Erzincan Üniversitesi Eğitim Fakültesi Dergisi

Erzincan University Journal of Education Faculty

https://doi.org/10.17556/erziefd.1801045

Araştırma Makalesi / Research Article

Improving Primary School Students' Number Sense Levels Through Scratch-Supported and Game-Based Activities*

İlkokul Öğrencilerinin Sayı Hissi Düzeylerinin Scratch Destekli ve Oyun Temelli Tasarlanan Etkinliklerle Geliştirilmesi

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Makale Bilgileri

Geliş Tarihi (Received)

10.10.2025

Kabul Tarihi (Accepted)

11.11.2025

Yayınlanma Tarihi (Published)

11.01.2026

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Abstract: The aim of this research is to determine the number sense levels of second-grade primary school students and to improve these levels with Scratch-supported activities and game-based activities. The research was conducted using a mixed method with an explanatory sequential design. The study group was determined through criterion sampling and convenience sampling and consisted of 14 second grade students studying at a primary school located in the Central Anatolia Region of Türkiye during the spring semester of the 2021-2022 academic year. Scratch-based activities and game-based activities were implemented within the framework of the lesson plans prepared for the students for 7 weeks. In the study, the Number Sense Test (NST), developed by considering the number sense components and the "Numbers and Operations" learning domain included in the curriculum, was administered as a pre-test and post-test, and semi-structured interviews were conducted based on the students' responses to the test. The data obtained were evaluated using the Wilcoxon signed-rank test and descriptive analysis. The findings showed that there was a statistically significant difference between the pre-test and post-test scores in favor of the post-test. Additionally, it was determined that students used number sense-based strategies rather than rule-based strategies at the end of the process. These results suggest that Scratch-supported and game-based activities are effective in developing students' number sense skills. Therefore, it can be recommended that number sense can be developed from an early age using computer software such as Scratch and game-based activities.

Keywords: Number sense, scratch, second-grade primary school students, mathematics teaching

Öz: Bu araştırmanın amacı, ilkokul 2. sınıf öğrencilerinin sayı hissi düzeylerini belirlemek ve bu düzeyi scratch yazılımı destekli ve oyun temelli etkinliklerle geliştirmektir. Araştırma, açımlayıcı sıralı desen ile karma yöntem olarak yürütülmüştür. Çalışma grubunun belirlenmesinde ölçüt örnekleme ve kolay ulaşılabilir durum örnekleme yöntemlerinden yararlanılmıştır. Bu doğrultuda araştırmanın çalışma grubunu 2021–2022 eğitim öğretim yılı bahar döneminde Türkiye'nin İç Anadolu Bölgesi'nde yer alan bir ilkokulun 2. sınıfında öğrenim gören 14 öğrenci oluşturmuştur. Öğrencilere 7 hafta boyunca hazırlanan ders planları çerçevesinde scratch tabanlı etkinlikler ile birlikte oyun temelli etkinlikler uygulanmıştır. Araştırmada, sayı hissi bileşenleri ve öğretim programında yer alan "Sayılar ve İşlemler" öğrenme alanı dikkate alınarak geliştirilen Sayı Hissi Testi (SHT) ön test ve son test olarak uygulanmış, öğrencilerin teste verdikleri yanıtlara göre yarı yapılandırılmış görüşmeler yapılmıştır. Elde edilen veriler, Wilcoxon işaretli sıralar testi ve betimsel analizle değerlendirilmiştir. Bulgular, ön-test ve son test puanları arasında son test lehine istatistiksel olarak anlamlı bir fark olduğunu göstermiştir. Ayrıca öğrencilerin süreç sonunda kural temelli stratejiler yerine sayı hissi temelli stratejiler kullandıkları belirlenmiştir. Bu sonuçlar scratch destekli ve oyun temelli etkinliklerin öğrencilerin sayı hissi becerilerini geliştirmede etkili olduğunu düşündürmektedir. Bu nedenle sayı hissinin erken yaşlardan itibaren scratch gibi bilgisayar yazılımları ve oyunlar ile geliştirilebileceği önerilebilir.

Anahtar Kelimeler: Sayı hissi, scratch, ilkokul 2. sınıf öğrencileri, matematik öğretimi

Murat, M. & Demirci, Ö. (2026). Improving primary school students'number sense levels through scratch-supported and game-based activities. *Erzincan University Journal of Education Faculty, 2026*, 1-16. https://doi.org/10.17556/erziefd.1801045

Introduction

Numbers are one of the cornerstones of mathematics education and play a critical role in the development of students' problem-solving, logical reasoning, and mental reasoning skills (Yang, 2005a; 2005b). Mathematics education is not limited to learning numbers, but also requires the ability to understand these numbers and use them effectively in daily life. Numbers, which form the basis of other areas of mathematics such as measurement, geometry, algebra, and data analysis, play an important role in shaping both academic and daily life skills (Van De Walle et al., 2020). Numbers, which appear in every area of life, are used in many contexts, from identity cards to telephone numbers, financial transactions to time measurement. Therefore, understanding the meanings of numbers and recognising the relationships between them is an indispensable requirement for mathematical thinking and success.

Skills such as quickly understanding the relationships between numbers, thinking about the magnitudes of numbers, performing mental calculations, and simplifying complex operations are defined in mathematics education as the concept of "number sense". Number sense encompasses a range of competencies, including estimating the magnitude of numbers, analysing the relationships between numbers, recognising patterns, performing mental calculations, and detecting arithmetic errors (Lago & DiPerna, 2010). These skills are not only important in mathematics lessons but also in individuals' daily lives. For example, estimating while shopping at the market, making quick decisions in financial calculations, or being effective in time management are among the practical applications of number sense.

When reviewing the literature, it is unclear when the concept of number sense first emerged, and there are many different definitions of this concept. In general, number sense

*This research was derived from the master's thesis completed by the first author under the supervision of the second author.

includes skills such as counting, comparing numbers, understanding the relationships between numbers, measuring, estimating and completing (Er & Dinç-Artut, 2021; Olkun & Toluk-Uçar, 2012). Similarly, number sense, with its ability to detect arithmetic errors, establish connections between concepts, and recognise patterns, facilitates understanding concepts and meaningful learning (Çekirdekçi et al., 2016). Research shows that developing this concept at an early stage lays the foundation for mathematical thinking and problem-solving skills (Yang & Li, 2008).

Students with low number sense tend to follow procedural steps by memorising them (Şengül & Gülbağcı-Dede, 2013). These students' weak flexible thinking, reasoning and evaluation skills limit their ability to develop strategies when faced with new problem situations. This limitation negatively affects students' mathematical achievement (Altun-Akbaba, 2025; Devlin et al., 2022; Jordan et al., 2006; MacDonald & Carmichael, 2018). Studies conducted in Türkiye show that sufficient teaching strategies for developing number sense skills are not being implemented, and that this situation has negative effects on mathematical achievement (Başer, 2025; Can, 2019; Harç, 2010; İymen, 2012; Karagöz, 2024). Alkaş-Ulusoy (2020) attributed students' low number sense to the lack of adequate opportunities to develop it. This can be interpreted as a result of mathematics education being largely limited to traditional methods. In this context, for students to effectively use number sense strategies, they need both to actively engage their mental processes and to have a solid command of the concept of number sense, which encompasses a fundamental understanding of numbers.

In addition, the emphasis placed on skills such as estimation, mental calculation, and reasoning in the Mathematics Curriculum published in Türkiye in 2018 and the Primary School Mathematics Curriculum published in Türkiye in 2024 (Ministry of National Education [MoNE], 2018, 2024) is directly related to the development of number sense. This is because number sense supports students' ability to understand the relationships between numbers, perform operations mentally, and effectively use their reasoning skills in problem-solving processes. Therefore, the skill-focused approach in these curricula provides an appropriate educational environment for the development of number sense.

It can be said that educational technologies and computer-assisted instruction can be utilised to create activities that can develop number sense and make mathematical skills meaningful (Doğmaz-Tunalı & Yıldız-Demirtaş, 2022; Taylan-Bektaş, 2021). Doğmaz-Tunalı and Yıldız-Demirtaş (2022) demonstrates in his study that computer-assisted mathematics instruction improves number sense, mathematical metacognitive awareness, and self-efficacy perceptions among middle school students with mathematics learning difficulties, based on quantitative and qualitative findings. Furthermore, Taylan-Bektaş (2021) demonstrates in their study that Minecraft-based three-dimensional video game activities positively affect the development of number sense in fourth-grade students. Akbabaoğlu (2023) examined the effects of a number sense education program supported by Web 2.0 tools on the number sense development of first-grade primary school students. The results revealed that the experimental group showed significant improvement in the subdimensions of number recognition, comparison, calculation, story problems, and number combinations, as well as in their total scores, demonstrating that Web 2.0 tools are effective in enhancing number sense skills. Therefore, technology increases students' motivation towards lessons and learning topics. It also supports them in becoming individuals who effectively reflect technology in their lives and produce solutions to problems (Saka & Çelik, 2018).

The use of technology is a very important factor in making abstract mathematical content concrete. Younger students in particular have difficulty with abstract concepts. Therefore, the use of technology appropriate to the age and level of children at this stage increases their interest and motivation in mathematics (Bozkurt & Yiğit-Koyunkaya, 2022; Köse, 2008; Perini et al., 2023; Yazlık, 2018). One of the topics that students find difficult to grasp is undoubtedly numbers and the sense of numbers associated with them. Therefore, the sense of numbers, which is an important step in understanding and making sense of mathematics, should be supported by utilizing appropriate technological tools to make it concrete and develop it.

