affects the understanding of the concept of exponents of mathematics education students.

Therefore, this study aims to explore the understanding of the concept of exponents of mathematics education students in terms of cognitive style. This research is expected not only to contribute to the development of mathematics learning the ory, but also to be the basis for the development of diagnostic instruments that can assist lecturers in adjusting teaching methods based on differences in student cognitive styles.

2. Methods

This study used a qualitative research type of case study approach. This study was designed to explore the understanding of the concept of mathematics education students based on cognitive style. Case study research is an effort made to describe and analyze in depth a particular case. Qualitative research is a research process to reveal a social phenomenon and human problems that occur in individuals, groups, communities, and organizations in the form of behavior, perception or action [15]. The subjects in this study were 2 mathematics education students consisting of 1 student with reflective cognitive style and 1 student with impulsive cognitive style. Students were given 2 items to measure exponent problem-solving ability.

The procedure in this study consisted of: (1) the preparation stage, namely the initial observation to identify the problem, Developing instruments consisting of cognitive style questionnaire, test questions understanding of exponent concepts and interview guidelines, and conducting expert validation of research instruments; (2) the implementation stage, namely giving a questionnaire to determine cognitive style and grouping subjects based on cognitive style, giving tests understanding of exponent concepts, and determining 2 subjects consisting of 1 subject reflective cognitive style and 1 subject impulsive cognitive style, and conducting interviews to each subject; (3) the final stage, namely analyzing and concluding how the understanding of the concept of exponent subjects based on cognitive style.

Furthermore, researchers conducted in-depth interviews to explore the understanding of the concept of exponents as well as tracing and confirming the test results of students' exponent problem-solving ability. The data analysis technique used is Miles et al. [16] which consists of: a) *data condensation*; b) *display data*; c) *verification*. The researcher set some indicators of understanding the concept of exponents in Table 1.

Table 1. Indicators of understanding the concept of exponents

No.	Indicator	Activity
1	Solving Exponent Problems	Able to solve exponent problems
2	Identifying Positive, Negative, and Zero Exponents	Able to distinguish and calculate the results of exponent operations with positive, negative, and zero numbers.
3	Using Exponent Rules	Able to apply the rules of exponents.
4	Understanding Fractional Roots and Ranks as Exponents	Able to relate fraction exponents with root operations.
5	Identifying and Correcting Exponent Misconceptions	Able to identify common errors in exponent calculation

3. Results and Discussion

3.1. Subject of Reflective Cognitive Style (SRCS)

The following are the results of the written test of SRCS's understanding of the concept of exponents in solving problem number 1.

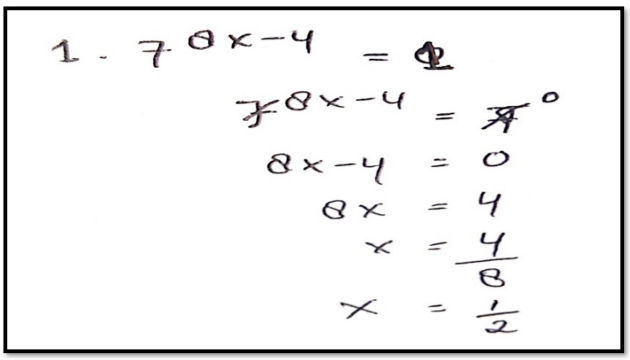

Figure 1. SRCS Test Results Problem 1

Based on the test results in Figure 1, SRCS seems to be able to solve problem number 1 of exponent problem solving. This shows that SRCS is able to fulfill the first indicator of understanding the concept of exponents, namely solving exponent problems. SRCS explained that in solving the problem, he only used one exponent rule, namely every number multiplied by zero is 1. So the number 1 in the question is changed to 7^0. The selection of 7^0 is adjusted to the number in the question, namely $7^{8\times-4}$. This was done to facilitate problem solving. Therefore, SRCS was also able to fulfill the second exponent concept understanding indicator which is identifying positive, negative, and zero exponents. This is also supported by the interview results which show that SRCS is able to understand and explain that $2^{-3} = \frac{1}{2^3} = \frac{1}{8}$. This is in accordance with one of the rules of exponents namely $a^{-n} = \frac{1}{a^n}$.

The following are the results of the written test of understanding the concept of SRCS exponents in solving problem number 2.

