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Number Sense Conceptions of Gifted and Talented Preschool Children

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Üstün Yetenekli Okul Öncesi Çocuklarında Sayı Algısı Kavramı

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Öz

Sayı algısı matematik eğitiminde temel kavramların gelişimini sağlayan önemli bir kavramdır. Ayrıca, sayı algısının okul öncesinde matematiksel algıyı şekillendiren ve gelecekteki matematiksel anlayış hakkında fikir veren kavram olması da onun önemli boyutlardan biridir. Şu bir gerçektir ki, üstün yetenekli öğrenciler erken yaşlarda olsalar bile farklı ve yaşıtlarına göre daha üst düzeyde sayı algılarına sahip olabilmektedirler. Bu farklılığı ortaya koymak, bu tarz öğrencilerin sayı algılarını anlamlandırabilmek adına bir gereklilik olarak görülebilir. Bu sebeple, bu örnek olay çalışmasının amacı, Ankara'da üstün yetenekliler merkezine devam eden 3-5 yaşlarındaki 3 tane üstün yetenekli çocuğun yarı yapılandırılmış görüşmeler yardımıyla, sayı algısı kavramını değerlendirmektir. Çalışmanın sonuçları, çalışmaya katılan üstün yetenekli çocukların geniş bir yelpazede sayı algılarının var olduğunu göstermiştir. Ayrıca çalışma, bu çocukların Howell ve Kemp'in (2010) çalışmasında kullanılan sayı algısı envanterinin uygulanmasında büyük bir başarı gösterdiklerini ortaya koymuştur. Bu çalışmanın, üstün yetenekli öğrencilerdeki sayı algısının önemi hakkında farkındalık yaratmak adına matematik eğitimine katkıları olabilecektir.

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Abstract

In mathematics education, number sense is a crucial concept that develops core ideas for mathematics. Moreover, it has another important dimension that number sense shape and predict the preschoolers' mathematical understanding in the future. The fact that gifted students are the ones can have a differentiated and higher level of number sense conceptions even if in their early ages, revealing this differentiation can be a necessity to understand their comprehension. Hence, the purpose of this case study is to assess the conceptions of gifted and talented preschool students in the domain of number sense, by conducting semi structured interviews with three children, ages 3-5, enrolling in a gifted and talented institute in Ankara, Turkey. The results of the study showed that these young gifted and talented students have a wide range of number sense comprehension and they showed a great success in the tasks adapted from Howell and Kemps' (2010) study. Moreover, the study might have so many contributions to create awareness about the importance of construction of number sense of gifted and talented students in mathematics education.

Introduction

Seeing mathematics as consisting of some strict rules, predetermined methods and application of these rules on the numbers is faulty for the reality that it consists of relationships among quantities and numerical symbols in a meaningful way (Griffin, 2004; National Council Teachers of Mathematics [NCTM], 2000; National Research Council, 2002). In that sense, construction and development of number sense has a crucial importance for students' mathematical understanding (Jordan, Kaplan, Locuniak, & Ramineni, 2007; Yang & Wu, 2000). There is a common problem on the agreement of the way of clear assessment and definition of number sense (Berch, 2005, Howell & Kemp, 2009). However, as in a general frame, number sense is seen as a vital component of mathematical comprehension (Dehaene, 1997; Dehaene, Molko, Cohen, & Wilson, 2004; Gilmore, McCarthy, & Spelke, 2007; Howell & Kemp, 2009) and it can be defined as "an intuition about numbers that is drawn from all varied meanings of number" (National Council Teachers of Mathematics [NCTM], 1989, p.39). This means that the ones having number sense can comprehend the meaning of the numbers as representation of relations, magnitudes, and materials (Van de Walle, 1990).