One of the technological tools that can be used to develop number sense is the Scratch software. Scratch, which can be easily integrated into mathematics lessons and teaching, creates a learning environment where students can have fun during class while also making learning more concrete (Gonzalez, 2013). With Scratch, a variety of visual and auditory content can be used together in an enjoyable teaching environment for students. In addition, it can also be used to give students the opportunity to produce new content (Çakıroğlu et al., 2008; Çatlak et al., 2015; Kobsiripat, 2015). In addition, incorporating Scratch-based games into the teaching process is seen as an effective method that supports students in achieving the objectives and behaviours included in the program (Okuducu, 2020). In this context, it is anticipated that game-based activities prepared by effectively using technology can positively influence students' attitudes towards mathematics as well as develop their sense of numbers. Considering that there are limited studies in the literature on the use of technological tools for the development of number sense (Akbabaoğlu, 2023; Doğmaz-Tunalı & Yıldız-Demirtaş, 2022; Taylan-Bektaş, 2021), it is thought that this study will fill an important gap.

In light of this information, it is anticipated that activities and game-based activities developed using Scratch Software will be effective in overcoming difficulties encountered during and after teaching, making learning meaningful, and ensuring retention, as this concept, which is considered fundamental in mathematics education, such as number sense, takes precedence over subsequent learning.

The most frequently examined characteristics in studies on number sense are the level and performance of number sense (Reys et al., 1999; Yang, 2005b), the relationships between number sense and various variables such as grade level, gender, or school type (Akkaya, 2015; Kayhan-Altay, 2010; Ma et al., 2024; Tsao, 2004), and the relationships between number sense and different subject areas such as mathematics achievement, mathematics attitudes, problem solving, and spatial ability (Sarı & Özmen, 2025; Şengül & Öztürk-Zora, 2023). Furthermore, recent studies have provided new perspectives to the literature by investigating the relationships between number sense and cognitive processes, especially working memory (Genç & Polat, 2025; van Bueren et al., 2022) and by exploring the neural foundations of number sense development (Chang et al., 2022). However, it has been determined that research examining the effects of different instructional designs on the development of number sense is still limited (Küçükay, 2022). This situation highlights the need for research on how number sense can be supported instructionally, and it is believed that this study will make significant contributions to literature.

Research Aim and Questions

Mathematics education is a process that aims to develop students' number sense skills, such as mental calculation, pattern recognition, and understanding the relationships between numbers. However, traditional teaching methods have been found to be insufficient in effectively developing these abstract skills. Technology-supported approaches to developing number sense skills offer significant opportunities in this regard. In particular, the Scratch software can contribute to the development of not only students' procedural knowledge but also their mathematical thinking, problem-solving, algorithmic reasoning, and creative thinking skills by creating a game-based and interactive learning environment in mathematics education. Within the Scratch environment, students can explore relationships among numbers and experience components of number sense such as estimation, reasoning, and flexible thinking, thereby constructing a deeper understanding of mathematical concepts.

The aim of this study was to determine the number sense levels of second-grade primary school students and to develop them through Scratch software-supported and game-based activities. Within the scope of the study, Scratch software-supported and game-based activities were implemented for second-grade primary school students. In this context, the study sought answers to the following sub-questions:

1. How do Scratch software-supported and game-based activities aimed at developing number sense in second-grade primary school students affect their number sense development?
2. How do the number sense skills used by second-grade primary school students when answering the number sense test vary according to number sense components?

Methodology

In this study, which aims to determine the number sense levels of second-grade primary school students and develop them through activities designed with Scratch software-supported and game-based learning, a mixed research method was used due to the combined use of qualitative and quantitative data. The reason for using the mixed method in the study is that the findings obtained from quantitative data are supported by the findings obtained from qualitative data. The aim of this study is to make the research meaningful and reliable by using both quantitative and qualitative data. In this study, the quantitative data obtained with the help of the Number Sense Test were supported by qualitative data obtained from observations and interviews conducted during the activities. In this context, the examination of multiple types of data within the scope of the research was effective in determining the research model as a mixed model.

Mixed research methods is a method in which qualitative and quantitative data are collected and both approaches are used together (Fraenkel et al., 2012; Gay et al., 2012). The adoption of mixed research methods facilitates a more comprehensive examination of the research situation and, at the same time, the detailed explanation and clarification of findings through the collaborative application of qualitative and quantitative methods (McMillan & Schumacher, 2010). There are different types of mixed research methods depending on the field. Different types of this research design are used in the social, educational, and health fields (Creswell, 2009). In the literature review conducted, the types of mixed research methods are expressed as diversification, explanatory, embedded, and interpretive (Creswell, 2009; Creswell & Plano Clark, 2011). In this study, the explanatory sequential design, one of the types of mixed research methods, was used in accordance with the purpose of the study. This design consists of two stages. Depending on the research problem, the process begins with the collection and analysis of quantitative data, followed by the collection and analysis of qualitative data (Creswell & Plano Clark, 2011).

Participants

The participants in the study consisted of 14 second-grade students attending a public primary school affiliated with the Ministry of National Education in the Central Anatolia Region of Türkiye during the spring semester of the 2021-2022 academic year. The participants were selected using convenience sampling and criterion sampling, which are among the purposive sampling methods. Convenience sampling was preferred to ensure the practical implementation of the study (Yıldırım & Şimşek, 2013). The criterion sampling method ensured that participants meeting specific criteria for the study were selected. The main reason for selecting second-grade students in this study was that they had basic prior knowledge related to the learning outcomes in the "Numbers and Operations" area of the mathematics curriculum. Additionally, students' reading and writing skills and their attainment of a certain level of proficiency in counting activities and in performing addition and subtraction operations were accepted as the criteria for the research. Furthermore, considering that number sense skills develop more quickly and effectively when supported by activities conducted at an early age (Yaman, 2015), this grade level was chosen.

Parental consent forms were obtained from the participants' parents, and research permission and ethical committee approval were obtained from the Provincial Directorate of National Education. The research was conducted in accordance with ethical principles. The confidentiality of the participants' personal information was protected, and the principle of voluntariness was taken into account in the study.

Data Collection Tools

In order to conduct the research, ethics committee approval was first obtained (Ethics Committee of Human Research in Educational Sciences at Erzincan Binali Yıldırım University, decision dated 28/02/2022 and protocol number 02/13). The data collection process in the study consists of quantitative and qualitative stages. In the quantitative stage, the Number Sense Test (NST) was used to determine students' number sense levels. The NST was revised and finalised by researchers based on expert opinions. In the qualitative stage, semi-structured interviews were conducted to enable students to explain how they thought about their answers to the NST items.

NST was developed by researchers to measure students' number sense skills. As the first step in developing the 2nd-grade NST, a literature review was conducted (Greeno, 1991; Harç, 2010; İymen, 2012; Kayhan-Altay, 2010; McIntosh et al., 1992; Yang, 1995), and the components of number sense and the learning outcomes included in the curriculum were examined. In the subsequent process, it was determined which of the learning outcomes in the "Numbers and Operations" learning area included in the 2nd-grade Mathematics Curriculum (MoNE, 2018) would be taken into consideration. Taking into account the 2nd grade Mathematics Curriculum, it was decided that the six basic components identified by Yang (1995) would form the structure of the NST. These components are understanding the meaning of numbers, understanding number sizes, separating and reassembling numbers, comprehending the effect and meaning of operations, flexibility with numbers and operations in computation situations, and utilizing the comparison (reference) point. The reason these components, developed by Yang (1995), were chosen is that they encompass the common points of the number sense components identified by earlier researchers (Greeno, 1991; McIntosh et al., 1992) and are consistent with the fundamental objectives of the Mathematics Curriculum. In particular, the fact that these components intersect with skills aimed at understanding the relationships between numbers and the meaning of operations is one of the reasons for their selection. Taking these circumstances into account, a draft NST consisting of open-ended and multiple-choice questions was prepared. Sample items were developed based on examples from the literature (Greeno, 1991; Harç, 2010; İymen, 2012; Kayhan-Altay, 2010; Singh, 2009; Şengül et al., 2012; Yaman, 2015; Yang, 1995; Yapıcı, 2013). Four field experts were consulted to determine the content validity, appropriateness for the student level, consistency with number sense components, and adherence to item writing principles of the items in the draft test. The experts' opinions were obtained using an Excel form that allowed them to indicate their thoughts on the suitability, validity, and need for correction of the items.

Experts generally stated that the test items were consistent with the target learning outcomes; however, they suggested simplifying the language of some items, making the instructions more understandable, and revising the balance of difficulty among questions of similar cognitive levels. Accordingly, some items with complex wording were revised, the distribution of questions with similar difficulty levels was balanced, the instructions were simplified, and appropriate visuals were added to items requiring visual support, resulting in the final version of the test. As an example of these adjustments, experts cautioned regarding the fourth question of the test that the question's wording might be confusing for students, that it did not adequately reflect numerical value estimation skills, and that the instructions encouraged direct calculations. Therefore, the context of the question was simplified, unnecessary details were removed to direct students' attention to numerical estimation, and numerical values were reorganized to facilitate mental estimation. Furthermore, the instructions were revised to focus on assessing estimation skills rather than precise calculations. An additional section, "How did you make your decision?", was created to allow students to express their thinking processes. As a result of these revisions, the question was structured more appropriately for the concept of number sense, both in terms of content and measurement purpose. Similarly, regarding the ninth question in the test, experts noted that the visual elements supported students' length comparisons, but that the instruction's statement "approximately equal to how many erasers?" might be perceived by some students as requiring direct measurement. Additionally, it was suggested that the "How did you make your decision?" section be structured more clearly to allow students to clearly explain their predictive thinking processes. To this end, the question's instructions were simplified, and explanatory statements were added to encourage students to focus on visual estimation rather than actual measurement. The size ratios of the pencil and eraser in the visual were made more apparent, allowing students to make their mental estimations more easily. Furthermore, the explanation section was designed to encourage students to express their thinking, making the question more suitable for assessing number sense and estimation skills.