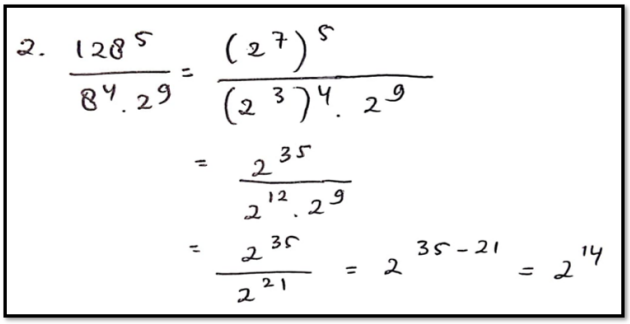

Figure 2. SRCS Test Results Problem 2

Based on the test results in Figure 2, SRCS appeared to be able to solve problem number 2 correctly. This shows that SRCS was able to fulfill the indicators of exponent problem solving in problem number 2. Based on the interview results, SRCS explained that 128 and 8 were converted into power form, so 128 became 2^7 and 8 became 2^3. Furthermore, using the rule of power multiplication, namely $(a^m)^n = a^{m.n}$. So $(2^7)^5$ became 2^{35}, while $(2^3)^4$ became 2^{12}. Furthermore $2^{12}.\ 2^9 = 2^{21}$. The exponent rule used is the power multiplication rule, which means that if the variables are the same, then the powers are added together.

The last step is to use the fraction power rule or division rule. In the rule, the power of the numerator minus the power of the denominator where the variables are the same value. So, the result obtained is $\frac{2^{35}}{2^{21}} = 2^{14}$. Therefore, SRCS was able to fulfill the third indicator of understanding the concept of exponents, namely using exponent rules, and the fourth indicator, namely understanding roots and powers of fractions as exponents. SRCS also fulfills the indicators of identifying and correcting the concept of exponents. This can be seen from the interview results which show that SRCS is able to identify errors in the statement $(2 \times 3)^2 = 2 \times 3^2 = 18$. SRCS stated that both statements were wrong. Based on the concept of exponents, the way to simplify the expression is $(2 \times 3)^2 = 2^2 \times 3^2 = 4 \times 9 = 36$. In the second statement, SRCS is also able to identify and correct exponent misconceptions, namely $2^3 + 2^4 = 2^{3+4} = 2^7$. On the concept of exponents, $a^m + a^n \neq a^{m+n}$. The correct concept is, $a^m \times a^n = a^{m+n}$. So that in this statement there is a misconception because it is not in accordance with the concept of exponents. The way to solve the problem that is in accordance with the concept of exponents is $2^3 + 2^4 = 8 + 16 = 24$.

3.2. *Subject of Impulsive Cognitive Style (SICS)*

The following are the results of the written test of understanding the concept of SICS exponents in solving problem number 1.

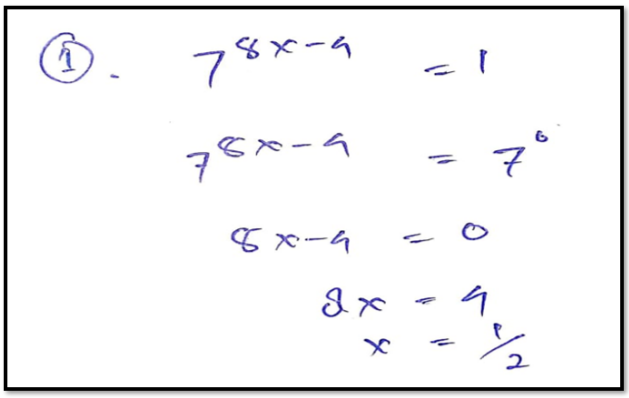

Figure 3. SICS Test Results Problem 1

Based on the test results in Figure 3, SICS seemed able to solve problem number 1 of exponent problem solving and was able to fulfill the first indicator of understanding the concept of exponents, namely solving exponent problems. SICS admitted that at first he had difficulty in solving the problem. SICS explained that it took time to determine the exponent concept used in solving the problem. Concept understanding ability is also very important, namely understanding the concept that every number multiplied by zero is 1. So the number 1 in the question is changed to 7^0 which is adjusted to the question, namely $7^{8\times-4}$. This is done to facilitate problem solving. SICS was also able to fulfill the second exponent concept understanding indicator which is identifying positive, negative, and zero exponents. **SICS** seemed to understand and was able to explain that $2^{-3} = \frac{1}{2^3} = \frac{1}{8}$. This is in accordance with one of the rules of exponents, namely $a^{-n} = \frac{1}{a^n}$.

The following are the results of the written test of understanding the concept of SICS exponents in solving problem number 2.

