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Research Article

Examination of the number sense performance of gifted students in terms of various variables

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Abstract

In this study, it is aimed to examine performance of number sense of gifted students in terms of gender, grade levels,number sense self-efficacy and number sense components. In line with the studies in the literature, due to the insufficent research on the number sense on students who diagnosed with special talents in our country, it is felt that in this research we need to study with these student and examine the level of student of this category in the scope of relevant study in terms of various variables. A quantitative descriptive research model was used to determine carefully and completely the level of students' number sense and their existing situations that is related to it. The study group consists of 6th and 7th-grade students attending Science and Art Centers located in 12 provinces in the Eastern Anatolia Region during the 2022-2023 academic year .286 students attended in this research that included 184 students in the 6th grade and 102 students in the 7th grade. This study included the Number Sense Scale and the Number Sense Self-Efficacy Scale as a data collection tools. It is indicated that in this research students diagnosed with special abilities didn't show high level of number sense performance; instead, they prefer rule-based solutions.It is revealed that , the component "flexibility in calculation" is the most succeded one among the components of number sense.When the students' grade level increases, it has been observed that , the number sense performance of students improves.When number sense performance was examined based on gender, it was seen that male students used number sense more than female students.When the relationship between the number sense test scores and number sense self-efficacy scores of gifted students was examined, an expressive positive correlation was found between the scores.

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Introduction

Numbers and arithmetic form the foundation of the mathematics course. However, arithmetic has long been considered as the basic four operations without attempting to make sense of it, remaining limited to standard algorithms as in the past (Şahin, 2019). Mathematics is not a discipline where rules are memorized and directly applied; it is an area where individuals develop their own methods to solve encountered problems, examine whether the methods they apply

lead to an appropriate solution, and question the meaningfulness of the obtained answers (Van De Walle, Karp, & By-Williams, 2012: 13). However, it is observed that during the solution process, students tend to focus more on the

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outcome rather than the process, use their computational skills without thinking critically, employ written algorithms without generating logical ideas, and frequently arrive at incorrect results (Harç, 2010; Kayhan Altay, 2010; İymen, 2012).

Howden (1989) emphasized that number sense is a significant intuition for students to engage in mathematics, allowing them to consider multiple ways of solving problems and logically evaluate their solutions. McIntosh, Reys, and Reys (1992) defined number sense as the ability to flexibly construct logical reasoning, develop useful strategies related to numbers and operations. Markovits (1989) interpreted number sense as the skill to solve problems that cannot be overcome with rule-based solutions or those that can be solved by rules more easily and efficiently without applying the rules. Within the elementary and middle school mathematics curriculum, the concept of number meaning is considered a crucial topic (Jordan et al., 2010; Dyson, Jordan, & Glutting, 2013). Therefore, examining and interpreting the number meanings in students' minds becomes crucial in this context.

Studies examining number sense reveal that students often exhibit low number sense performance and generally prefer rule-based solutions (Alsawaie, 2012; Yang, 2005; Yang, Li, & Li, 2008; Kayhan Altay, 2010; İymen, 2012; Harç, 2010). These studies have predominantly attempted to understand and evaluate number sense comprehensively by addressing its components alongside number sense itself (Menon, 2004; Facun & Nool, 2012; Reys, Kim, & Bay, 1999; Doğan & Paydar, 2020; Tunalı, 2018). Additionally, research exists where students' number sense performance is considered in relation to their number sense self-efficacy (Çaylı Suel, 2019; Yarar, Es, & Gürefe, 2018), grade level (Singh, 2009; Şahin, 2009; Mohamed & Johnny, 2010), and gender (Er & Artut, 2017; Peker, 2019; Yenilmez & Yıldız, 2018). Studies conducted both in our country and abroad have generally been carried out with undiagnosed students. However, the educational system is multidimensional, where each individual within the system is not at the same level, and there exist individual differences. Among observed groups of students with individual differences are those who exhibit special abilities. Çepni, Gökdere, and Bacanak (2004) have mentioned that individuals diagnosed with special abilities possess qualities such as being creatively above average, having artistic talent, assuming leadership roles, or achieving high success in any academic field, and furthermore, they are capable of taking these qualities to a more advanced level. Based on studies in the literature, due to the inadequacy of research on number sense among students diagnosed with special abilities in our country, there is a felt need in this current study to work with students diagnosed with special abilities to examine their levels in the relevant subject area regarding various variables. It is considered important to determine the level of number sense skills among individuals diagnosed with special abilities and to examine the relationship of their number sense performance with identified variables. In this regard, it is believed that examining the number sense performance of individuals diagnosed with special abilities, especially in terms of their number sense self-efficacy, will significantly fill the gap in the current literature on number sense. This study differentiates itself from existing studies on number sense by focusing on students diagnosed with special abilities. It will provide a basis for future studies on the relationship between number sense and number sense self-efficacy in individuals diagnosed with special abilities. Moreover, it is believed that this study will shed light on educators by encouraging students to use number sense strategies rather than relying predominantly on rule-based approaches in problem-solving. In this study, it is aimed to determine the number sense levels of students diagnosed with special abilities studying at Science and Art Centers (Bilsem) located in the provinces of Ağrı, Erzurum, Bingöl, Ardahan, Bitlis, Elâzığ, Hakkari, Iğdır, Muş, Tunceli, Van, and Kars, and to examine their number sense performance in terms of gender, grade, number sense components, and number sense self-efficacy. The problem of this research is defined as "How do the number sense performances of students diagnosed with special abilities differ in terms of various variables?" In line with this, the following sub-problems are addressed:

- At what level are the number sense skills of students diagnosed with special talents?
- Do the number sense scores of students diagnosed with special talents show a significant difference concerning the gender variable?
- Do the number sense scores of students diagnosed with special talents show a significant difference concerning the class variable?

- How do the number sense averages of students diagnosed with special talents vary according to the subcomponents of numerical sense?
- Do the number sense self-efficacy scores of students diagnosed with special talents show a significant difference concerning the class variable?
- Do the number sense self-efficacy scores of students diagnosed with special talents show a significant difference concerning the gender variable?
- Is there a significant relationship between the number sense test scores and numerical sense self-efficacy scores of students diagnosed with special talents?

Method

Research Design

The model for this research is determined as a quantitative "descriptive survey design" since it aims to determine the number sense levels of individuals diagnosed with special abilities and to examine their number sense performances concerning grade level, gender, number sense components, and number sense self-efficacy variables. A survey research aims to collect data to identify and interpret the current characteristics of a group. The survey model typically involves working with larger samples compared to other research types, aiming to determine opinions or skill, interest, and attitude characteristics related to an event or subject (Büyüköztürk et al., 2018:184).

Study Group

In this research, students from the 6th and 7th grades attending Science and Art Centers in Ağrı, Erzurum, Bingöl, Ardahan, Bitlis, Elâzığ, Hakkari, Iğdır, Muş, Tunceli, Van, and Kars during the 2022-2023 academic year were included. An appropriate sampling method was used for the ease of implementation and to increase the collected data. If the researcher creates the required sample group starting from an easily accessible group in terms of workforce and time, it is an appropriate sampling method (Büyüköztürk et al., 2016). The distribution of the sample according to demographic variables used in the research is indicated in Table 1.

Table 1. Distribution of demographic variables in the sample

Variables		**f**	**%**
Gender	Girl	129	45.1
	Boy	157	54.9
Grade	6th grade	184	64.3
	7th grade	102	35.7
	Total	286	100.0

Data Collection Instruments

In order to examine the number sense performance of middle school-level students diagnosed with special abilities, the Number Sense Scale developed by Kayhan Altay and Umay (2013) was utilized in this study. The reliability of the scale was determined by calculating the Kuder-Richardson Formula 20 (Kr-20), yielding a value of 0.742. The Kr-20 calculation was considered appropriate as items were measured in binary format, and the obtained value above 0.70 indicates the scale's reliability (Büyüköztürk, 2019).

To determine the number sense self-efficacy of students diagnosed with special abilities, the Number Sense Self-Efficacy Scale developed by Alkaş Ulusoy and Şahiner (2017) was employed. A reliability study of the scale was conducted using Cronbach's alpha coefficient, resulting in a value of 0.825. Since the used test was scored on a 5-point Likert scale, internal consistency was considered as an indicator of reliability. As the calculated value exceeded 0.7, the test was assumed to be reliable for this study (Büyüköztürk, 2019).