Following revisions agreed upon by experts, the pilot implementation of the NST was completed in March 2022. As a result of the pilot implementation, items that were unclear in terms of language were also revised, and the draft test was finalised with 15 items. The stabilized version of the NST that was applied in the study is presented in the appendix section. The NST was first applied as a pre-test in April 2022 as part of the main implementation.

However, while the responses given by students were identified through NST, the underlying thought processes and number sense strategies used in these responses were not fully understood. Semi-structured interviews were conducted to address this gap and identify the strategies used by students. During the interviews, students were asked the following questions based on their responses to the items in the number sense test:

- What approach did you take when giving this answer?
- Could there be a different solution?
- What other approaches could you use to reach the solution?

These questions aimed to analyse students' solution processes in detail and gain a deeper understanding of their number sense strategies.

Data Collection Process

The data collection process of the study began in the first week of April 2022, with the necessary permissions being obtained and the pre-test being administered under the supervision of the NST classroom teacher. Students were informed about the duration and content of the test and that it would not be graded. The data obtained from the pre-test was then evaluated, and semi-structured interviews were conducted based on the responses given by the students during the same week in order to interpret their answers, determine solutions, and clearly identify their number sense levels. The interviews were recorded using audio recordings and brief notes. Following the completion of the interviews, the first author of the study conducted the implementation over a period of 7 weeks, with two class hours per week. One class hour of the applications was conducted in the school's computer lab using Scratch-based games, while the other class hour was conducted in the classroom with non-computer-based activities. During the implementation period, students' number sense strategies were observed, and guidance was provided when necessary. In the week following the 7-week period, the NST was again administered as a post-test in a similar manner, and evaluations were conducted, completing the semi-structured interview process in a similar way.

The Scratch activities and games designed during the implementation phase of the research were developed by taking into account the learning outcomes included in the curriculum and the number sense components identified for the research. The activities were reviewed by an expert in the field of mathematics education, and various revisions were made to develop number sense. Subsequently, the Scratch-supported activities were presented to another expert in the field of computer and instructional technology education for their opinion. Regarding Scratch-supported games, experts stated that they have the potential to support number sense skills, but that some game designs should be directly linked to target outcomes. Specifically, recommendations were made to better align game scenarios with educational objectives, present instructions clearly and concisely, and strengthen feedback mechanisms to increase student engagement. To this end, game content was revised; complex or abstract task steps were simplified, and new task types were added to make students' estimation, reasoning, and comparison processes more visible. Furthermore, difficulty transitions between game stages were more balanced, and the scoring system was revised to reward students' accurate estimation strategies. Visual and audio feedback were designed to increase student motivation, and the overall game design was restructured to more effectively support cognitive processes related to developing number sense. For example, based on expert opinions, various adjustments were made to both the visual design and cognitive structure of the game "Pattern-Loving Frog." Experts noted that the primary goal of the game was to develop students' ability to recognize and predict number patterns. However, some visual and instructional elements in the initial design could distract students. They also offered suggestions for gradually increasing the difficulty of the number sequences, providing descriptive feedback for incorrect choices, and maintaining a time limit that motivates students without causing anxiety. In line with these suggestions, the number sequences on the tiles in the game were rearranged, making pattern transitions clearer and more logical. Guidance prompts were added for incorrect choices, the timer was simplified, and distracting visuals were reduced to create a more focused learning environment. Thus, the game has been finalized, improving both visually and pedagogically, and more effectively supporting number sense skills. Based on the opinions received, the activities were finalised for use in the implementation phase of the research. Scratch-supported activities were administered individually to the students participating in the study in the computer lab of the school where the study was conducted. The reason for administering Scratch-supported games individually was to more closely monitor differences in students' learning processes and to independently assess each student's number sense development. Because interaction and guidance that can occur in group settings can make it difficult to objectively measure individual performance, the administration was conducted on an individual basis to maintain the validity and reliability of the study. The 7-week implementation phase was carried out as follows.

Week 1: In the first week of implementation, activities were carried out within the scope of the "Numbers and Operations" learning area, targeting the learning outcome of "identifying and writing numbers up to 100". In the first lesson, students played a Scratch-supported digital game called "I Saw a UFO!" where they guessed the positions of numbers between 1 and 100 on a number line and tried to identify the position closest to the number given by the UFO symbol. In the second lesson, the "Bingo" game was played to help students recognize and understand different representations of numbers. During the game, students matched the numbers drawn from a bag, ranging from 1 to 100, with different visual or symbolic representations on their cards. Both activities aimed to develop students' ability to understand the meaning of numbers and recognize number sizes.

Week 2: In the second week of the implementation, in the "Numbers and Operations" learning area, the learning outcomes related to identifying, comparing, adding, subtracting, and multiplying numbers up to 100 were covered. In the first lesson, the activity "Finding Numbers with a Pencil," a Scratch-supported digital game, aimed to predict the location of numbers between 1 and 100 on a number line and make the closest guess. In the second lesson, with the activity "Who Am I?", students guessed the hidden number between 1 and 100 based on the clues given. The activities aimed to develop students' understanding of the meaning of numbers, utilizing the comparison (reference) point, and flexibility in operations.

Week 3: In the third week of the implementation, gains related to addition and subtraction operations were addressed in the "Numbers and Operations" learning area. The first lesson hour featured the "Mario Math Game" activity, a Scratch-supported digital game that is an interactive math game adapted from the Mario game. Students tried to reach the correct result with appropriate strategies by guessing the operations given at each stage. The game aimed to develop number sense skills in a fun environment. In the second lesson, in the "Hexagons and Addition-Subtraction" activity, students wrote the sums of the given numbers in boxes to understand the effect of the operations and the structure of numbers. This week aimed to develop students' skills in separating and reassembling numbers, flexibility in operations, and recognizing the relationship between addition and subtraction.

Week 4: In the fourth week of the implementation, activities were conducted within the "Numbers and Operations" learning area, focusing on counting forward and backward, completing number patterns, comparing numbers, and performing mental calculations. In the first lesson, students played a Scratch-supported digital game called "Pattern-Loving Frog," where they identified patterns by connecting numbers, continued the patterns, and found the missing numbers. In the second lesson, in the "Number Puzzle" activity, students used the logic of increasing and decreasing numbers to understand the relationships +1, -1, +10, and -10 and completed the puzzle. These Scratch-supported activities aimed to develop students' skills in number size, comparison, and using reference points.

Week 5: In the fifth week of the implementation, activities were conducted within the "Numbers and Operations" learning area, focusing on counting forward and backward and performing mental calculations. In the first lesson, the "Pattern-Loving Frog" activity was played again. In the second lesson, the "Box Game" was played. In this game, students rolled the dice starting from 100 and reduced their points by the number rolled; the player closest to 0 won the game. During this activity, students learned to calculate by determining different strategies, comprehending the effect and meaning of operations, and simplifying operations using reference points.

Week 6: During the sixth week of the implementation, activities were conducted within the "Numbers and Operations" learning area to achieve the learning outcome of "identifying and writing numbers up to 100." In the first lesson, a Scratch-supported digital game called "Number Game with Cubes" was played. Students quickly guessed the numbers on randomly given cubes and wrote the closest or correct answer in the boxes. Each box contained different number representations, and the different ways of showing the numbers were constantly changed. In the second lesson, the “Number Explorer” activity was carried out. In this activity, students tried to create specified number combinations using the numbers given in the table; they placed the numbers side-by-side, top-to-bottom, or crosswise by choosing the appropriate method from the four operations. With this activity, students had the opportunity to recognize different representations of numbers, understand the relationships between numbers, separate and reassemble numbers, and develop flexibility skills in calculations.

Week 7: During the seventh week of the implementation, activities were carried out that corresponded to all learning outcomes within the “Numbers and Operations” learning area. In the first lesson, the digital games “Small-Big-Equal Cube” and “Stork and Greater-Less Than” were played, both of which are Scratch-supported digital games. In these activities, students compared the given quantities with numbers and used the symbols “>”, “<”, and “=” correctly. In the second lesson, an activity called “I Evaluate Myself” was implemented. This activity was designed to comprehensively evaluate the skills acquired in the Scratch-supported and game-based activities carried out in previous weeks. In this process, consisting of six different gamified activities, students used number sense skills such as understanding the meaning of numbers, recognizing the effect of operations, separating and reassembling numbers, flexible thinking, and comparison.

Data Analysis

The graded scoring key developed by Reys et al (1999) was used to evaluate the responses given to the NST. The responses were initially classified as correct or incorrect, and then the explanations given for each item were examined in detail. The correctness or incorrectness of the responses to the items was scored based on the students' solution methods.

Table 1. NST scoring process

Answer Type	Strategy Type	Score
Correct	Number Sense-Based Solution (NSS)	4
	Rule-Based Solution (RBS)	2
Incorrect	Number Sense-Based Solution (NSS)	3
	Rule-Based Solution (RBS)	1
	Unsubstantiated Answers, Non-Scientific Generalisations	0

According to the scoring criteria presented in Table 1; 4 points were awarded for correct answers obtained through number sense-based solutions, and 2 points were awarded for correct answers obtained through rule-based solutions. Incorrect answers number sense-based solutions are awarded 3 points, while rule-based incorrect answers are awarded 1 point. Non-scientific generalisations or unexplained answers are scored as 0 points. Within this framework, the maximum total score that can be obtained from the NST is 60, and the minimum total score is 0.