Especially for mathematics, early preschool years are the crucial part of the children's life shaping their mathematical understanding and mathematical world (McGuire, Kinzie, & Berch, 2012). In their early life, children put initial actions to acquire the number sense with the help of their environment; moreover, preschoolers' acquisitions of number sense can be a way to increase the feeling of their self-confidence while solving numerical problems in their lives (Van de Walle, 1990). Besides, the number sense can be seen as the most crucial concepts that children should have in their early mathematics (Baroody, 2009; Jordan, 2007; Kilpatrick, Swafford, & Findell, 2001; McGuire, Kinzie & Berch, 2012; NCTM 2008; Van de Walle 2003). Similarly, early number sense conceptions of young children can predict how their math performance will be in the future (Chard, Clarke, Baker, Otterstedt, Braun, & Katz, 2005; Jordan, Kaplan, Olah, & Locuniak, 2006).

Number sense is used commonly in the area of special education (Bryant, Bryant, Gersten, Scammacca, & Chavez, 2008; Fuchs et al., 2007; Howell & Kemp, 2009) and it can be one of these concepts which gifted and talented students develop in their preschool years. Thus, based on the idea that revealing and developing the maths performance of gifted students are crucial (Özdemir, 2018), early years are vital in terms of structuring this performance (Gross, 1999). That is, early school years of gifted students are crucial so as to frame the number sense of young gifted learners.

Throughout the history, various definitions of giftedness posed by various researchers due to the cultural variations of these researchers (Sousa, 2003). Moreover, these definitions have become widespread and based on the properties of giftedness. Initial studies of these definitions goes back to the Terman's (1921) study and as a general framework, he deals as being higher than the peers in terms of emotional, social and healthy as well as cognitively such as attention, learning and speed (Uyaroğlu, 2011). The needs of gifted students have had significant importance (Hannah, James, Montelle & Nokes, 2011; Özdemir 2016) and depending the equity principle of education (Van de Walle, Karp, & Bay-Williams, 2013), it is their right to benefit from differentiated educational opportunities parallel to their needs (Wilkins, Wilkins, & Oliver, 2006). That is, gifted students need additional support in classroom environments for mathematics education (Dimitriadis, 2012) due to their differentiated perceptions and understandings in terms of mathematical concepts. Particularly, in mathematics, more attention and focus should be on the gifted students so as not to lose their potential and get boredom (Dimitriadis, 2012).

However, studies concentrating on the discussion of these three dimensions as; gifted, number sense and preschool students, are not available in the accessible literature and due to existence of gap in this area, what remains to be explored is to reveal the number sense conceptions of preschool gifted students. Thus, it is crucial to analyze deeply how gifted students' conception of number sense is and how different their understandings are. By this way, mindfulness about this issue in the field of both mathematics education and early childhood education would be increased more. Furthermore, necessary modifications to the education of these young gifted students by including activities and assessments into mathematics curriculum and program can be conducted. Taking into account all of these issues, in this study, it was intended to assess the conceptions of gifted preschool students, in the domain of number sense.

Method

In order to assess the number sense comprehension of gifted students, the tasks used in the study of Howell and Kemp (2009; 2010) were used. In their study, they developed the tasks including components required to assess number sense comprehension of pre-school students by taking the literature, research results and international experts' opinions into account.

The tasks were applied to preschool students in the sample of this study, which was formed by using purposive sampling method from a Gifted and Talented Institute where gifted and talented students enroll, assess and educated in Ankara, Turkey. The students in the study were diagnosed by the institute as gifted by taking various assessment and evaluation procedures and results into attention. In the institute, students identified as gifted are lead to Special Group Programs conducted at weekends. One of these groups includes students whose age ranges from 3 to 5. Among those eight students enrolling in this group program, three preschool gifted students; 2 boys and 1 girl student; were randomly selected. During the data analysis process, these boy students were labeled as Ali (aged 3), Veli (aged 5) and one girl student was labeled as Ayşe (aged 3).

During the study, qualitative research method was used to explore the number sense comprehension of gifted students because this method enables researchers in–depth analysis (Frankell & Wallen, 2006). Moreover, because participants are students who have even difficulty to talk and express themselves, qualitative research method not only helped to probe the answers and thinking process of students but also provided opportunity to interpret nonverbal clues about the idea (Creswell, 2009). Among qualitative research methods, this study was case study which allowed a concentrated and systematics examination of the data about this group of people (Gustafsson, 2017).