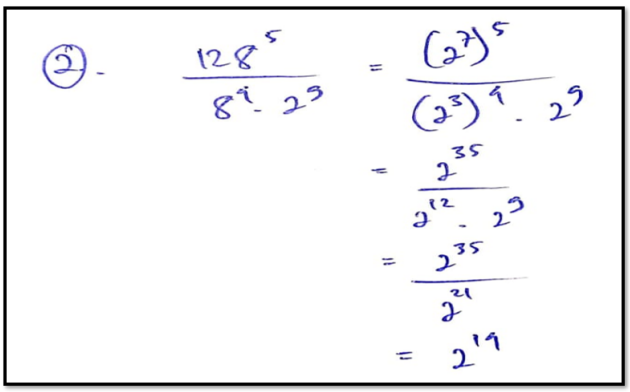

Figure 4. SICS Test Results Problem 2

Based on the test results in Figure 4, SICS appears to be able to solve problem number 2 so that it is also able to fulfill the indicators of exponent problem solving. SICS explained that 128 and 8 were converted into power form first, so 128 became 2^7 and 8 became 2^3. Because the variables are the same, the next step is to use the power multiplication rule, namely $(a^m)^n = a^{m.n}$. So $(2^7)^5$ became 2^{35}, meanwhile $(2^3)^4$ became 2^{12}. Furthermore, using the rule $a^m \times a^n = a^{m+n}$ so 2^{12}. $2^9 = 2^{21}$.

The last step used is the fraction rule or division rule, which is $\frac{a^m}{a^n} = a^{m-n}$, so the result obtained is $\frac{2^{35}}{2^{21}} = 2^{14}$. Therefore, SICS was able to fulfill the third indicator of understanding the concept of exponents, namely using the rules of exponents, and the fourth indicator, namely understanding the roots and powers of fractions as exponents. However, SICS was unable to fulfill the indicator of identifying and correcting the concept of exponents. SICS seems unable to identify errors in the statement $(2 \times 3)^2 = 5^2 = 25$. SICS explained that the statement was correct. In the second statement, SGKI was also able to identify and correct exponent misconceptions, namely $(-2)^3 = -2^3 = -8$. Although the result is correct, conceptually the sequence of operations is wrong.

Table 2. Conclusion of Subject's Concept Understanding

Indicator/Subject	SRCS	SICS
Solving Exponent Problems	✓	✓
Identifying Positive, Negative, and Zero Exponents	✓	✓
Using the Rules of Exponents	✓	✓
Understanding Fractional Roots and Powers as Exponents	✓	✓
Identifying and Correcting Exponent Misconceptions	✓	

Reflective Cognitive Style Subjects were able to fulfill all indicators of understanding the concept of exponents, namely indicators of solving exponent problems, identifying positive, negative, and zero exponents, using exponent rules, understanding roots and powers of fractions as exponents, and identifying and correcting exponent misconceptions. Meanwhile, Impulsive Cognitive Style Subjects only did not fulfill the indicators of identifying and correcting exponent misconceptions. This aligns with the findings of Khodijah et al. [17], which show that only 43.33% of students have a high level of conceptual understanding. The level of understanding of the concept of the subject tends to be good, although the subject of impulsive cognitive style still requires a deep thought process before drawing a conclusion. Other findings are also in line, such as Rohmah et al. [18], which shows that impulsive-category subjects tend to answer questions without detail. Impulsive subjects tend to have lower problem-solving skills than reflective subjects. This is due to the lack of consideration in making decisions, while reflective subjects tend to think deeply in making decisions, even though it takes relatively longer [19].

So, there are differences in the level of understanding of the concept of exponents based on cognitive style. This is in line with the findings of research which states that there are differences in metacognitive level based on cognitive style [20]. Differences in cognitive style, affect the level of understanding of the concept of exponents. So, it is important for educators to design learning strategies that are in accordance with the characteristics of each student, in order to maximize their potential to understand mathematical concepts including the concept of exponents.

Based on the results of the analysis, the cognitive style of learners plays a crucial role in the learning strategies applied by educators. This aligns with Farhan et al. [21], who states that cognitive factors are one of the main pillars in achieving better education. Reflective cognitive style has characteristics slow in answering but tends to be accurate, so the answers tend to be correct. While impulsive cognitive style has the characteristics of fast in answering, but less careful in answering, so the answers tend to be wrong.

4. Conclusion

Based on the results of research and discussion, it can be concluded that there are differences in the level of understanding of the concept of exponents of reflective cognitive style subjects and impulsive cognitive style subjects of mathematics education students of Universitas Muhammadiyah Gorontalo class of 2024. These findings result in the postulate that cognitive style can affect the ability to understand the concept of exponents, where subjects with reflective cognitive style have a better understanding because they tend to analyze deeply, while impulsive cognitive style subjects tend to rely on intuition in solving problems.

Author Contributions. **Hikmahturrahman:** Conceptualization, methodology, formal analysis, visualization. **Suhardiman Darson Tamu:** Resources, data curation, software. **Nosva Adam Yunus:** Writing—review and editing, validation. **Febiyanti R. Hasan:** Writing—review and editing, supervision. **Rizal Masaniku:** Project administration, writing—review and editing. All authors discussed the results and contributed to the final manuscript.

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