Semi-structured interviews were conducted in order to analyse students' responses to NST in greater depth and to gain a clearer understanding of their solution strategies. Descriptive analysis was used to analyse the data obtained from these interviews. In presenting the data obtained from interviews with students, descriptive analysis was used, and the ideas expressed by students in the interviews were detailed with direct quotations in order to understand their solution processes in detail. Descriptive analysis involves presenting the subject of research in an organized and interpreted manner, using direct quotations to reflect the thoughts and behaviours of the individuals interviewed or observed (Yıldırım & Şimşek, 2013).

This process, combined with quantitative and qualitative data sources, made it possible to more comprehensively assess students' number sense skills and the strategies they used. The transparency of the scoring system and the straightforward presentation of interview data were considered factors that enhanced the validity and reliability of the study.

In the literature, it is emphasised that non-parametric tests are more appropriate when the study group size is less than 30 (Büyüköztürk, 2012; Kalaycı, 2006). In this context, considering that the study group consisted of 14 people, it was decided to apply the Wilcoxon Signed-Rank Test in the analysis.

The process of measuring involves stages of implementing measurement tools, scoring, and interpreting, all of which may be impacted by random errors. Reliability can be described as the extent to which scores obtained from a measuring instrument are free from such random errors, indicating its ability to produce stable and consistent outcomes. Due to the potential for scorers to introduce errors, it's essential to determine the degree of agreement between the scores assigned by independent evaluators assessing the same characteristic (Cohen & Swerdlik, 2010). For this reason, the researchers evaluated the data obtained from the NST independently of each other. The researchers then came together to discuss the items that had been evaluated differently and reached a consensus, completing the analysis process.

Findings

Findings Regarding the Comparison of Second Grade Primary School Students' Responses to the Pre-Test and Post-Test NST

This study examined the effect of Scratch-supported game-based activities on the development of number sense in second-grade students. To achieve this goal, students were administered a number sense test (NST) as a pre-test and post-test. The Wilcoxon Signed-Rank Test was used to compare the development levels of students' number sense skills. The analysis results are presented in Table 2.

Table 2. Results of the Wilcoxon signed-rank test for comparing students' pre-test and post-test NST success rates

Post-Test / Pre-Test	n	Mean Rank	Sum of Ranks	z	p
Negative Rank	0	.00	.00	-3.302	.001*
Positive Rank	14	7.50	105.00		

* *p <.05*

Upon examination of Table 2, a statistically significant difference was found between the students' pre-test and post-test scores ($z = -3.302, p < .05$). This difference indicates a favourable outcome for positive rankings and, consequently, post-test scores.

Based on these findings, it can be stated that the Scratch-supported game-based teaching application improves students' number sense skills. While the maximum score that can be obtained from the test is 60, the median of the students in the pre-test was determined to be 28. This situation reveals that the students' number sense skills were low before the application. It was determined that students used memorisation and rule-based solutions instead of number sense before the application. The increase in students' medians to 47.50 in the post-test indicates a significant improvement in their number sense skills. This result shows that the implementation had a positive effect on students' success and contributed to the development of their number sense skills.

Findings on the Development of Number Sense Levels of Second Grade Primary School Students According to Number Sense Components

Within the scope of the research, students' number sense levels were also examined using qualitative findings based on number sense components, and the quantitative findings were supported. Students' responses to the questions in the number sense test were examined in terms of mathematical accuracy and the strategies used. Table 3 presents the percentage and frequency values for the accuracy of students' answers to the questions in the pre-test and post-test. In addition, the strategies students used in answering the questions were examined, and the percentage and frequency values of students who used number sense-based and rule-based solution methods are also included. The responses obtained from the pre-test showed that students tended to use more rule-, formula-, and operation-based, rote-learning solution methods. The responses obtained from the post-test revealed that students produced solutions in line with number sense components and used the flexible structure of numbers in their solutions by representing numbers in different forms, which is one of the most significant indicators of number sense development. Student responses and interviews detail the transformation in strategy use observed as a result of the application, specifically in terms of Number Sense components.

The findings obtained from the responses to the pre-test and post-test administered to students within the scope of the *Understanding the Meaning of Numbers* component of the number sense components are presented in Table 3.

When examining the data in Table 3, three different questions were asked to students for the *Understanding the Meaning of Numbers* component. When the answers given to the questions in the pre-test were examined, it was observed that the answers considered correct were largely given using RBS, and there were no answers given using NSS. In addition, it was found that the solution methods of those who gave incorrect answers were similarly RBS-based or concentrated on Unsubstantiated Answers and Non-Scientific Generalization. In the post-test answers, the number of correct answers increased, and the solution strategies applied were largely of the NSS type.

The first question in the *Understanding the Meaning of Numbers* component of the NST is presented in the appendix section. Almost all students *(f=11)* who answered this question correctly in the pre-test used RBS. For example, although student S1 found the correct answer in the pre-test, when asked to present a different solution during the interviews, they stated, *"I counted one by one towards the side where the arrow pointed after 60; I couldn't do it any other way,"* indicating that they adhered to a rigid counting rule. In contrast, S5, who used NSS in the post-test, explained their solution as follows: *"The number shown is between 50 and 100 and closer to 50, and also in the sixties,"* demonstrating their ability to intuitively determine the approximate value and position of numbers.

Table 3 shows that in the pre-test, students predominantly *(f=13)* preferred RBS in their solutions to NST's second question and struggled to find a different solution path. For example, when asked for a different strategy, S6 responded, *"I can't think of one,"* and was unable to use number sense skills. In the post-test, however, the majority of students *(f=13)* used NSS. S10 explained in their answer by combining tens and ones: *"blocks are tens, smaller ones are units. 10-20-30-40-50-51-52."* This answer was considered an indication that the student had transitioned to meaningful counting.

Table 3 shows that in the pre-test, 85.8% of students *(f=12)* used Unsubstantiated Answers and Non-Scientific Generalization in response to the third question of the NST. S1 had difficulty interpreting the number 8 in different ways and stated in the interview, *"We subtract and add with eight, and I also said it means eight units... maybe eight pencils or eight fruits."* In the post-test, however, the majority of students *(f=11)* supported the development of number sense by presenting NSS-type strategies. The student coded as S13 related the given number to personal and social contexts and was able to represent the number in different ways: *"I am 8 years old, my mother is 38 years old, there are 8 children in my family. 5+3=8."* This transformation demonstrated that the student understood the abstract nature of the number through concrete life experiences and was able to represent the number in different ways.

Within the scope of the *Separating and Reassembling Numbers* component of the number sense components, the findings obtained from the responses to the pre-test and post-test questions related to NST administered to students are presented in Table 3.

As shown in Table 3, the NST included two different items related to the *Separating and Reassembling Numbers* component. When examining students' responses to these items, it is observed that the number of NSS-based solutions increased in the post-test compared to the pre-test, and the number of correct responses similarly rose. This increase reflects that students were able to develop an understanding of numerical flexibility in their calculations. For example, in the pre-test, most students who answered question 4 correctly *(f = 8)* used RBS, and when asked for an alternative solution, student S3 provided a limited response: *"I can add them side by side; I can't think of another way, teacher."* In the post-test, however, among the students who answered correctly using NSS *(f = 10)*, student S6 applied rounding and strategic grouping. The student explained the solution as: *"Since 23 is between both 25 and 21, I added the 23s and solved it simply."* Additionally, as an alternative solution, the student stated: *"I round 21 to 20, 23 to 20, 25 to 30, then add them all; the approximate total is 70,"* demonstrating the ability to round numbers and find an estimated result.

Again, when Table 3 is examined, all students *(f=12)* who correctly answered the fifth question of the post-test used NSS. S11, who used RBS in the pre-test, stated that they found the solution using a trial-and-error solution strategy and said, *"I can also do it by adding them up one by one"* for different methods. In the post-test, S7, who used NSS, stated, *"To find the correct result, I separated the tens and ones, broke them down, and used the appropriate numbers,"* indicating that they reached the result by breaking down and reassembling the numbers.

Table 3. Students' performance in using number sense according to the number sense components in the pre-test and post-test NST