Data Analysis

Upon examining the responses given by students diagnosed with special abilities in the number sense test, scoring was conducted based on whether they employed number sense strategies. During the assessment phase, students using

number sense strategies were assigned a score of 1, while those who applied rule-based operations without using number sense strategies were assigned a score of 0 (Kayhan Altay and Umay, 2013). The data, coded as 0 and 1, was transferred to the SPSS program for analysis.

In this study, which addressed the number sense test achievements and number sense self-efficacy of students diagnosed with special abilities, the first step involved the analysis of data normality. Median and mean values, Q-Q plots, boxplots, Kolmogorov-Smirnov, and Shapiro-Wilk tests were examined, revealing that the data did not exhibit a normal distribution. Non-parametric tests, specifically the Mann-Whitney U test for comparing scores between two groups and Spearman's Rank-Order Correlation Coefficient for calculating the relationship between variables, were utilized in the data analysis.

Findings

The study aimed to determine the number sense levels of students diagnosed with special abilities and to examine their number sense performances concerning various variables. Based on the answers provided by students, the following findings were obtained:

The first sub-problem of the research, 'What is the level of number sense skills among students diagnosed with special abilities?' is addressed. Table 2 presents the averages obtained from the number sense achievement test of students diagnosed with special abilities.

Table 2. Average number sense scores of students diagnosed with special abilities

	Number Sense
Lowest Score	0
Highest Score	15
Average	5,82
Standard Deviation	3,18

Upon reviewing Table 2, in this study, a total of 286 students participated, and the average score obtained by the participants from the number sense scale is 5.82 out of 15 points. The average scores and standard deviations that students diagnosed with special abilities obtained from each question in the number sense test are presented in Table 3.

Table 3. Average scores and standard deviations obtained by students diagnosed with special abilities from the items of the number sense test

Item number	$\overline{X}$	**ss**
1	0,56	0,50
2	0,13	0,33
3	0,54	0,50
4	0,55	0,50
5	0,33	0,47
7	0,65	0,48
8	0,20	0,40
10	0,23	0,42
11	0,31	0,46
12	0,59	0,49
13	0,27	0,44
14	0,30	0,46
15	0,36	0,48
16	0,65	0,48
17	0,18	0,38

Upon examining Table 3, it is observed that the participants' averages vary between 0.13 and 0.65 on a question-by-question basis. Students solved 38.8% of the questions using number sense strategies in the test. Based on these findings, it can be inferred that students diagnosed with special abilities tend to prefer developing solutions based on rules rather than using number sense strategies.

When examining the number sense averages per question, the highest average was achieved in questions 7 and 16. While question 7 pertains to flexibility in computation, question 16 focuses on the use of comparison (reference) points. The lowest average was obtained in question 2, which is also related to the use of comparison (reference) points.

The second sub-problem of the research is 'Do the number sense scores of students diagnosed with special abilities show a significant difference concerning the variable of grade?' The differentiation of number sense test scores among students diagnosed with special abilities concerning the grade variable was analyzed using the Mann-Whitney U test due to the non-normal distribution of the data. The results obtained from this analysis are indicated in Table 4.

Table 4. The differentiation of number sense test scores among students diagnosed with special abilities concerning the variable of grade

Test	Grade	N	Mean rank	Rank Sum	U	Z	p
Flexibility in computation	6th grade	184	123,24	22675,50	5655,5	-5,637	.000
	7th grade	102	180,05	18365,50			
Conceptual thinking in fractions	6th grade	184	126,29	23237,00	6217	-4,873	.000
	7th grade	102	174,55	17804,00			
Use of comparison (reference) points	6th grade	184	128,95	23727,50	6707,5	-4,211	.000
	7th grade	102	169,74	17313,50			
Total	6th grade	184	121,25	22310,00	5290	-6,136	.000
	7th grade	102	183,64	18731,00			

When examining Table 4, a significant differentiation is observed in the total and components of the number sense test scores of students diagnosed with special abilities concerning the variable of grade [$U_{\text{Flexibility in Calculation}}$ =5655.5, z=-5.637, p<0.05; $U_{\text{Conceptual Thinking with Fractions}}$ =6217, z=-4.873, p<0.05; $U_{\text{Comparison Point Usage}}$ =6707.5, z=-4.211, p<0.05; U_{Total}=5290.00, z=-6.136, p<0.05]. Upon examining the mean ranks of the total number sense test scores and component scores concerning the grade variable, a significant difference in favor of 7th-grade students compared to 6th-grade students is evident.

