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Examination of the Number Sense Skills of Secondary School Students (6^{th}-8^{th} Grades)[1]

Meral Cansız Aktaş[1*] Emine Tuğrul Özdemir[2] Hayal Yavuz Mumcu[1]

1. Faculty of Education, Ordu University, PO box 52200, Ordu, Türkiye
2. Kökenli Middle School, Ordu, Türkiye

* E-mail of the corresponding author: meralcaktas@odu.edu.tr

Abstract

The aim of this study is to examine the number sense skills of secondary school (6th-8th grades) students. The screening model among the descriptive research methods was used in the study. 366 secondary school students (6th-8th grades) in Ordu province participated in the study. The study data were collected by the number sense test developed by Kayhan- Altay (2010). The findings of the study showed that the number sense performances of the students were very low. It was determined that there was a significant difference in favour of the 8th-grade students in terms of the grade levels and in favour of the female students in terms of the gender in the number sense performances between 6th-8th-grade students and 7th-8th-grade students. On the other hand, it was determined that there was a significant positive relationship between the mathematical achievements and number sense performances of the students.

Keywords: number sense, secondary school students

1. Introduction

The number sense that has been emphasized in recent years is examined with different definitions by researchers. For example, there are definitions for the number sense, such as “the sense that is related to the meanings of numbers” (Berch, 2005), “the general comprehension of numbers and operations, the ability to develop strategies while dealing with them, and to flexibly build mathematical reasoning skills” (McIntosh, Reys and Reys, 1992; Reys, Reys, McIntosh, Emanuelsson, Johansson and Yang, 1999). Again, we can encounter many definitions for the number sense, such as “the ability to recognize multiple ways by making reasonable deductions to come to a solution” (Howden, 1989), “the ability to think flexibly, make predictions while making calculations, and make deductions about numerical quantities” (Greeno, 1991), etc. When the literature is examined, it is understood that the number sense is generally examined in the direction of the determined components; however, no common terminology has been formed in these components as in the definition of the number sense, and that although it covers the same skill, different researchers prefer to use different nomenclatures.

The first classification coming to mind aimed at revealing the characteristics of children with a number sense was performed by the NCTM, and the following characteristics were listed. (1) They know and understand the meanings of numbers very well, (2) They can develop multiple relationships between numbers, (3) They can recognize the relative sizes of numbers, (4) They know the effects of operations on numbers, (5) They can develop reference points for the measurements of the objects around them (NCTM, 1989: 38). In other words, the strategies used by students with the number sense in solving the problems are different compared to other students. While students with the number sense can develop flexible strategies for solving the problems, students with a low number sense can perform an operation by referring to the rules they have learned previously and based on paper and pencil (Yang, 2005).

In the studies carried out on the number sense, an attempt to determine at what level the number senses of students from different grade levels are and how their performances change in terms of various variables such as gender, grade level, and mathematical achievement was made. In the studies carried out to determine the level of number sense, it was determined that the performances of students were very low and students referred to rule-based solutions in their solutions (Yang and Li, 2008; Singh, 2009; Harç, 2010; Kayhan Altay, 2010; Mohamed

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and Johnny, 2010; Işık and Kar, 2011; Şengül and Gülbağcı, 2012; İymen, 2012). In some of the studies in which how the number sense performances changed in terms of grade level was determined, it was reported that the usage ratio of number sense decreased as the grade level increased (Menon, 2004; Kayhan Altay, 2010; Mohamed and Johnny, 2010), while it was reported in some studies that this ratio increased (Singh, 2009; Şengül and Gülbağcı, 2013). Although it was determined that there is no significant difference in the number sense performance in terms of the variable of gender in many studies (Aunio, Lim, Hautamaki and Van Luit, 2004; Aunio, Niemivirta, Hautamaki, Van Luit, Shi and Zhang, 2006; Harç, 2010; Kayhan-Altay, 2010; Menon, 2004; Takır, 2016; Yang and Li, 2008), it is possible to find studies indicating that there is a significant difference (Singh, 2009). On the other hand, studies revealing the relationship between the mathematical achievements and number sense performances of students (Yang, 2005; Jordan, Kaplan, Locuniak and Ramineni, 2007; Yang, Li and Lin, 2008; Harç, 2010; Kayhan-Altay, 2010; Mohamed and Johnny, 2010; Şengül and Gülbağcı, 2012; Bayram and Duatepe-Aksu, 2014) indicate that students with high mathematical achievements can use the number sense better than students with low achievement.