Component	Question No	Answer Type	Strategy Type	Pre-Test		Post-Test	
				f	%	*f*	%
Understanding the Meaning of Numbers	1	Correct	NSS	-	-	3	21.5
			RBS	11	78.5	11	78.5
		Incorrect	NSS	-	-	-	-
			RBS	3	21.5	-	-
			Unsubstantiated Answers, Non-Scientific Generalisations	-	-	-	-
	2	Correct	NSS	-	-	13	92.8
			RBS	13	92.8	1	7.2
		Incorrect	NSS	-	-	-	-
			RBS	1	7.2	-	-
			Unsubstantiated Answers, Non-Scientific Generalisations	-	-	-	-
	3	Correct	NSS	-	-	11	78.5
			RBS	-	-	-	-
		Incorrect	NSS	2	14.2	-	-
			RBS	-	-	-	-
			Unsubstantiated Answers, Non-Scientific Generalisations	12	85.8	3	21.5
Separating and Reassembling Numbers	4	Correct	NSS	1	7.1	10	78.5
			RBS	8	57.1	3	21.4
		Incorrect	NSS	3	21.4	-	-
			RBS	1	7.1	1	7.1
			Unsubstantiated Answers, Non-Scientific Generalisations	1	7.1	-	-
	5	Correct	NSS	6	42.8	12	85,7
			RBS	4	28.5	-	-
		Incorrect	NSS	1	7.1	-	-
			RBS	2	14.2	-	-
			Unsubstantiated Answers, Non-Scientific Generalisations	1	7.1	2	14.2
Number Size	6	Correct	NSS	-	-	3	21.5
			RBS	9	64.2	10	71.5
		Incorrect	NSS	-	-	-	-
			RBS	5	35.8	-	-
			Unsubstantiated Answers, Non-Scientific Generalisations	-	-	1	7.1
	7	Correct	NSS	-	-	12	85.8
			RBS	10	71.4	1	7.1
		Incorrect	NSS	-	-	-	-
			RBS	4	28.6	-	-
			Unsubstantiated Answers, Non-Scientific Generalisations	-	-	1	7.1
	8	Correct	NSS	12	85.8	13	21.5
			RBS	-	-	-	71.5
		Incorrect	NSS	-	-	-	-
			RBS	-	-	1	-
			Unsubstantiated Answers, Non-Scientific Generalisations	2	14.2	-	-
Utilizing the Comparison (Reference) Point	9	Correct	NSS	2	14.3	3	21.5
			RBS	-	-	10	71.5
		Incorrect	NSS	10	71.5	-	-
			RBS	1	7.1	-	-
			Unsubstantiated Answers, Non-Scientific Generalisations	1	7.1	1	7.1
	10	Correct	NSS	1	7.1	6	42.8
			RBS	5	35.7	2	14.2
		Incorrect	NSS	-	-	2	14.2
			RBS	5	35.7	4	28.4
			Unsubstantiated Answers, Non-Scientific Generalisations	3	21.4	-	-
Comprehending the Effect and Meaning of Operations	11	Correct	NSS	3	21.4	7	50
			RBS	2	14.2	1	7.1
		Incorrect	NSS	-	-	2	14.2
			RBS	8	57.1	4	28.4
			Unsubstantiated Answers, Non-Scientific Generalisations	1	7.1	-	-
	12	Correct	NSS	-	-	-	-
			RBS	6	42.8	9	64.3
		Incorrect	NSS	-	-	-	-
			RBS	3	21.4	5	35.7
			Unsubstantiated Answers, Non-Scientific Generalisations	5	35.7	-	-
Flexibility with Numbers and Operations in Computation Situations	13	Correct	NSS	10	71.4	12	85.7
			RBS	2	14.2	1	7.1
		Incorrect	NSS	-	-	-	-
			RBS	-	-	1	7.1
			Unsubstantiated Answers, Non-Scientific Generalisations	2	14.2	-	-
	14	Correct	NSS	-	-	10	71.4
			RBS	3	21.4	2	14.2
		Incorrect	NSS	-	-	1	7.1
			RBS	9	64.2	1	7.1
			Unsubstantiated Answers, Non-Scientific Generalisations	2	14.2	-	-
	15	Correct	NSS	-	-	6	42.8
			RBS	1	7.1	1	7.1
		Incorrect	NSS	3	21.4	5	35.7
			RBS	9	64.2	2	14.2
			Unsubstantiated Answers, Non-Scientific Generalisations	1	14.2	-	-

NSS=Number Sense-Based Solution; RBS=Rule-Based Solution

Within the *Number Size* component of number sense components, findings obtained from students' responses to pre-test and post-test questions related to NST are presented in Table 3.

Table 3 shows that three questions that can be solved using the *Number Size* component are included in the NST. The findings obtained from the responses indicate that students gave correct answers based on RBS in the pre-test, while the responses given in the post-test showed that correct answers emerged based on NSS strategies. This situation reveals that students have acquired the ability to compare the sizes of numbers without performing operations. None of the students who answered correctly in the pre-test used NSS for question 6 of the NST. Student S9 wrote all the operations one below the other and ranked the results based on the rules. When asked about a different solution method, they implied that they had just discovered the potential to switch to a guessing strategy, saying, *"I do the operations in order, maybe I can guess."* In the post-test, S13, who used NSS, compared the operations before performing them, stating, *"I compared the operations first and guessed the results,"* and *"The sum of 23+15 is greater than the result of 40-21,"* demonstrating effective use of the number size component.

When examining the data in Table 3, none of the 10 students who correctly solved question 7 of the pre-test NST used NSS; all preferred the rule-based counting method. In the post-test, 12 of the 13 students who answered correctly used NSS. For example, S7 understood the number line concept and, based on number size, made comparisons as evidenced by their explanation: *"Numbers on the number line go from smallest to largest... I also compared the numbers based on their size and quantity and put them in order, teacher."*

Question 8 of the *Number Size* component in the NST was also solved with a high rate of NSS *(f=12)* in the pre-test. In the pre-test, S11 stated, *"I compared the numbers without performing any operations and then checked them. Perhaps I could have found it by sorting them,"* indicating that they used number sense. In the post-test, S5, one of the students who used NSS and gave the correct answer *(f=13),* used a more systematic NSS by referring to the place value when determining the number size: *"I compared the tens, for example, 66, 52, 44. Look at the tens place, and I can easily find the highest one."*

Within the scope of the number sense component *Utilizing the Comparison (Reference) Point* component, the findings obtained from the responses given to the NST questions in the pre-test and post-test administered to students are presented in Table 3.

When examining the findings in Table 3, in the pre-test, 2 students answered question 9 of the NST correctly, while 11 answered incorrectly. In the post-test, 13 students answered the NST correctly, while 1 used Unsubstantiated Answers, Non-Scientific Generalizations. Two of the students who answered correctly in the pre-test used the NSS approach, while in the post-test, 3 of the 13 students who answered correctly were determined to have used NSS. In the pre-test, students generally tended to use a ruler. S3, who answered correctly using NSS, described the strategy of using erasers as reference points as follows: *"I found out how many erasers there were by drawing new erasers next to the eraser."* S1, who used NSS but gave an incorrect answer in the post-test, explained, *"I found it by drawing the erasers... I guessed it would be 9,"* relating the solution to visual estimation. This demonstrates the student's effort to develop a concrete reference point for measurement and comparison.

When examining the data in Table 3, only 1 of the students who answered question 10 of the NST correctly in the pre-test used NSS, while the remaining 5 used RBS. S2, who used RBS, continued to be process-dependent, stating that they would *"do the operation again"* when asked for an alternative solution. In the post-test, the majority of correct answers *(f=6)* were given using NSS strategies. S14 developed a strategy by rounding the subtraction operation and explained this situation by stating, *"I rounded 18 to 20 and got 45."*

Within the scope of the *Comprehending the Effect and Meaning of Operations* component of number sense components, the findings obtained from the responses to questions related to NST in the pre-test and post-test administered to students are presented in Table 3.

Table 3 shows that two questions were presented to students to measure the *Comprehending the Effect and Meaning of Operations* component. In the pre-test, 5 students answered question 11 of the NST correctly, while 8 answered incorrectly. In the post-test NST, 8 students answered correctly, while 6 answered incorrectly. Three of the students who answered correctly in the pre-test used the NSS method, while 7 of the 8 students who answered correctly in the post-test were determined to have used NSS. These results reveal that the application contributed to students' orientation towards number sense-based solution strategies. For example, in the pre-test, S10 performed the operation based only on place value and had difficulty understanding the effect of the calculation error. In the post-test, S9, who answered correctly using NSS, stated, *"There is a difference of 10 numbers between 23 and 13. So I subtracted 10 and added 33 and 10,"* demonstrating that they understood the logic of the operation, i.e., that their conceptual understanding of the operation had developed.

When examining the data in Table 3, it is seen that in the pre-test, 6 students answered question 12 of the NST correctly, while 3 answered incorrectly. In the post-test, 9 students answered the NST correctly, while 5 answered incorrectly. None of the students used NSS in this question in either the pre-test or the post-test. Students used trial and error to find the rule. For example, S5, despite finding the correct rule, explained the method as *"I try them one by one, then look at the rules, and then I find the result."*

One of the number sense components, *Flexibility with Numbers and Operations in Computation Situations*, which is one of the components of number sense, the findings obtained from the responses given to the pre-test and post-test questions related to NST administered to students are presented in Table 3.

When examining the findings in Table 3, it can be said that students' visual perception skills showed improvement in their ability to count quickly when combined with creative grouping strategies. In the pre-test, 12 students answered question 13 of the NST correctly, while 2 used Unsubstantiated Answers, Non-Scientific Generalizations. S14, who answered the question using RBS, found the answer by counting *"the insides of the two boxes."* In the post-test NST, 13 students answered correctly, while 1 answered incorrectly. Furthermore, in the post-test, 12 correct answers were solved using NSS. S1, who used NSS, stated that they arrived at their answer through eye contact and explained their solution as follows: *"I understood that the square and the circle were together and in greater quantity without counting them."* This

explanation indicates that the student was able to perceive quantities in groups through quick counting.
According to Table 3, in the pre-test, none of the students who answered question 14 of the NST correctly used NSS, while in the post-test, a large proportion of those who answered correctly *(f=10)* used NSS. S13 developed a grouping strategy that drew attention to this question in the post-test. The student explained this situation as follows: *"Now these numbers come one after another. I added the first and last ones and found it easily. For example, 1 and 9, one at the beginning and one at the end. Then 2 and 8... they all add up to 10. Then 5 remain, I add them up."* This approach demonstrates the student's flexible thinking and ability to reduce the processing load.

When examining the data in Table 3, in the pre-test, 1 student answered question 15 of the NST correctly, while 12 answered incorrectly and 1 used Unsubstantiated Answers, Non-Scientific Generalizations. In the post-test, 7 students answered NST correctly, while 7 answered incorrectly. While none of the correct answers in the pre-test were answered using NSS, 6 of the 7 correct answers in the post-test were answered using NSS. For example, S10, who used NSS, estimated the folded parts while solving the problem: *"When I unfold the folded parts, the string takes up 1 cm, so it is 7 cm."* Additionally, as a different strategy, they demonstrated flexible thinking by offering an alternative solution: *"I think we can guess where the string will unfold. On one side, it unfolds to 9, on the other to 2, and the string in between is 7 cm. Easy."*

Conclusion, Discussion and Recommendation

This study aimed to determine the number sense levels of second-grade primary school students and to develop these skills through game-based activities supported by Scratch Software. As part of the study, the NST pre-test was administered to assess students' current number sense skills before the activities began. The pre-test results revealed that students' number sense skills were at a low level prior to the application.