Data Collection and Analysis

Data was collected by using the eighteen tasks developed by Howell and Kemp (200, p. 416-417) about number sense comprehension for preschool children with three preschool students enrolling in the institute. The tasks were consisted of three distinct parts. In the first part, there were 11 tasks to measure counting components as can be seen in Table 1.

Table 1. Tasks to Measure Counting Components (Howell & Kamp, 2010, p. 416)

Component	Task Description
Rote counting	Allow the child three opportunities to count aloud. Stop counting at 30.
Count from a given number	Ask the child to count on from three numbers (other than 1) within their rote counting range.
Counting backwards	Ask the child to count backwards from three numbers within their counting range (excluding 10).
1:1 correspondence	Ask the child to count a random display of 7 items and 9 items. If the child cannot do this, ask the child to count 7 items and 9 items displayed in a horizontal line.
Cardinal value	In the task above, the child is asked to count the sets and say how many there are.
Counting out a set to match a spoken number	Ask the child to count out 6 and 8 counters from a group of counters
Number after	Say, 'I'm going to say a number and I want you to tell me the number which comes next. 5 – What number comes next?' Repeat with 2 and 7.
Number before	Say, 'I'm going to say a number and I want you to tell me the number which comes before it. What number comes before 10?' Repeat with 6 and 3.
Ordinal value	Ask the child to point to the third of 10 apples, sixth of 10 swans and ninth of 15 bugs shown on cards in a horizontal line.
Addition story (addition to 5)	Explain that the child can use counters if they like. Say, 'If you have 3 sweets and I give you 2 more how many will you have?'
Subtraction story (subtraction from 4)	Explain that the child can use counters if they like. Say, 'If you have 4 sweets and you eat 3 sweets how many will you have left?'

In a similar manner, in the second part; 3 tasks (Table 2) to measure number principle components were given to the students. In these tasks, items that need modification or adaptation for the culture of the children were carried by the researcher. After this process, in the last part (Table 3); 4 tasks to measure number magnitude components were given to the students. In this task, they were wanted to complete the activities or games as in the instructions in which students needed to determine and interpret the magnitude of components.

Table 2. Tasks to Measure Number Principle Components (Howell & Kamp, 2010, p. 417)

Component	Task Description
Order irrelevance	The child observes a puppet counting and says whether the count is right or wrong. The puppet counts correctly from left to right starting with the first item, correctly but starting from the third item and incorrectly counting the third item twice.
Inversion	Establish with the child that two groups of counters are 'equal' (each group has four counters). The two groups are each hidden under a card. Two counters are added to one side of one group, and then two counters are removed from the other side of that group. The child says whether the two groups are the same or different. The process is repeated by adding and removing one counter from one group. In the third trial, one counter is added to a group, but two counters are removed.
Commutative addition	Establish that the containers with the same coloured sweets have the same number of sweets. The assessor shares out the containers of sweets to two puppets. The puppets receive containers of coloured sweets in different order. The child says whether the assessor has been fair and given the puppets the same number of sweets.

In this study, so as to collect the data about number sense comprehension of the gifted students, semi-structured interviews were conducted at times and places which students feel comfortable. Required permissions were obtained from the parents of the children and interviews were lasted about 40 minutes. The interviews were started with informal talks between the researcher and students; by this way, it was aimed to create an atmosphere in which children are at ease. Besides, the researcher was the person who assisted the Special Group Program in the center during 4 weeks so as both to help for the institute and make the students accustomed to the existence of the researcher. Moreover, during the interviews, needed notes were hand written and the interviews were audio typed. Further, when necessary, to elicit and elaborate details, probing questions were employed.

Table 3. Tasks to Measure Number Magnitude Components (Howell & Kamp, 2010, p. 417)

Component	Task Description
Larger group	Show two cards and ask the child to point to the group with more. Present groups of 2 and 5, 8 and 4.
Larger number	The child says which of the two numbers spoken by the assessor is the biggest. Spoken numbers 4 and 2, 3 and 5, 2 and 1.
Ordering groups Ordering two groups Ordering three groups	After a demonstration of the task, the child places two cards, each displaying a group of dots in order on a ladder with the small group low on the ladder and big group high on the ladder. The task is repeated with three cards.
Subitizing	The child is told that a card will be quickly shown and that they are to say how many dots they see. A card with random dot pattern of 2, 4 and 3 is flashed.

In order to collect data about students' achieving these tasks, the researcher ticked up the tasks that were completed successfully. Besides, as in the Howell and Kemp's study (2010), when students needed help or prompt, as a note (P) was added near to the score of the task. Moreover, in order to examine students' number sense comprehension as similar to their study, for the task of counting back, students were asked for counting back from 5, 8 and 15, which had the top points for this task in their study. At sometimes, when they had difficulty, students were given 3 opportunities to reconstruct the task and if they could not, they were given a prompt or any clue/example for the question. For the students given opportunities, the notes were taken about in which trial s/he could do the task. That is, if the student can perform the instruction in the task, the researcher ticked the question. If s/he could perform in his/her second trial, TR-2 was noted and if s/he could perform in his/her third trial TR-3 was noted. Besides, if the child completed the task by means of prompt, the question was labeled as (P), which reflects the successful completion of the task after prompt was given. Moreover, as stated previously, some probing questions were used for some part of the process when the researcher needed to expand on the data. Then, according to the answers, the data about tasks completed successfully and students' way of explanation of conceptions as well as their way of answering the instructions gathered from these children.

For the analysis of the data, initially, all interviews were audiotaped and they were transcribed through the data analysis period. All transcribed data was read several times to acquire general sense of data and most importantly, students' answers were coded as successful or not in accordance with the components in the tasks and whether children were accomplished the tasks or not. Moreover, it was also analyzed that in which trial they were accomplished and whether any prompt was given or not. Moreover, data was also evaluated based on the difficulty that the student had while performing the task. For this aim, the data about students' trial number was considered as the reflection of difficulty, which was noted as TR-2, TR-3 or (P) in data collection process. Based on these coded data, assessment of students' conceptions in the number sense items were revealed in terms of interpretations and inferences from the categorization of these coding.

Moreover, for checking the reliability, transcripts are checked to be sure whether a clear mistake is made or not and codes were checked with the transcripts and memos taken during the interview procedures. Moreover, as an inter-coder, another researcher having PhD in mathematics education field checked the codes and inferences. Then, the agreement with the researcher is checked, which was found as reliable through interrater agreement of 0,93 (Miles & Huberman, 1994). Furthermore, an expert and a graduate student in the gifted education field are used for peer debriefing and external auditor is used to validate the accuracy of the findings (Creswell, 2009).

Findings

The findings of the study reflected that through the tasks, gifted children did not face any real difficulty for the items. That is, none of the data obtained, as the answers of the tasks, students' interpretations in the interviews and researcher's observation notes, indicated uneasiness or trouble on completing the instruction of the task. The data about completing the task as successful or not was provided in Table1.

Table 3.2 Summary of Characteristics of Teachers in Try-Out

	Ali	Veli	Ayşe
Task-1	✓	✓	✓
Task-2	✓	✓	✓
Task-3	✓	✓	✓
Task-4	✓	✓	✓
Task-5	✓	✓	✓
Task-6	✓	✓	✓
Task-7	✓	(TR2)	✓
Task-8	✓	✓	✓
Task-9	✓	✓	(TR2)
Task-10	✓	(P)	✓
Task-11	(TR2)	✓	(P)
Task-12	✓	✓	✓
Task-13	✓	✓	✓
Task-14	(P)	✓	✓
Task-15	✓	✓	✓
Task-16	✓	(P)	(P)
Task-17	✓	✓	✓
Task-18	(P)	TR3	(P)

As seen in Table 1, none of the task was completed unsuccessfully; that is, all the students could perform the tasks successfully. Especially in counting tasks (Tasks 1-11), all students revealed a great success by completing each instruction successfully. In order to explore the exact case about students' number sense, some other tasks were used to clearly see whether this successful counting is because of comprehension or memorization. Data obtained through these tasks showed that all gifted students could count consciously rather than memorizing strategy. To reveal this, although the task used in the study wants students to count from 1 to a given number, it was modified based on the developmental properties and difference of the gifted students like increasing the stopping number while counting. Besides, the researcher asked some probing questions to reveal the students' counting abilities. In a general sense, students showed great success at tasks counting from a given number, counting backwards, cardinal, counting out a set to match a spoken number, number after and number before. Even, they did not face any real difficulty while performing these components as can be seen in Table 1.

It was the only item they had some difficulty that Veli made error by counting apples on the set; 1:1 correspondence in the 4th task. However, this mistake was due to counting the apples two times. Because the apples were so complex randomized, the child did not recognized that he put her finger on the apples on the set two times. However, when this child was asked to count in a horizontal line, he did not make any mistake and the same children did not do any mistake for the other examples of this task. Even, while researcher was counting a set, she made a mistake on purpose by counting one apple two times in order to see whether the mistake made by the child is a real mistake. The child quickly recognized the mistake that the researcher made and counted the set in a correct way. In that sense, this was analyzed in a way that the counting two times mistake made by the children may not directly related with his deficiency on the number sense; it was only related with the attention paid to the apples at that time due to the age of the child.

Specially, other than this, until last 2 tasks in this part, none of the students even needed any prompt. In those tasks, Ali could complete all of them successfully and sometimes Veli and Ayşe only needed to think and try the task one more time. For instance, while for the task-7, Veli gave an answer of 5 when it is asked what comes after 5; however, when the researcher wanted him to think again and highlighted the word of "after" and its meaning, he could gave the proper answer. Even, he could completed this task by replying the other examples like after 2 and after 7 successfully. Moreover, in the 9th task about ordinal value, Ayşe showed the 4th of the apple as three in her first trial. However, the researcher noticed that while counting them, she putted her finger for each apple but unfortunately her finger hindered the second apple. Then, she couldn't see and has to pass it; then, counted the third one as the second; so she could show the fourth one as the third. Though, when the researcher wanted her to repeat her way of answering the task and show the third item again, she could completed the task successfully as well as other examples about swans and bugs.

In addition to these, for the last two tasks about addition and subtraction, the children could completed the tasks successfully but sometimes, the prompt was given due to their misunderstanding or not understanding in the language and complex words according to their ages. For example, before succeeding some tasks, researcher gave prompts to Veli and Ayşe. That is, Veli needed an expression in the meaning of total and adding in 10th task while Ayşe needed the similar expression in the 11th task for the meaning of "left" as remaining at the end. Likewise, the analysis of the data obtained through students' performance in tasks of second part (12-14) reflected that students excelled to measure number principle components. In the 12th and 13th tasks, they didn't face any problem, only, Ali wanted to be sure in the 14th task so that he waited in a long time and counted the shared parts again and again to ensure fairness. Moreover, all the students could perform the tasks in Part-2 successfully as can be seen in Table 1.

Lastly, in the third part of the tasks, all students could manage the instructions about measuring number magnitude components, as seen from the data in Table 1. In addition to this success, in the 16th task, Veli and Ayşe could not understand the meaning of "biggest" and they were given as an example and explanation as having more. After that, they could complete the task easily. Additionally, the last task was the only task which the researcher had difficulty. In other words, it is the only task that the researcher had trouble so as to complete the task as in the instruction of the original study conducted by Howell and Kemp (2009). Although the students could succeed the task at the end, as seen in Table 1, they needed trials or prompt because the task was difficult in order to take the children's attention. That is, for the instruction, it was needed to show the card quickly; however, the children couldn't focus on the magnitude. So, the researcher had to adapt the instruction by showing the cards by not in a quick way and waited for counting. Apart from that, the last part of the tasks were appropriate for the children and so they could also perform them successfully.

Discussion

It is the major point of the findings reflected in this study that the tasks developed and used for preschool children were easy for gifted students despite the fact that they are 3 and 5 years old. In a general sense, although they sometimes needed to try the tasks one/two more times or the researcher needed to give a prompt or example, it was seen that the students' didn't face any difficulty in terms of the mathematics side of the tasks. This may be due to the fact that these tasks were developed for regular students and so, most of the items were so easy going to conduct for gifted children and so most of the tasks did not challenge these gifted students.

The only problem faced in the tasks was about the last task about subitizing the items. So, it was the only item that the researcher had to change or modify the task. The reason for this modification may not reflect students' deficiency in subitizing the magnitude of the dots in the card, it may be only related with their inability to subitize any subject in these ages because as Beckmann (1924) states, children use counting instead of subitizng in their younger age or as Silverman and Rose (1980) indicate, they can develop this ability as a short way after counting consciously. Thus, this subsisting ability can develop in their later ages and as it is stated in the findings, when a little time was given, all the children could complete the task successfully.

Additionally, throughout the tasks, children did not need prompt due to their lack of comprehension on their number sense conceptions. On the contrary, they needed prompt because they could not understand what they should do. Moreover, it can also be concluded that although they didn't experience before, when students are given an example they could relate their knowledge about numbers with the example and they could manage any other similar task, which reflected their conceptual understanding in terms of number sense.

In the actual study, where the developed tasks are taken, conducted by Howel and Kemp (2010), although it was scored and analyzed differently, when a small amount of comparison made with this study, the students were in 4,5 to 5,5 aged in their sample, whereas the mean of the children in this study is 3, 7. Moreover, in their study, only 40% of the students could count to the 20 and 19% could count to after 30 while 100% of students in our study could complete these counting tasks successfully. Similarly, their percentages were lower for the tasks such as counting from a number bigger than 10, addition, subtraction, order irrelevance, ordering groups and it is stated that they had most difficulty on understanding of number principles. When these findings compared with our study, the gifted students in the sample of this study conducted the tasks easily. What is more, although it was not any item in the tasks, these children were counting greater than 30 and even, we could not stop one of them to count to 700 and he could answer the question about what come next or before 727 kinds of questions. Moreover, they did not face any real difficulty on answering questions in other tasks too.

In addition to these, as different from Howell and Kemp's (2010) conclusion that most children begin school without understanding counting principles such as order irrelevance, inversion or the commutative law of addition, it can be said that the gifted students in this study have a conceptual understanding about counting principles before their school years because they could complete all the tasks successfully. Hence, as one of the most vital interpretation of the findings of this study, such kind of tasks should be enlarged for gifted students in order to completely reveal the number sense comprehension of these students. That is, special tasks should be developed so as to test gifted preschool students' limits in terms of their number sense comprehension.

Moreover, the results of this study also coincides with Mulligan, Mitchelmore and Prescott's (2005) report that young mathematically gifted children have more structured conceptions. The results of this study also show similarities with the interpretations made by Harrison (2004) that families and educators should plan gifted students' learning process and opportunities carefully and in detail. Besides, gifted students have a great potential whose development depends on some factors like education and guidance at home and at school (Özdemir, 2016).

The fact that children in this study are very young, gathering data about their conceptions and usage of number sense become the most difficulty of this study. Although they have a great number sense, they had difficulty to express themselves and explain their conceptions. Hence, revealing their conceptions due to their difficulty in speaking and poor language was the limitation of this study.

The findings of the study also provide a point of view for the application area. That is, the findings highlight the fact that, if schools or families of these gifted students as the same with other students, they can lost this great potential and even they can lose these children. For this example, providing them easy and routine exercises about counting can make them get bored and lose their enthusiasm towards numbers and mathematics. Thus, the tasks and opportunities should be differentiated for gifted students even if they are age of 3. If these students are provided with enriched and differentiated opportunities in line with their cognitive and mathematical development, the tasks that can help them to move on unlike their age appropriate tasks.

To sum up, the result of this data gave valuable information about gifted preschool students' conceptions of number sense. Moreover, the study would make so many contributions to create awareness about the importance of construction of number sense of gifted and talented students in mathematics education. If the more challenging tasks are developed for the gifted students, their full potential on construction of number sense can be seen more clearly. Hence, for the further study, the studies revealing their actual strategies that they used in the explanation of more challenging tasks can be developed and applied for these kinds of gifted students. Additionally, as another further research, this study can be conducted with different students and with different tasks that can help to reveal their limits in terms of number sense. Moreover, some other studies to see how these students' number sense can be developed and some tasks to develop their number sense could be tested in different environments.

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