The third sub-problem of the research is: 'Do the numerical sense scores of students diagnosed with special talents show a significant difference based on the gender variable?' The differentiation of number sense test scores of students diagnosed with special talents based on the gender variable was analyzed using the Mann Whitney U Test due to the data not showing a normal distribution, and the results are indicated in Table 5.

Table 5. Status of differentiation in number sense test scores of students diagnosed with special talents concerning the gender variable.

Test	Gender	N	Mean Rank	Rank Sum	U	Z	p
Flexibility in calculation	Girl	129	126,47	16314,00	7929	-3,198	0,001
	Boy	157	157,50	24727,00			
Conceptual thinking in fractions	Girl	129	146,86	18945,00	9693	-0,642	0,521
	Boy	157	140,74	22096.00			
Use of comparison (reference) points	Girl	129	131,14	16917,50	8532,5	-2,414	0,016
	Boy	157	153,65	24123,50			
Total	Girl	129	131,29	16936,00	8551,0	-2,273	0,023
	Boy	157	153,54	24105,00			

When examining Table 5, a significant differentiation in the total and components specifically, 'Flexibility in Calculation' and 'Use of Comparison Point' of number sense test scores among students diagnosed with special talents is observed based on the gender variable [$U_{\text{Flexibility in Calculation}}$ = 7929, z = -3.198, p < 0.05; $U_{\text{Conceptual Thinking with Fractions}}$ =9693, z = -0.642, p > 0.05; $U_{\text{Comparison Point Usage}}$ = 8532.5, z = -2.414, p < 0.05; UTotal = 8551, z = -2.273, p < 0.05]. Upon examining the rank means of the total scores of number sense tests and the scores of components 'Flexibility in Calculation' and 'Use of Comparison Point' based on the gender variable among students diagnosed with special talents, it is evident that there is a significant favoritism towards male students compared to female students.

The fourth sub-problem of the research is 'How do the number sense averages of students diagnosed with special talents vary according to the subcomponents of numerical sense?' Table 6 presents the numerical sense averages for each subcomponent.

Table 6. Distribution of number sense score averages of students diagnosed with special talents across number sense components

Components	Number Sense Averages
Flexibility in calculation	2,99
Conceptual thinking in fractions	1,55
Use of comparison (reference) points	1,27

According to Table 6, when examining the number sense score averages based on components, the component with the highest achievement is 'flexibility in calculation' (2.99). The component where students diagnosed with special talents show the least achievement is 'use of comparison (reference) point' (1.27).

The fifth sub-problem of the research is 'Do the number sense self-efficacy scores of students diagnosed with special talents show a significant difference concerning the class variable?'The differentiation of number sense self-efficacy scores of students diagnosed with special talents concerning the class variable was analyzed using the Mann Whitney U Test due to the data not showing a normal distribution, and the results are indicated in Table 7.

Table 7. Status of differentiation in number sense self-efficacy scores of students diagnosed with special talents concerning the class variable

Test	Grade	N	Mean Rank	Rank Sum	U	Z	p
Total	6th Grade	184	140,14	25786,00	8766	-0,923	0,000
	7th Grade	102	149,56	15255,00			

Upon examining Table 7, it is observed that there is a significant differentiation in the number sense self-efficacy scores of students diagnosed with special talents concerning the class variable [UTotal=8766, z=-0.923, p<0.05].

The sixth sub-problem of the research is 'Do the number sense self-efficacy scores of students diagnosed with special talents show a significant difference concerning the gender variable?'The differentiation of number sense self-efficacy scores of students diagnosed with special talents concerning the gender variable was examined using the Mann Whitney U Test due to the data not demonstrating a normal distribution, and the results are indicated in Table 8.

Table 8. Status of differentiation in number sense self-efficacy scores of students diagnosed with special talents concerning the gender variable

Test	Gender	N	Mean Rank	Rank Sum	U	Z	p
Total	Girl	129	127,10	16396,50	8011,5	-3,041	0,002
	Boy	157	156,97	24644,50			

Upon examining Table 8, there is observed to be a significant differentiation in the number sense self-efficacy scores of students diagnosed with special talents concerning the gender variable [U=8011.5, z=-3.041, p<0.05]. Upon examining the rank means of the total scores of number sense self-efficacy based on the gender variable among students

diagnosed with special talents, it is evident that there is a significant favoritism towards male students compared to female students.

The seventh sub-problem of the research is 'Is there a significant relationship between the number sense test scores and number sense self-efficacy scores of students diagnosed with special talents?' The Spearman Rank-Order Correlation Coefficient was calculated to determine whether there is a significant relationship between the numerical sense test scores and numerical sense self-efficacy scores of students diagnosed with special talents, and the results obtained from the test are provided in Table 9 .

Table 9. Relationship between number sense test scores and numerical sense self-efficacy scores of students diagnosed with special talents

	Sub-Dimensions	**1**	**2**	**3**	**4**	**5**
1	Flexibility in calculation	1				
2	Conceptual thinking in fractions	0,512**	1			
3	Use of comparison (reference) points	0,492**	0,413**	1		
4	Number Sense Scale total score	0,893**	0,772**	0,720**	1	
5	Number Sense Self-Efficacy	0,292**	0,201**	0,224.**	0,301**	1

According to Table 9, there is a significant positive correlation between the 'Number Sense Scale' total score and the 'Number Sense Self-Efficacy' total score of students diagnosed with special talents (r=0.301).

Conclusion and Discussion

Number Sense

When examining the number sense performance of students diagnosed with special abilities, it was revealed that they scored an average of 5.82 out of 15 on the number sense achievement test. Students solved approximately 38.8% of the questions using number sense strategies. An analysis of their solutions indicated their inadequacy in mental computation and generating flexible strategies for problem-solving. It was observed that they often attempted to solve problems using rule-based approaches. This inclination towards rule-based solutions aligns with previous studies (Alsawaie, 2012; Yang et al., 2005; Yang et al., 2008; Şengül & Gülbağcı, 2013; Kayhan, 2010), indicating a preference for rule-based solutions over number sense strategies. Similarly, İymen (2012) found that students utilized number sense strategies only when asked for shortcuts, generally preferring rule-based solutions. This tendency might stem from the habituation of relying on rule-based approaches during problem-solving sessions in classes. Studies suggest that the prevalent use of written materials by teachers and their inclination towards rule-based approaches during lessons (Purnomo et al., 2014), as well as the evaluation of students with questions that tend to follow rule-based solutions rather than questions that encourage interpretation (Eraslan, 2009), contribute to lower number sense performance among students.

When examining students' number sense performance based on components, it was found that the most successful component with an average of 2.99 was 'Flexibility in Calculation.' The flexibility in calculation component is regarded as choosing the easiest way in operations and seeking solutions that make problems more practical by recognizing various representations of numbers (Kayhan, 2010). Upon analyzing students' solutions, it was observed that there were few students struggling with the equivalence of 0.25 to 1/4. Similarly, studies suggesting that students are approaching the desired level in 'Understanding and Using Number Equivalents' (Doğan & Paydar, 2020) and demonstrating good numerical knowledge, enabling flexible operations (Tunalı, 2018), support the findings of our research.

The component where students showed the least success in the study is 'Comparison (Reference) Point Usage.' Existing literature suggests that students often struggle with the use of reference points and encounter difficulties in developing number sense strategies related to this component (Kayhan, 2010; İymen, 2012; Menon, 2004; Facun & Nool, 2012). Under this component, students are expected to use halves and quarters as reference points to make operations more practical. However, upon reviewing students' solutions, it was observed that they mostly attempted to reach a solution by equalizing denominators. Similarly, in a study conducted by Reys, Kim, and Bay (1999), when

comparing fractions, students generally preferred to equalize denominators or create equivalent fractions rather than using reference points for comparison.

When the number sense test scores of students diagnosed with special talents were examined based on the class variable, a significant difference was found in favor of 7th-grade students over 6th-grade students. This suggests that as students receive more mathematics education and progress through grades, their number sense develops. It could be inferred that the increase in age and the expansion of subject knowledge predispose students to use number sense strategies. This result aligns with studies indicating that number sense levels increase as students advance through grades in research conducted with typically developing students (Tunalı, 2018; Şengül & Gülbağcı, 2013). Findings from Mohamed and Johnny (2010) and Kayhan's (2010) studies suggest that as grade levels increase, there is a tendency to apply standard procedures more and a decrease in the use of number sense. Kayhan (2010) explained this phenomenon by stating that although students engage with the concept of number sense at a young age, as their technical knowledge in mathematics increases, they tend to adopt more rule-based strategies and reduce the use of number sense strategies.

When the number sense test scores of students diagnosed with special talents were examined according to the gender variable, a significant difference was observed in favor of male students over female students. This aligns with the findings of Şahin (2019) and Singh (2009), indicating that male students tend to use number sense more than female students. However, Yenilmez and Yıldız (2018) obtained the opposite result, suggesting that in their research, female students had better number sense compared to male students. Additionally, there are studies in the literature indicating that there is no difference in number sense scores based on gender (Menon, 2004; Er & Artut, 2017; Peker, 2019).

Numerical Sense Self-Efficacy

When examined according to the class variable, a significant difference in favor of the 7th grade students was observed in the number sense self-efficacy scores of students who have been diagnosed with special talents. This result indicates that as the grade level progresses, it influences the students' self-efficacy feelings towards using number sense strategies. It can be said that as mathematics education increases and subject knowledge enhances, it affects the students' self-efficacy in developing flexible solutions to problems and making practical calculations without using pen and paper. When examining the literature, it is observed that there are very few studies on number sense self-efficacy. Çaylı Suel (2019) considered number sense self-efficacy on a class basis in her study and concluded that as the class level increases, the average number sense self-efficacy also increases. Conversely, Yarar, Es, and Gürefe (2018) obtained the opposite result in their study, indicating that 5th-grade students have higher number sense self-efficacy than 7th-grade students. This study does not align with the findings of the current research.

When the numerical sense self-efficacy scores of students diagnosed with special talents were examined according to the gender variable, a significant difference in favor of male students was observed compared to female students. Besides demonstrating better number sense performance, it is notable that male students also had more advanced number sense self-efficacy. Aşkar and Umay (2001) mentioned that in the Turkish society, cultural perceptions, such as male students having more experience in daily life activities like trade and repairs, might be a reason for this outcome. Studies in the literature also indicate that there are no differences in number sense self-efficacy according to gender (Yarar, Es, and Gürefe, 2018; Çaylı Suel, 2019). This finding does not align with the results of the present research.

When examining the relationship between the scores of the number sense scale and the number sense self-efficacy scores of students diagnosed with special talents, a positive and significant relationship between the scores was found. It was observed that as the numerical sense scores of individuals in the study increased, their number sense self-efficacy scores also increased, or conversely, as the number sense scores decreased, so did the number sense self-efficacy scores. It can be said that the beliefs of students regarding problem-solving, understanding relationships between numbers and operations, and creative thinking affect their ability to use number sense strategies. Studies suggest that individuals with low self-efficacy are not persistent in seeking success (Deniz, 2017), self-efficacy is a predictor of success in mathematics (Chen and Zimmerman, 2007), and for students to persist in using numerical sense strategies, their self-efficacy needs to be high (Çaylı Suel, 2019), affirming this result.

Recommendations

Based on the current results, the following recommendations have been proposed:

- The reason behind students approaching problem-solving in rule-based methods is believed to stem from the predominant use of standard routine methods during class. Therefore, there should be an emphasis on using number sense strategies rather than rule-based approaches in solving problems during lessons.
- Exercises and activities in textbooks should be designed to enhance number sense.
- Guidelines aimed at enhancing number sense for teachers should be published, and seminars focusing on developing number sense in students should be conducted for mathematics teachers.
- Efforts should be made to raise awareness among teacher candidates about numerical sense, and there should be more emphasis on teaching number sense in courses to improve the expertise of teacher candidates in this area.
- This research was conducted with students diagnosed with special talents. There are few studies in the literature regarding the number sense performance of individuals diagnosed with special talents. Hence, future studies focusing on number sense should also consider this area.
- The research findings revealed a positive relationship between number sense and number sense self-efficacy. Detailed research should be conducted through interviews with students diagnosed with special talents to explore numerical sense self-efficacy further.
- As observed from the data obtained, having number sense self-efficacy also correlates with number sense success. Therefore, efforts should be made to raise awareness regarding number sense self-efficacy among students diagnosed with special talents to enhance their mathematical abilities.

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