It has been determined that students do not use number sense components effectively enough and instead try to solve problems using rule-, formula- and process-oriented approaches, i.e. rule-based methods. This finding shows that students focus on rote learning methods rather than number sense-based strategies in mathematics lessons. Student interviews conducted to support the pre-test results also yielded similar findings. These interviews confirmed that students are inadequate in using their number sense skills and prefer time-consuming methods based on memorised rules and operations. This situation is considered to stem from the lack of activities focused on number sense in mathematics lessons. The lack of activities aimed at developing number sense skills in mathematics lessons can cause difficulties for students in arithmetic operations and the process of producing practical solutions to problems. This deficiency can also negatively affect students' academic achievement and mathematical thinking skills.

When reviewing the literature, many studies are found that are parallel to the results of this research (Bayram, 2013; Çekirdekçi et al., 2016; Harç, 2010; Jordan et al., 2009; Kayhan-Altay, 2010; Soyuk, 2018; Yang & Li, 2008). In a study conducted by Çekirdekçi et al. (2016), the relationship between fourth-grade primary school students' use of number sense skills and their academic achievement in mathematics was examined. The study indicated that students' levels of number sense usage were low and that they tended to use rule-based strategies when answering questions. Similarly, in a study conducted by Yang and Li (2008) with Taiwanese students, it was found that students' number sense success rates were as low as 34%, that they preferred written operations in solving questions, and that they relied heavily on rote-based methods. The research revealed that students rarely used estimation and mental calculation skills. Kayhan-Altay's (2010) study on middle school students also reached similar conclusions. In this study, it was determined that students' number sense success rates were at a very low level of 22.6% and that they generally relied on rule-based methods when solving problems. Additionally, it was emphasised that this situation limited the use of number sense-based methods due to various obstacles.

In this study, after the Scratch-supported game-based activities were carried out, the NST was re-administered to the students as a post-test, and the findings revealed a statistically significant difference in favour of the post-test in the students' number sense skills, indicating an improvement in their number sense. Therefore, it can be said that Scratch software-supported game-based activities develop students' ability to use number sense to produce more practical and concise solutions to problems.

Scratch-supported activities and games have provided students with important opportunities to understand and develop the conceptual structure of numbers. Throughout the process, a significant increase in number sense skills was observed among students who actively participated in these activities; it was found that these students referred to number sense components more frequently when solving problems. Findings from students' responses in the post-test and interviews revealed significant improvements in their abilities to use the flexible structure of numbers to separate numbers, perform mental calculations, identify appropriate reference points in calculations, and recognise the magnitude and meaning of numbers. This is considered one of the important outcomes of the study.

These findings are consistent with various studies in the literature (Alkaş-Ulusoy, 2020; Çiçek, 2023; Kaminski, 2002; Markovits and Sowder, 1994; Tsao, 2004). For example, Çiçek (2023) examined the effect of number sense education on number sense strategies in fourth-grade primary school students and found that the experimental group of students who received this education showed a significant increase in their number sense skills. Alkaş-Ulusoy (2020), on the other hand, reported in his study that students who participated in a number sense-based teaching process showed a significant increase in their number sense, ability to notice mathematics in daily life, and problem-solving success compared to those who did not participate.

This study shows that number sense-focused activities implemented for primary school students play a fundamental role in the development of number sense skills. Number sense is considered one of the early mathematical skills and forms the basis for the development of other mathematical skills (Harç, 2010; Yang & Li, 2008). In this context, it is important to systematically integrate activities aimed at developing number sense skills into primary school education programmes. Based on the research results, it can be said that number sense-focused teaching processes designed with Scratch-based activities improve students' conceptual understanding of numbers and positively affect their mathematical problem-solving skills. Enriching primary school students' mathematics lessons with number sense activities can contribute to their increased awareness of numbers, enabling them to perform more effectively in both mathematical thinking and problem-solving processes.

When examining the components of number sense, it was found that the most progress was made in components such as "flexibility with numbers and operations in computation situations, separating and reassembling numbers, and utilizing the comparison (reference) point". In contrast, more limited development was observed in components such as "number sizes, understanding the meaning of numbers, and comprehending the effect and meaning of operations".

The component "flexibility with numbers and operations in computation situations" stands out as the component in which students use their sense of numbers most intensively (80.95%). Tunalı (2018) supports this finding in his study, stating that the component in which students are most successful is flexibility with numbers and operations in calculation situations. Similarly, Kayhan-Altay (2010), Cansız-Aktaş and Tuğrul-Özdemir (2017), and Takır (2016) also obtained findings parallel to this result in their studies.

The component of "separating and reassembling numbers" stands out as another area where students use their number sense skills the most (78.57%). Many studies in the literature are consistent with this result. For example, in his study examining the topic of exponential expressions in terms of number sense components, İymen (2012) stated that students successfully performed separation and recombination operations in sections related to the multiplication of exponential numbers. However, it has been stated that this skill is not sufficiently used in challenging questions (Gülbağcı-Dede & Şengül, 2016).

The "utilizing the comparison (reference) point" component is another component that students frequently use (75%). Harç (2010) supports this finding in his study, noting that the percentage of correct answers given by students using reference points is higher than that of other components. Alkaş-Ulusoy (2020) revealed that number sense-based teaching develops estimation and mental calculation skills as well as the ability to use reference points. However, some studies in the national and international literature indicate that primary and secondary school students have difficulty using reference points (Cramer et al., 2002; Çekirdekçi et al., 2016; Kayhan-Altay, 2010; Markovits & Sowder, 1994; Yang, 1995; Yang, 2005a). These findings differ from the results of the current study.

The "number sizes" component stands out as another component that students frequently use (69.04%). Soyuk (2018) stated that students were most successful in this component. It has been suggested that this situation is related to the intensive content offered in teaching programmes on this subject and the fact that students demonstrate performance that is not based on memorisation.

"Understanding the meaning of numbers" is one of the components that students use relatively less (57.14%). A study conducted by Yang et al. (2008) differs from the findings of this study. The study in question states that the component in which students use number sense in the best way is knowing the relative sizes of numbers. It is thought that this difference may be due to the differences in the grade levels and curriculum content.

The "comprehending the effect and meaning of operations" component was found to be the component in which students used number sense the least (32.14%). It was stated that this may be due to misconceptions and overgeneralisations. In his study, Peker (2019) revealed that the lowest correct answer rate was obtained in the effect of operations component. Similarly, İymen and Duatepe-Paksu (2015) and Harç (2010) stated that students were inadequate in this component. However, Yenilmez and Yıldız (2018), in their study on number sense components, found that this component was more successful than the others. This situation shows a contradiction with the findings of the current study.

Teachers have a critical role in the development of number sense. In this context, the Ministry of National Education should organise in-service training programmes, and the Faculties of Education should add number sense content to the courses for prospective teachers. Digital tools such as Scratch, GeoGebra and Geometer's Sketchpad can contribute to the development of this skill by gamifying and enriching mathematics teaching. Number sense should be supported from an early age and activities should be designed for different age groups. Acquisitions for number sense should be clearly defined in curricula, and textbooks should be enriched with content to support this skill. Research on the development of number sense should be conducted with larger and more diverse samples, and students' mathematics learning processes should be supported with in-class activities related to real life.

Author Contributions

This study was derived from the master's thesis prepared by the first author under the supervision of the second author. All authors equally contributed to the writing of the article. They read and approved the final version of the study.

Ethical Declaration

This study was conducted with the approval obtained from the Ethics Committee of Human Research in Educational Sciences at Erzincan Binali Yıldırım University, granted during the meeting held on 28 February 2022 (Protocol No: 02/13).

Conflict of Interest

The authors declare that they have no conflict of interest with any institution or person within the scope of this study.

Declaration of Generative AI Use

In this study, an artificial intelligence–assisted translation tool, DeepL Translate, was used solely to support English language editing and grammatical corrections. All translations were subsequently reviewed and revised by the authors.

References

Akbabaoğlu, Z. (2023). *The effect of number sense education program supported by Web 2.0 tools on number sense development of first grade primary school students'* (Publication No. 857393). [Master's Thesis, Afyon Kocatepe University]. YÖK Thesis Center

Akkaya, R. (2015). An investigation into the number sense performance of secondary school students in Turkey. *Journal of Education and Training Studies, 4*(2), 113–123. https://doi.org/10.11114/jets.v4i2.1145

Alkaş-Ulusoy, Ç. A. (2020). Effects of number sense-based instruction on sixth-grade students' self-efficacy and performance. *Education and Science, 45*(202), 417–439. https://doi.org/10.15390/EB.2020.8381

Altun-Akbaba, Z. (2025). *Investigation of number sense strategies used by fifth grade students about fractions* (Publication No. 955720). [Master's Thesis, Kütahya Dumlupınar University]. YÖK Thesis Center

Başer, N. (2025). *An overview of number sense research published in international journals: A bibliometric analysis* (Publication No. 932890). [Master's Thesis, Akdeniz University]. YÖK Thesis Center

Bayram, G. (2013). *The relationship between 8th grade students' number sense and achievement related to exponentials* (Publication No. 384161). [Master's Thesis, Pamukkale University]. YÖK Thesis Center

Bozkurt, G., & Yiğit-Koyunkaya, M. (2022). Supporting prospective mathematics teachers' planning and teaching technology-based tasks in the context of a practicum course. *Teaching and Teacher Education, 119*, 1-20. https://doi.org/10.1016/j.tate.2022.103830

Bruce, C. D., Flynn, T., Yearley, S., & Hawes, Z. (2023). Leveraging number lines and unit fractions to build student understanding: Insights from a mixed methods study. *Canadian Journal of Science, Mathematics and Technology Education, 23*(2), 322–339. https://doi.org/10.1007/s42330-023-00278-x

Büyüköztürk, Ş. (2012). *Sosyal bilimler için veri analizi el kitabı* (16th Edition). Pegem Akademi Publishing.