In many countries, in the last 10 years, mathematics educators have pointed out how important the development of the number sense is and have suggested that it should be integrated into mathematics curriculum (Yang and Li, 2008; Yang, Reys and Reys, 2009). Although there is no acquirement or activity for creating the number sense in the mathematics curriculum being implemented in Turkey, the importance of the number sense is emphasized (Umay, Akkuş and Duatepe, 2006). For this reason, to determine at what levels the number sense performances of secondary school students are is important in terms of determining the measures to be taken in curriculum and learning environments. In this context, the aim of this study is to examine the number sense skills of secondary school students (6-8th grade) in terms of various variables. In this context, answers to the following questions were searched in this study:

1) At what level is the mathematical achievement of secondary school students (6-8th grade) in the number sense test?
2) At what level is the number sense performance of secondary school students (6-8th grade) in the number sense test?
3) Is there a significant difference between the number sense performances of secondary school students (6-8th grades) according to the grade level?
4) Is there a significant difference between the number sense performances of secondary school students (6-8th grades) according to the sub-dimensions of the number sense test?
5) Is there a significant difference between the number sense performances of secondary school students (6-8th grades) according to gender?
6) Is there a significant relationship between the mathematical achievements and number sense performances of secondary school students (6-8th grades)?

2. Method

This research is a descriptive study. The screening model was used to examine the number sense performances of secondary school students in terms of various variables. 366 6-8th grade students studying in Ordu province are the participants of the study (Table 1).

Table 1. Sample of the study

Grade	Female	Male	Total
6th grade	77	72	149
7th grade	66	51	117
8th grade	54	42	100
Total	197	169	366

The "Number Sense Test" consisting of 17 questions and three sub-dimensions which was developed by Kayhan-Altay (2010) was used as a data collection tool in the study. This test consists of the sub-dimensions of "Flexibility in Calculation" consisting of eight questions, "Conceptual Thinking in Fractions" consisting of four questions and "Using the Reference Point" consisting of five questions. The practical way is expected to be chosen in simple operations encountered in the questions of flexibility in the calculation component, the fractions are expected to be expressed by different representation forms such as the number line of fractions and the field model in the questions of the conceptual thinking in fractions dimension, and the reference point is expected to be decided and used in the questions of using the reference point dimension. Kayhan-Altay (2010) found the reliability coefficient for the test measurements to be 0.86. In this study, the KR-20 internal consistency coefficient for the test measurements was calculated to be .78. This value indicates that the test measurements are reliable.

For the analysis of the data, firstly, the correct answers were evaluated as "1 point", and the incorrect answers were evaluated as "0 point", and the mathematics performance scores of the students were calculated over a total of 17 points. Secondly, students were scored according to their use of number senses while solving the problems, "1 point" was given for number sense-based answers, and "0" point was given for solutions that were obtained by making some calculations with rule-based, unclear and uncertain answers and incorrect answers. The distribution of the answers given by all the participants to the questions in the test was primarily examined for the analysis of the data. On the other hand, the Kruskal-Wallis H and Mann-Whitney U tests of nonparametric tests were used in the data analysis because the data obtained did not show a normal distribution. Furthermore, the Spearman Brown correlation coefficient was calculated to determine the relationship between students' mathematical achievement scores and number sense performance scores.

3. Findings

The data collected during the first phase of the study were analyzed using appropriate statistical techniques, and the obtained findings were explained by means of the tables.

3.1. Findings for the First Sub-Problem

The mathematical achievement scores obtained within the scope of the sub-problem of "At what level is the mathematical achievement of secondary school students (6-8th grade) in the number sense test?" were analyzed, and the descriptive statistics of the scores obtained are presented in Table 2.

Table 2. Descriptive statistics of the mathematical achievement scores

	n	Highest Score to obtain	Mean	Standard deviation
Mathematical Achievement Score	366	17	7.04	4.13

3.2. Findings for the Second Sub-Problem

The number sense scores obtained within the scope of the sub-problem of "At what level is the number sense performance of secondary school students (6-8th grade) in the number sense test?" were analyzed, and the descriptive statistics of the scores obtained are presented in Table 3.

Table 3. Descriptive statistics of the number sense scores

	n	Highest Score to obtain	Mean	Standard deviation
Number sense score	366	17	3.29	3.02

It is understood from Table 3 that the mean of the number sense scores obtained by the students in the number sense test is 3.29. When it is considered that the highest score to obtain is 17, it is remarkable that the mean of the students' mathematical achievement scores is very low.

Table 4 was obtained when the students' number sense scores were examined according to the components of the number sense test.

Table 4. Descriptive statistics of the number sense scores according to the components of the number sense test

	Highest Score to obtain	Mean	Standard deviation
Flexibility in calculation	8	2.08	1.82
Conceptual Thinking in Fractions	4	.77	.98
Using the Reference Point	5	.43	.87

It is understood from Table 4 that the mean number sense score of the students was the highest in the flexibility component and the lowest in the component of Using the Reference Point.

3.3. Findings for the Third Sub-Problem

To test this sub-problem, the mean and standard deviations of the scores of the number sense test of the students at each grade level were firstly calculated and are presented in Table 5.

Table 5. Number sense scores according to the grade level

Grade levels	n	X	ss
6	149	2.68	2.42
7	117	3.15	2.89
8	100	4.37	3.64

When Table 5 is examined, it is observed that the 8th-grade students have the highest average by 4.37, and the 6th-grade students have the lowest average by 2.68. Whether there was a significant difference in the number sense performances of the students according to the grade level was tested by the Kruskal-Wallis H test, and it is presented in Table 6.

Table 6. Kruskal-Wallis H test results of the number sense performances according to the grade levels

Grade	n	Mean Rank	sd	X^2	p	Significant differences
6	149	165.33	2	14.87	.001	6-8, 7-8
7	117	178.16				
8	100	216.83				

When Table 6 is examined, it is observed that the number sense performances significantly differ in terms of grade levels ($X^2_{(2-366)}$=14.877; $p<.01$). According to Table 8,a significant difference was found in terms of the number sense performances between the 6th-grade students and 8th-grade students (U=5280.50, $p<.01$) and between 7th-grade students and 8th-grade students (U=4686.50, $p<.01$).

3.4. Findings for the Fourth Sub-Problem

To test this sub-problem, the averages of the number sense scores of the students at each grade level according to the components of the number sense test and the percentages of the averages were firstly calculated and are presented in Table 7.

Table 7. Number sense test scores according to the grade levels and the components of the number sense test

Grade Levels		Flexibility in Calculation	Conceptual Thinking in Fractions	Using the Reference Point
6th grade	X	1.61	.68	.39
(n=149)	%	20.12	17.00	7.80
7th grade	X	2.13	.72	.31
(n=117)	%	26.63	18.00	6.20
8th grade	X	2.75	.98	.64
(n= 100)	%	34.38	24.5	12.80

When Table 7 is examined, it is observed that the mean score percentages increased from 6th grade to 8th grade in the components of "flexibility in calculation" and "conceptual thinking in fractions". In the component of using the reference point, it is understood that the 8th-grade students have the highest percentage, and the mean score percentage of the 6th-grade students is higher than the mean score percentage of the 7th-grade students.

Whether there was a significant difference between the scores of the secondary school students (6-8th grades) of the questions for the components in the number sense test in terms of the grade level was tested by the Kruskal-Wallis H test for unrelated measures, and the obtained data are presented in Table 8.

Table 8. Kruskal-Wallis H test results for unrelated measures of the scores of the questions of the components in the number sense test according to the grade levels

Sub-dimensions	Grade level		Mean rank	sd	X^2	p	Significant Differences
Flexibility in Calculation	6	149	161.17		16.87	.000	6-8
	7	117	183.90	2			7-8
	8	100	216.31				
Conceptual Thinking in Fractions	6	149	175.20		5.78	.056	-
	7	117	177.06	2			
	8	100	203.40				
Using the Reference Point	6	149	182.33		5.64	.59	-
	7	117	171.96	2			
	8	100	198.75				

It is understood from Table 8 that the students' performances of the questions in the sub-dimension "flexibility in calculation" differed significantly in terms of grade levels ($X^2_{(2-366)}$=16.87; p< .01). Two-by-two Mann-Whitney U tests were performed between the grade levels to determine the source of this difference between grade levels. In terms of the "flexibility in calculation" component performances of the number sense test, a significant difference was found between the 8th-grade students and the 6th and 7th-grade students (U=5157.00, p<.01; U=4862.50, p<.01).

3.5. Findings for the Fifth Sub-Problem

The statistics for determining how the number sense performances of secondary school students (6-8th grades) changed according to gender are presented in Table 9.

Table 9. The scores obtained by the secondary school 6-8th grade students from the number sense test according to their gender

Gender	N	Rank Mean	Rank Sum	U	p
Male	169	171.74	29024.50	14659.50	.047
Female	197	193.59	38136.50		

As it is observed in Table 9, a significant difference was found between the number sense performances of the 6-8th-grade students according to gender (U=14659.5, p=.047 p<.05). When mean ranks were taken into account, it was understood that the difference was in favour of female students.

3.6. Findings for the Sixth Sub-Problem

The averages of the mathematical achievement and number sense of the secondary school (6-8th grades) students were calculated according to the grade levels, and the obtained findings are presented in Table 10.

Table 10. Averages of the mathematical achievement and number sense of the secondary school 6-8th-grade students

Grade Level	N	Mathematical Achievement Mean	sd	Number Sense Mean	sd
6th grade	149	6.42	3.86	2.68	2.42
7th grade	117	6.37	3.97	3.15	2.89
8th grade	100	8.75	4.22	4.37	3.64
Total	366	7.04	4.12	3.29	3.02

When Table 10 is examined, it is understood that the mathematical achievements and the number sense performances of the students increase together as the grade level increases. The Spearman correlation was used to determine the relationship between students' mathematical achievement scores and number sense performance scores.

Table 11. Correlation between the number sense and mathematical achievements of the 6-8th-grade students

Correlation			
Mathematical Achievement	Spearman Correlation	1	.831
	P		.000
	N	366	366
Number Sense	Spearman Correlation	.831	1
	P	.000	
	N	366	366

The Spearman Brown correlation coefficient was calculated as (r=.831) to determine the relationship between the mathematical achievement scores and number sense performance scores of the students. This finding indicates that there is a positive, high correlation between the mathematical achievement and number sense scores of the students.

5. Discussion

When the general objectives of mathematics education are examined, the "development of mental computation skills" is accepted as the basis (NCTM, 1989). In the mathematics curriculum which has been implemented in our country since 2005 and has been put into practice for the 5-8th grades as of the 2013-2014 academic year, the statements that "The student will be able to effectively use his/her estimation and mental computation skills, to develop problem-solving strategies and to use them in everyday life" are among the general objectives of mathematics. In line with the aim determined within the scope of this study, important clues have been obtained regarding to what extent these objectives that are associated with the number sense have been achieved.

The findings obtained to determine at what level the number sense of secondary school (6-8th grades) students is indicate that students' success in using their number sense is low. This finding indicates the same point with the results of many studies that were previously carried out with students at various levels (Işık and Kar, 2011; Kayhan-Altay, 2010; Markovits and Pang, 2007; Mohamed and Johnny, 2010; Reys, Reys, McIntosh, Emanuelsson, Johansson and Yang, 1999; Reys and Yang; 1998; Şengül and Gülbağcı, 2012; Şengül, Gülbağcı and Cantimer, 2012; Yang, 2005; Yang, Li and Lin, 2008). When the mean scores of the questions in the number sense test are taken into account, it is understood that students prefer to calculate and refer to the rules instead of guessing and commenting for asolution. This finding has similarities with the results of many previous studies (İymen, 2012; Kayhan-Altay, 2010; Markovits and Pang, 2007; Mohamed and Johnny, 2010; Reys and Yang, 1998; Şengül and Gülbağcı, 2012; Şengül, Gülbağcı and Cantimer, 2012; Yang, 2005; Yang, 2007). The data obtained within the scope of the study show that the number sense performance of students in the same question is lower than their mathematical performances. This shows that there is a gap with respect to students' ability to perform anoperation and the meanings of the operations they perform. This indicates the same point with the results of Bayram's (2013) study. Students need to be supported to be able to comprehend what the operations they perform mean and whether calculation is really needed and to use strategies in such cases such as making appropriate estimates. Although the number sense is not clearly included in the mathematics curriculum, it can be said that many acquirements in the curriculum are associated with the number sense. However, the way these acquirements, which can be associated with the number sense, are addressed can pose an obstacle to the inclusion of number sense usage because similarly to previous studies in students' solutions (Markovits and Sowder, 1994; Reys and Yang, 1998; Reys, Reys, McIntosh, Emanuelsson, Johansson and Yang, 1999; Tsao, 2004; Yang, 2007), it was determined that students perform rule-based solutions such as routinely calculating the results of equalizing the denominator, multiplication and division operations, and converting a fraction to a decimal. How the acquirements in the curriculum will be presented to students depends on the course teacher; therefore, it is clear that the role of teachers is important in learning environments (Gülbağcı-Dede, 2015). The fact that the use of number sense has been neglected by teachers on account of the fact that they are not directly included in the curriculum could be one of the reasons for the low number sense scores obtained within the scope of the study. Therefore, to bring together these acquirements with students in well-designed activities and learning environments will contribute to the development of number sense.

In this study how the number sense performance changed according to the components of the number sense test was determined. The results of the previous studies (Harç, 2010; Kayhan-Altay, 2010; Mohamed and Johnny, 2010; Yang, 2005; Yang and Li, 2008; Yang, Li and Li, 2008) are different because there is no association on the components of number sense in the literature. In this study, the most successful component of students at each grade level was the Flexibility in Calculation component while the most unsuccessful component of them was the component of Using the Reference Point. This finding obtained is consistent with the results of the study of Takır (2016), who applied the same scale to the same age group. Although more activities for the use of reference point are included in the mathematics curriculum, it is remarkable that the average of this component is low. On the other hand, it was determined that there was a significant difference in the Flexibility in Calculation component in terms of grade levels. This finding obtained shares similarity with the findings of the study carried out by Yaman (2015) on preservice teachers using the same scale. On the other hand, it was found out that the determined difference was between the 6-8th-grade students and 7-8th-grade students as in the whole number sense test.

The effect of gender on success is a frequently-discussed issue in the mathematics education literature. When the place of number sense in mathematics education is considered, whether the number sense changes according to gender arouses curiosity. For this purpose, how the number sense changes according to gender was examined within the scope of the study. The findings obtained in this context show that there is a significant difference in students' number sense performances in favour of female students. This finding shares similarity with the results of the study conducted by Singh (2009). In many other studies (Aunio, Lim, Hautamaki and Van Luit, 2004; Aunio, Niemivirta, Hautamaki, Van Luit, Shi and Zhang, 2006; Harç, 2010; Kayhan-Altay, 2010; Menon, 2004; Takır, 2016; Yang and Li, 2008), it was reported that there was no significant difference in the number sense performance in terms of gender.

In the study, a high degree of relationship was found between the number sense performances and mathematical achievement performances of secondary school (6-8th grades) students. This result shares similarity with the results of many studies (Bayram and Duatepe-Aksu, 2014; Jordan, Kaplan, Locuniak and Ramineni, 2007; Kayhan-Altay, 2010; Mohamed and Johnny, 2010; Şengül and Gülbağcı, 2012; Yang, 2005; Yang, Live Lin, 2008). This finding means that the number sense-based answering success increases as the mathematical achievement increases.

The mean mathematical achievement of students was found to be 7.04 over 17 points while the mean score of the number sense was calculated to be 3.29. This finding also means that students refer to a written calculating in a question that can be solved by the number sense. Gülbağcı-Dede (2015) listed the reasons that could be effective in the low number sense of students; these are the fact that the number sense is not sufficiently included in the curriculum, that the activities in textbooks do not contribute to the development of the number sense and that the examination system leads to the use of rules that provide the fastest way to get the correct answer. When these factors are taken into account, activities designed for the use of number sense should be included in textbooks and learning environments.

The findings obtained from the study showed that there were significant differences in the number sense performances in terms of grade level between the 6-8thgrades and 7-8th grades in favour of the 8th grade. The fact that the average of the number sense increased as the grade level increased also attracted attention. This finding shares similarity with the results of the studies of Takır (2016), Işık and Kar (2011) and Şengül and Gülbağcı (2012). On the other hand, Kayhan-Altay (2010) reported that the number senses of students decreased as the grade level increased and stated that increasing age did not guarantee the development of number sense.

The data obtained during the study showed that students could not use their number senses in the desired way. Therefore, it is important for teachers who are the planners of courses to design activities in which students can use their number senses. Although the number sense is not clearly emphasized in the acquirements of the curriculum, a lot of studies for the development of number sense should be included in the relevant acquirements.

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