Çakıroğlu, Ü., Güven, B., & Akkan, Y. (2008). Examining mathematics teacher' beliefs about using computers in mathematics teaching. *Hacettepe University Journal of Education, 35*(35), 38-52.

Can, D. (2019). Examination of the number sense performance of the fourth grade elementary school students based on some variables. *Elementary Education Online*, *18*(4), 1751-1765. https://doi.org/10.17051/ilkonline.2019.639317

Cansız-Aktaş, M., & Tuğrul-Özdemir, E. (2017). An examination of the number sense performances of preservice elementary school mathematics teachers. *European Journal of Education Studies, 3*(12), 133-144. https://doi.org/10.5281/zenodo.1117088

Çatlak, Ş., Tekdal , M., & Baz, F. (2015). The status of teaching programming with Scratch: A document review work. *Journal of Instructional Technologies & Teacher Education. 4*(3), 13-25.

Çekirdekçi, S., Şengül, S., & Doğan, M. (2016). Examinig the relationship between number sense and mathematics achievement of the 4th grade students. *Qualitative Studies*. *11*(4), 48-66. https://doi.org/10.12739/NWSA.2016.11.4.E0028

Chang, H., Chen, L., Zhang, Y., Xie, Y., de Los Angeles, C., Adair, E., Zanitti, G., Wassermann, D., Rosenberg-Lee, M., & Menon, V. (2022). Foundational number sense training gains are predicted by hippocampal–parietal circuits. *The Journal of Neuroscience, 42*(19), 4000–4015. https://doi.org/10.1523/JNEUROSCI.1005-21.2022

Çiçek, A. (2023). *The effect of number sense strategies education given to 4th grade students on the development of number sense skills* (Publication No. 821746). [Master's Thesis, Kütahya Dumlupınar University]. YÖK Thesis Center

Cramer, K., Post, T., & delMas, R. (2002). Initial fraction learning by fourth- and fifth-grade students: A comparison of the effects of using commercial curricula with the effects of using the rational number project curriculum. *Journal for Research in Mathematics Education, 33*(2) 111-144. https://doi.org/10.2307/749646

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd Edition). Sage Publications.

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd Edition). Sage Publications.

Devlin, D., Moeller, K., & Sella, F. (2022). The structure of early numeracy: Evidence from multi-factorial models. *Trensd in Neuroscience and Education, 26,* 1-9. https://doi.org/10.1016/j.tine.2022.100171

Doğmaz-Tunalı, S., & Yıldız-Demirtaş, V. (2022). Mathematics learning disability and number sense. *EDUCATIONE*, *1*(1), 105-127.

Er, Z. & Dinç-Artut, P. (2021). Investigation of number sense strategies used by primary school teachers and mathematics teachers. *Journal of Education, Theory and Practical Research, 7*(1), 48-61. https://doi.org/10.38089/ekuad.2021.40

Fraenkel, W., Wallen, N., & Hyun, H. (2012). *How to design and evaluate research in education* (8th Edition). McGraw-Hill.

Gay, L. R., Mills, G., & Airasian, P. (2012). *Educational research: Competencies for analysis and applications.* Pearson.

Genç, G., & Polat, K. (2025). The relationship between working memory performance and number sense skills in primary school. *International Journal of Turkish Education Sciences, 13*(2), 767–796. https://doi.org/10.46778/goputeb.1606014

Gonzalez, C. (2013). *Student usability in educational software and games: Improving experiences.* IGI Global.

Greeno, J. G. (1991). Number sense as situated knowing in a conceptual domain. *Journal for Research in Mathematics Education, 22*(3), 170-218. https://doi.org/10.2307/749074

Gülbağcı-Dede, H., & Şengül, S. (2016). An investigation of pre-service elementary and secondary mathematics teachers' number sense. *Turkish Journal of Computer and Mathematics Education (TURCOMAT), 7*(2), 285–303. https://doi.org/10.16949/turcomat.96275

Harç, S. (2010). *Analysis of the current situation of the 6th grade students in terms of number sense concept* (Publication No. 279888). [Master's Thesis, Marmara University]. YÖK Thesis Center

İymen, E. (2012). *Analysis of 8 grade students' number sense on exponents in terms of number sense components* (Publication No. 325769). [Master's Thesis, Pamukkale University]. YÖK Thesis Center

İymen, E., & Duatepe-Paksu, A. (2015). Analysis of 8th grade students' number sense related to the exponents in terms of number sense components. *Education and Science*, *40*(177), 109-125. https://doi.org/10.15390/EB.2015.2710

Jordan, N., Kaplan, D., Olah, L., & Locuniak, M. (2006). Number sense growth in kindergarten: A longitudinal investigation of children at risk for mathematics difficulties. *Child Development, 77*(1), 153-175. https://doi.org/10.1111/j.1467-8624.2006.00862.x

Kalaycı, Ş. (2014). *SPSS uygulamalı çok değişkenli istatistik teknikleri* (6th Edition). Asil Publishing

Kaminski, E. (2002). Promoting mathematical understanding: Number sense in action. *Mathematics Education Research Journal, 14*, 133-149.

Karagöz, B. (2024). *The effect of mathematical modeling activities on elementary school students' number sense and attitudes towards mathematics* (Publication No. 852369). [Master's Thesis, Kastamonu University]. YÖK Thesis Center

Kayhan-Altay, M. (2010). *An investigation of middle grade students' number sense in terms of grade level, gender and components of number sense* (Publication No. 265189). [Doctoral Dissertation, Hacettepe University]. YÖK Thesis Center

Kobsiripat, W. (2015). Effects of the media to promote the scratch programming capabilities creativity of elementary school students. *Procedia-Social and Behavioral Sciences, 174*, 227-232. https://doi.org/10.1016/j.sbspro.2015.01.651

Köse, N. (2008). *Determining fifth grade primary school students' understanding of symmetry using dynamic geometry software cabri geometry: An action research* (Publication No. 229177). [Doctoral Dissertation, Anadolu University]. YÖK Thesis Center

Küçükay, S. (2022). *Examination of graduate theses prepared on number sense in Turkey* (Publication No. 773008). [Master's Thesis, Eskişehir Osmangazi University]. YÖK Thesis Center

Lago, R., & DiPerna, J. (2010). Number sense in kindergarten: A factor-analytic study of the construct. *School Psychology Review*, *39*(2), 164-181. https://doi.org/10.1080/02796015.2010.12087771

Ma, M., Likhanov, M., & Zhou, X. (2024). Number sense-arithmetic link in grade 1 and grade 2: A case of fluency. *British Journal of Educational Psychology, 94*(3), 897–918. https://doi.org/10.1111/bjep.12693

MacDonald, A., & Carmichael, C. (2018). Early mathematical competencies and later achievement: Insight from the longitudinal study of australian children. *Mathematcs Education Research Journal, 30*(4), 429-444. https://doi.org/10.1007/s13394-017-0230-6

Markovits, Z., & Sowder, J. (1994). Developing number sense: An intervention study in grade 7. *Journal For Research in Mathematics Education*, *25*(1), 4-29. https://doi.org/10.2307/749290

McIntosh, A., Reys, B., & Reys, R. (1992). A proposed framework for examining basic number sense. *For The Learning of Mathematics, 12*(3), 209-221.

McMillan, J. H. & Schumacher, S. (2010). *Research in education: evidence-based inquiry* (7th Edition.). Pearson Publishing.

Ministry of National Education [MoNE] (2018). *Matematik Dersi Öğretim Programı (İlkokul ve ortaokul 1, 2, 3, 4, 5, 6, 7 ve 8. sınıflar) [Mathematics curriculum (Primary and secondary grade 1, 2, 3, 4, 5, 6, 7 and 8)].* Ankara.

Ministry of National Education [MoNE] (2024). *İlkokul Matematik Dersi Öğretim Programı (1, 2, 3 ve 4. sınıflar) [Primary school mathematics curriculum (Grades 1, 2, 3 and 4)].* Ankara.

Okuducu, A. (2020). *The effect of scratch based mathematics instructions on 6th grade sutdents' academic achievements and attitudes in algebraic expressions* (Publication No. 628951). [Master's Thesis, Ağrı İbrahim Çeçen University]. YÖK Thesis Center

Olkun, S., & Toluk-Uçar, Z. (2012). *İlköğretimde etkinlik temelli matematik öğretimi* (5th Edition). Eğiten Kitap Publishing.

Peker, E. S. (2019). *Investigation of the 8th grade students' performance of number* (Publication No. 557705). [Master's Thesis, Uşak University]. YÖK Thesis Center

Perini, N., Porru, A., Moeller, K., Jay, T., Lucangeli, D., & Sella, F. (2023). Number express: A digital game to improve early numeracy. *The Electronic Journal of e-Learning, 22*(10), 37-51. https://doi.org/10.34190/ejel.22.10.3522

Reys, R., Reys, B., Emanuelsson, G., Johansson, B., McIntosh, A., & Yang, D. C. (1999). Assessing number sense of students in Australia, Sweden, Taiwan, and the United States. *School Science and Mathematics, 99*(2), 61–70. https://doi.org/10.1111/j.1949-8594.1999.tb17449.x

Saka, E., & Çelik, D. (2018). A study on the computer usage in mathematical modeling of pre-service mathematics teacher. *Turkish Journal of Computer and Mathematics Education, 9*(3), 618-635. https://doi.org/10.16949/turkbilmat.409160

Sarı, M. H., & Özmen, B. (2025). The role of number sense performance in the relationship between math anxiety and math achievement among second-grade primary school students. *Kastamonu Educational Journal, 33*(4), 889–902. https://doi.org/10.24106/kefdergi.1797587

Şengül, S., & Gülbağcı-Dede, H. (2013). An investigation of classification of number sense components. *The Journal of Academic Social Science Studies, 6*(8), 645-664. https://doi.org/10.9761/JASSS1000

Şengül, S., & Öztürk-Zora, L. (2023). Identification of number sense strategies used by eighth-grade students in fractions questions in figure, operation, and scenario forms. *Education and Science, 48*(214), 117–147. https://doi.org/10.15390/EB.2023.11339

Şengül, S., Gülbağcı, H., & Gerez-Cantimer, G. (2012). Examining the number sense strategies about percent of the 6th grade students. *The Journal of Academic Social Science Studies, 5*(8), 1055-1070. https://doi.org/10.9761/jasss_407

Singh, P. (2009). An assessment of number sense among secondary school students. *International Journal for Mathematics Teaching and Learning, 5*(9), 1-29.

Soyuk, R. (2018). *Investigation of number sense of 8th grade students related to square root expressions* (Publication No. 507319). [Master's Thesis, Eskişehir Osmangazi University]. YÖK Thesis Center.

Takır, A. (2016). Investigating the relations number sense ability of 6th, 7th and 8th grade students between their grade level, gender and mathematics self-efficiency level. *Dicle University Journal of Ziya Gökalp Faculty of Education*, *29*, 305-315. https://doi.org/10.14582/DUZGEF.738

Taylan-Bektaş, D. (2021). *The effect of game-based learning on fourth-grade students' number sense abilities* (Publication No. 699451). [Master's Thesis, Boğaziçi University]. YÖK Thesis Center.

Tsao, Y. L. (2004). Exploring the connections among number sense, mental computation performance, and the written computation performance of elementary preservice school teachers. *Journal Of College Teaching & Learning, 1*(12), 71-90.

Tunalı , C. (2018). *The determination of gifted students' level of number sense* (Publication No. 512940). [Master's Thesis, Dokuz Eylül University]. YÖK Thesis Center.

van Bueren, N. E. R., van der Ven, S. H. G., Roelofs, K., Cohen Kadosh, R., & Kroesbergen, E. H. (2022). Predicting math ability using working memory, number sense, and neurophysiology in children and adults. *Brain Sciences, 12*(5), 550-570. https://doi.org/10.3390/brainsci12050550

Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. M. (2020). *Elementary and middle school mathematics: Teaching developmentally* (10th Edition). Pearson.

Yaman, H. (2015). Number sense performances of preservice teachers by grade level. *Kastamonu Education Journal, 23*(2), 739-754.

Yang, D. C. (1995). *Number sense performance and strategies possessed by sixth and eighth grade students in taiwan* (Publication No. 9705388). [Doctoral Dissertation, University of Missouri]. Columbia Proquest Dissertation and Theses.

Yang, D. C. (2005a). Developing number sense through mathematical diary writing. *Australian Primary Mathematics Classroom, 10*(4), 9-14.

Yang, D. C. (2005b). Number sense strategies used by 6th-grade students ın taiwan. *Educational Studies*, *31*(3), 317-333. https://doi.org/10.1080/03055690500236845

Yang, D. C., & Li, M. F. (2008). An investigation of 3rd-grade taiwanese students' performance in number sense. *Educational Studies, 34*(5), 443-455. https://doi.org/10.1080/03055690802288494

Yang, D. C., Li, M. & Lin, C. (2008). A study of the performance of 5th graders in number sense and its relationship to achievement in mathematics. *International Journal of Science and Mathematics Education, 6*(4), 789-807. https://doi.org/10.1007/s10763-007-9100-0

Yazlık, D. Ö. (2018). The views of teachers about use of concrete teaching materials in mathematics teaching. *International Journal of Society Researches, 8*(15), 775–805. https://doi.org/10.26466/opus.417200

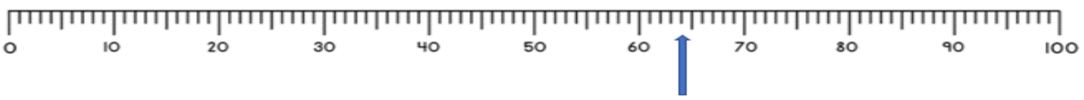
Yenilmez, K., & Yıldız, Ş. (2018). Investigation of number sense strategies of 7th grade students on rational numbers. *Journal of Theoretical Educational Science*, *11*(3), 457-485. https://doi.org/10.30831/akukeg.349650

Yıldırım, A., & Şimşek, H. (2013). *Sosyal bilimlerde nitel araştırma yöntemleri* (9th Edition). Seçkin Publishing.

Appendix

2nd Grade Number Sense Test

1)

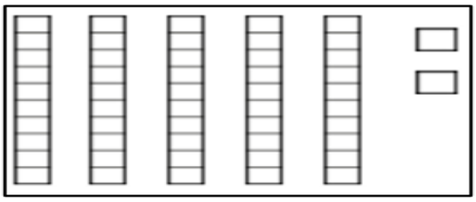


Which number should be placed at the point indicated by the arrow on the number line above?

Solution:

How did you make your decision?:

2)



What number is represented by the base-ten blocks shown in the image above?

Solution:

How did you make your decision?:

3) What are the first five expressions that come to your mind when you hear the number **8**? Write them below.

Solution:
1-
2-
3-
4-
5-

How did you make your decision?:
1-
2-
3-
4-
5-

4) Their father asked Ahmet, Buse, and Özlem to go fishing. Ahmet caught 21 anchovies, Buse caught 23 turbot, and Özlem caught 25 whiting. Let's estimate how many fish Ahmet, Buse, and Özlem caught together. *(Without calculating exactly)*

Solution:

How did you make your decision?:

5)

☐ + ☐ = ☐

☐ + ☐ = ☐

☐ - ☐ = ☐

☐ - ☐ = ☐

Use only the numbers **8, 14,** and **22** to fill in the empty boxes and complete the operations shown on the left.

How did you make your decision?:

6)

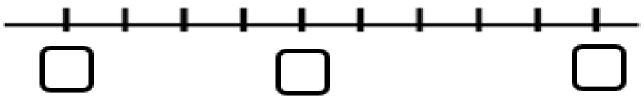
23	40	36	86
+15	-21	+19	- 12

Solve the four operations shown above, and then list your answers from largest to smallest.

Solution:

How did you make your decision?:

7) Place the numbers 83, 79, and 88 into the appropriate boxes on the number line segment shown below.



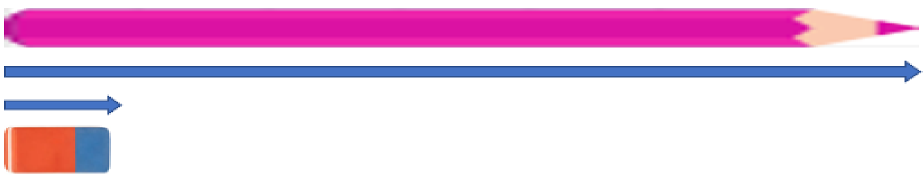
How did you make your decision?:

8) Circle the largest number in each box shown below.

44 66 52	76 33 65	38 75 49	23 32 14

How did you make your decision?:

9)



A pencil and an eraser are shown above. Based on this, how many eraser lengths is the pencil approximately equal to?

Solution:

How did you make your decision?:

10) Consider the subtraction **65 − 18**. Do you think the result is greater than or less than 45? Write your guess without calculating.

Solution:

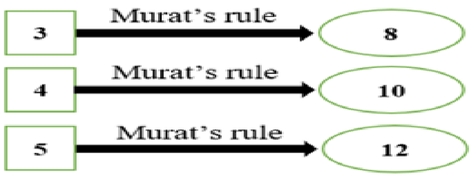
How did you make your decision?:

11) Ekin wanted to check the result of 56 − 23 = 33, but accidentally entered 56 − 13 into the calculator. Which of the following statements is correct regarding the result Ekin obtained?

A) It is 13 less than 33. **B)** It is 10 less than 33. **C)** It is 10 more than 33.

How did you make your decision?:

12)



In the figure on the left, Murat used a rule to move from  to . Which of the following rules did he use?

A) Multiply by 1 and add 5. **B)** Multiply by 2 and add 2. **C)** Multiply by 3 and subtract 1.

How did you make your decision?:

13)

In the figures given above, are there more dots inside the circle or inside the square? Write your estimate without counting.

Solution:

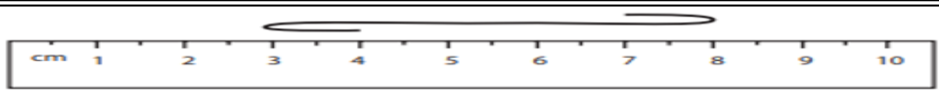
How did you make your decision?:

14) Estimate the result of the operation 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 = ? Explain the strategy you used to make your estimate.

Solution:

How did you make your decision?:

15-



Look at the string in the figure above. If the string is stretched out straight, how long do you think it would be? Write your estimate in centimeters.

Solution:

How did you make your decision?: