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Research Article

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Unveiling the numerical insights: A study on number sense skills of first graders and their teachers

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ABSTRACT

This study explores the number sense skills of classroom teachers and first-grade primary school students in Uşak, Turkey, examining the impact of various demographic factors. A quantitative research design was employed, utilizing a survey model to gather data from 102 teachers and 341 students. The Number Sense Test (Teacher Form), developed by Kayhan Altay (2010), and the Number Sense Screener (Student Form), adapted by Uyanık Aktulun (2018) based on Jordan et al. (2010), were used as measurement instruments. The results revealed significant differences in number sense skills among teachers based on gender, professional experience, and training, and among students based on gender and parental education levels. Male teachers exhibited higher number sense skills compared to female teachers, and those with more professional experience and specific number sense training performed better. Among students, males outperformed females in certain number sense subcomponents, and higher parental education levels were associated with better student performance. These findings highlight the importance of targeted professional development for teachers and the crucial role of parental education levels in children's numerical development. The study underscores the need for early intervention programs and parental involvement to foster strong number sense skills, which are foundational for later mathematical achievement.

Introduction

Enhancing students' fundamental mathematics skills and their success in this field is a primary objective in contemporary education systems (Mazzocco & Thompson, 2005). Among the mathematical competencies emphasized in recent years, number sense has gained significant attention due to its crucial role in early mathematical development (Courtney-Clarke, 2012; Şengül & Gülbağcı Dede, 2013; Tsao & Lin, 2011). Number sense involves understanding numerical magnitudes, relationships between numbers, and performing mental calculations, all of which are essential for mathematical proficiency and practical problem-solving in daily life (Dehaene, 2011).

Number sense is a multifaceted construct that encompasses abilities such as recognizing numerical patterns, estimating quantities, and understanding the effects of operations on numbers (Kalchman et al., 2001). These skills develop from birth and are influenced by environmental stimuli and experiences, reaching a certain level of maturity by the age of seven (Dehaene, 2011). Consequently, fostering number sense in early childhood is crucial for ensuring long-term success in mathematics.

Research has demonstrated that children with strong number sense skills perform better in mathematics throughout their educational life (Jordan et al., 2009; Lipton & Spelke, 2003). Jordan et al. (2009) found that early number sense proficiency significantly predicts later mathematical achievement, indicating that foundational numerical skills established in early childhood are critical for future success. Similarly, Lipton and Spelke (2003) highlighted the innate numerical abilities of infants, which evolve into more complex mathematical skills through interaction with their environment.

Interventions aimed at improving number sense have shown significant positive effects on students' overall mathematical achievement (Gersten & Chard, 1999). For instance, interventions that focus on enhancing students' ability to estimate, understand numerical relationships, and perform mental calculations have been effective in boosting their mathematical performance (Fuchs et al., 2001). These findings underscore the importance of integrating number sense development into early education curricula to promote mathematical literacy from a young age.

The role of teachers in developing students' number sense is paramount. Effective teaching strategies and a strong understanding of mathematical concepts by teachers can significantly enhance students' number sense (Sowder, 1992). Teachers with well-developed number sense are better equipped to foster these skills in their students, leading to improved mathematical understanding and performance (Howden, 1989). Despite extensive research on number sense, there is a notable gap in studies focusing on the number sense skills of classroom teachers and first-grade students in Turkey.

Several studies have examined the number sense abilities of students and teachers in various contexts. For example, Kayhan Altay and Umay (2011) explored the number sense skills of prospective teachers and found that their proficiency levels were closely linked to their future teaching effectiveness. Similarly, Yang (2003) emphasized the importance of teachers' number sense in facilitating students' understanding of mathematical concepts. Recently, Gözüm et al. (2024) conducted a latent profile analysis on preschoolers and first graders to identify their number sense skills. However, there remains a lack of research specifically addressing the number sense skills of elementary school teachers and their impact on first-grade students in Turkey.

Parental involvement in educational activities and the variety of educational content activities they engage in with their children differ according to their socio-demographic characteristics (Aikens & Barbarin, 2008; Işıkoğlu Erdoğan, 2016; Kaya, 2023; Son & Morrison, 2010). Factors such as parents' education level, socio-economic status, and social prestige underpin these differences. Socio-economic status leads to notable differences in the quality of the child's environment and the opportunities provided, impacting physical and mental health as well as cognitive development (Adler et al., 1994; Şirin, 2005). Families with higher socio-economic and cultural levels can contribute to a well-prepared period for supporting children's mathematical skills by providing a science-rich environment. Additionally, children who spend quality time with parents possessing high general culture knowledge can communicate with adults on various science-related topics and conduct various investigations, sharing their findings about their surroundings. This process increases children's motivation to learn science, leading them to ask questions and conduct various investigations. Children who grow up in an environment that supports curiosity towards science at home and school can successfully develop and use skills like number sense (Charlesworth & Lind, 2007; Kandır et al., 2016).

Children starting primary school can have very different experiences in number sense skills based on the socio-demographic characteristics of their families. This creates diversity in number sense among students of the same age group. Research has shown that variables such as the education level and occupations of children's parents cause differences in students' number sense skill levels (Case & Okamoto, 1996; Dehaene, 2011; Elliott & Bachman, 2018; Gunderson, Ramirez et al., 2012; Jordan et al., 1992; Jordan et al., 2007; Jordan & Levine, 2009; Siegler & Ramani, 2008; Starkey et al., 2004). Similarly, these socio-demographic factors affect not only parents but also teachers, influencing their number sense skills. When considering teachers, although not directly related to number sense, variables such as gender, professional seniority, class size, and participation in in-service training are seen to create differences in teaching skills in the literature (Harris & Sass, 2011; Ilany, 2022). Therefore, it is thought that these variables might also lead to differences in teachers' number sense skills.

The purpose of this study is to fill this gap by examining the number sense skills of classroom teachers and first-grade primary school students in Uşak, Turkey. The study also aims to explore the impact of various demographic and educational variables on these skills. Previous research has highlighted the importance of number sense in early education (Jordan et al., 2009; Lipton & Spelke, 2003), yet the relationship between teachers' number sense skills and their students' skills remain underexplored, particularly in the Turkish educational context.

This study is significant in explaining the effects of socio-demographic factors on the number sense skills of elementary school teachers and first-grade students, and in expanding the literature on development. The significance of this study lies in its potential to provide valuable insights into the number sense skills of both teachers and students, highlighting areas for improvement and informing the development of targeted educational programs. By understanding the current state of number sense skills and the factors that influence them, educators and policymakers can implement strategies to enhance mathematical education and support student success from an early age. The findings of this study are expected to make significant contributions to updating teacher training programs and in-service training to improve number sense skills while considering the demographic characteristics of teacher candidates and teachers. This study is particularly critical given the limited research on number sense within non-Western contexts, such as Turkey, thereby filling a significant gap in the existing literature. To address these issues, this study aims to answer the following research questions:

1. What is the distribution of number sense test scores among first-grade teachers?
2. Is there a significant difference in number sense scores between male and female first-grade teachers?
3. Do first-grade teachers' number sense scores differ significantly based on their years of professional experience and whether they have received number sense training?
4. What is the distribution of number sense assessment scores among first-grade students?
5. Is there a significant difference in number sense assessment scores between male and female first-grade students?
6. Do first-grade students' number sense assessment scores differ significantly based on their parents' education level?
7. Is there a significant relationship between first-grade teachers' number sense skills and the students' number sense skills?

Method

Research design

This study employs a quantitative research design, utilizing a survey model to investigate the number sense skills of classroom teachers and first-grade primary school students in Uşak, Turkey. The survey model is chosen for its effectiveness in gathering data from a large population and its ability to provide a comprehensive analysis of the research variables (Creswell, 2012). This method allows for the collection of numerical data that can be statistically analyzed to identify patterns and relationships between the number sense skills of teachers and students and various demographic factors.

Sample of the study

I The sample for this study comprised two main groups: 102 classroom teachers (i.e. educators responsible for teaching various subjects to a single class of students in elementary schools) and 341 first-grade primary school students from schools affiliated with the Ministry of National Education in Uşak, Turkey. Participants were selected using a simple random sampling technique to ensure the sample was representative of the population (Creswell, 2012; Teddlie & Yu, 2007). This method involved randomly selecting participants from the population without any specific stratification, allowing for a diverse and unbiased sample.

The 102 classroom teachers included individuals with varying years of professional experience and educational backgrounds, ensuring a broad range of perspectives on number sense skills. These teachers were responsible for teaching different grade levels, not exclusively first grade. Among them, 23 teachers were first-grade teachers whose students participated in the study. The remaining 79 teachers, while contributing valuable data on their own number sense skills and demographic information, did not have students included in the student sample because they taught other grade levels.

The student sample consisted of 341 first-grade students taught by the 23 first-grade teachers. The number of students per teacher varied, ranging from a minimum of 12 to a maximum of 20 students, with an average of approximately 15 students per class. This variation reflects the typical class sizes within the schools sampled. The focus on first-grade students was intentional, as this stage is critical for the development of number sense skills, and it allowed for a more targeted examination of the factors influencing these skills in young learners.

The demographic characteristics of the teachers are detailed in Table 1, providing an overview of the participants' distribution across variables such as gender, class size, teaching experience, and prior training in number sense. This random sampling approach enhances the generalizability of the study's findings to the broader population of teachers and students in Uşak, Turkey.

Table 1 Demographic characteristics of teachers

Variable	Category	n	%
Gender	Male	52	51
	Female	50	49
	Total	*102*	*100*
Class Size	Less than 25 students	54	52.9
	25-35 students	36	35.3
	More than 35 students	12	11.8
	Total	*102*	*100*
Experience	Less than 10 years	56	54.9
	10-15 years	16	15.7

	16-20 years	12	11.8
	More than 20 years	18	17.6
	Total	*102*	*100*
Number Sense Training	Yes	10	9.8
	No	92	90.2
	Total	*102*	*100*

Table 1 shows the demographic characteristics of the teachers who participated in the study. The gender distribution is fairly balanced, with 50 female teachers (49%) and 52 male teachers (51%). In terms of class size, the majority of teachers (52.9%) reported having less than 25 students, while 35.3% had between 25-35 students, and 11.8% had more than 35 students. Regarding teaching experience, more than half of the teachers (54.9%) had less than 10 years of experience, 15.7% had between 10-15 years, 11.8% had between 16-20 years, and 17.6% had more than 20 years of experience. Furthermore, only 9.8% of the teachers had received specific training in number sense, while a significant majority (90.2%) had not. The total number of teachers in the study was 102, providing a comprehensive overview of their demographic profiles. Additionally, the demographic characteristics of the students and their parents are given in Table 2.

Table 2 Demographic characteristics of students and their parents

Variable	Category	n	%
Gender	Male	206	60
	Female	135	40
	Total	*341*	*100*
Number of Children in Family	One	47	14
	Two	205	60
	Three	68	20
	Four or more	21	6
	Total	*341*	*100*
Mother's Age	29 or below	116	34
	30-39	202	59
	40-49	23	7
	Total	*341*	*100*
Father's Age	29 or below	70	20
	30-39	173	51
	40-49	98	29
	Total	*341*	*100*
Mother's Education	Primary/Secondary	208	61
	High School	80	23
	University	53	16
	Total	*341*	*100*
Father's Education	Primary/Secondary	168	49
	High School	106	31
	University	67	20
	Total	*341*	*100*
Mother's Occupation	Domestic Worker	180	53
	Civil Servant	50	15
	Worker	79	23
	Self-Employed	32	9
	Total	*341*	*100*
Father's Occupation	Civil Servant	78	23
	Worker	179	52
	Self-Employed	86	25
	Total	*341*	*100*

Table 2 shows the demographic characteristics of the students and their parents. The gender distribution among students is 40% female (n=135) and 60% male (n=206). Most families have two children (60%), followed by those with three children (20%), one child (14%), and four or more children (6%). The majority of mothers are aged between 30-39 years (59%), with 34% aged 29 or below, and 7% aged 40-49. Similarly, most fathers are aged 30-39 years (51%), with 20% aged 29 or below, and 29% aged 40-49. In terms of education, 61% of mothers have primary or secondary education, 23% have a high school education, and 16% have a university degree. For fathers, 49% have primary or secondary education, 31% have a high school education, and 20% have a university degree. Regarding occupation, 53% of mothers are domestic workers, 15% are civil servants, 23% are workers, and 9% are self-employed. For fathers, 52% are workers, 25% are self-employed, and 23% are civil servants.

Data collection tools

To assess the number sense skills of classroom teachers and first-grade primary school students, several data collection tools were utilized. These instruments were chosen for their reliability and validity in measuring the constructs of interest.

General information form

The General Information Form was developed by the researcher to collect comprehensive demographic and background information about the teachers, students, and their families. For teachers, the form included questions about gender, years of professional experience, class size, and prior training in number sense. Additionally, it gathered information about teachers' educational backgrounds and any professional development courses they had attended related to mathematics education. For students, the form collected data on gender, age, number of siblings, parental education levels and parental occupations. This detailed information was critical for analyzing how various demographic factors might influence number sense skills.

Number sense test (teacher form)

The Number Sense Test (Teacher Form) was developed by Kayhan Altay in 2010 to assess the number sense skills of classroom teachers. This test consists of 17 items designed to evaluate various aspects of number sense, including numerical estimation, understanding numerical magnitudes, and performing mental calculations.

The original reliability of the test, as reported by Kayhan Altay, had a Cronbach's Alpha coefficient of 0.86, indicating a high level of reliability. In the current study, the reliability analysis was conducted again to ensure the consistency of the test within the new sample. The Cronbach's Alpha coefficient for this study was calculated to be 0.781, which falls into the "quite reliable" category according to the reliability scale by Kayış (2014) .

The selection of this test was driven by its established validity and reliability in measuring the constructs of interest, as well as its previous use in similar studies. The test's administration time is approximately 20-25 minutes, making it a practical tool for classroom settings. By utilizing a well-validated instrument, the study aims to provide robust and comparable results concerning the number sense skills of teachers. This test's reliability and the comprehensive nature of its items make it an appropriate tool for understanding the numerical competencies of educators, which is crucial for effective mathematics instruction and consequently for student achievement in mathematics.

Number sense screener (student form)

The Number Sense Screener (Student Form) was adapted by Uyanık Aktulun in 2018 based on the original tool developed by Jordan et al. (2010). This evaluation tool is designed to assess the number sense skills of first-grade primary school students, providing a comprehensive measure of their numerical competencies.

The tool consists of six subtests with a total of 29 items. These subtests cover various dimensions of number sense, including counting skills, number recognition, number comparisons, nonverbal calculation, and story problems. The administration of the test takes approximately 20-25 minutes, making it practical for use in classroom settings.

The original reliability of the Number Sense Screener, as reported by Jordan et al. (2010), demonstrated a high level of reliability with a Cronbach's Alpha coefficient of 0.85. In the current study, the reliability analysis was conducted again to ensure the consistency of the tool within the new sample. The Cronbach's Alpha coefficient for this study was calculated to be 0.821, indicating a high level of reliability.

The selection of this tool was driven by its established validity and reliability in measuring number sense skills, as well as its previous use in similar studies. By utilizing a well-validated instrument, the study aims to provide robust and comparable results regarding the number sense skills of students. This tool's reliability and the comprehensive nature of its items make it an appropriate choice for understanding the numerical competencies of young learners, which is crucial for early mathematics instruction and subsequent academic achievement.

Validity and reliability

To ensure the validity and reliability of the research instruments and procedures, several measures were taken in this study. Validity was addressed by utilizing well-established and validated instruments appropriate for the Turkish educational context. The Number Sense Test (Teacher Form) developed by Kayhan Altay (2010) and the Number Sense Screener (Student Form) adapted by Uyanık Aktulun (2018) based on Jordan et al. (2010) were employed. These instruments have been previously validated and shown to effectively assess number sense skills among teachers and students in Turkey (Kayhan Altay & Umay, 2011; Uyanık Aktulun, 2019), thereby ensuring content and construct validity.

Reliability was ensured through the calculation of Cronbach's alpha coefficients for both instruments. The Number Sense Test (Teacher Form) yielded a Cronbach's alpha of 0.781, and the Number Sense Screener (Student Form) had a Cronbach's alpha of 0.821, both indicating acceptable internal consistency (George & Mallery, 2010). Standardized administration procedures were followed, and data collectors were trained to ensure consistency in test administration and scoring (Creswell, 2012). These measures enhanced the reliability and validity of the data collected, providing a solid foundation for the study's findings.

Data collection procedure

Data collection for this study was meticulously planned and executed to ensure the reliability and validity of the results. The process began with obtaining the necessary ethical approvals from Afyon Kocatepe University Ethics Committee and securing permissions from the relevant authorities within the Ministry of National Education in Uşak, Turkey.

Upon receiving the approvals, the researchers approached the selected schools, held meetings with school principals and teachers, and secured their consent to participate in the study. The participants, including teachers, students, and their parents, were fully informed about the study's objectives and procedures. They were assured that the data collected would be used exclusively for research purposes and kept confidential. Participation was entirely voluntary, with the option to withdraw at any stage without any consequences.

Data collection from the teachers involved administering the General Information Form and the Number Sense Test (Teacher Form). The General Information Form gathered detailed demographic data, including gender, years of professional experience, class size, and prior training in number sense. The Number Sense Test, consisting of 17 open-ended questions, was completed by the teachers in written form. Before the test administration, the researcher ensured that all materials were prepared and that the teachers understood the instructions.

For the students, data collection involved the General Information Form and the Number Sense Screener (Student Form). The General Information Form collected demographic details such as gender, age, number of siblings, birth order, preschool attendance, parental education levels, parental occupations, and parental ages. This information was obtained from the students' school records with parental permission.

The Number Sense Screener, adapted for Turkish children by Uyanık Aktulun (2018), was administered individually to each student. The administration of this tool took place in a quiet room, separate from the regular classroom environment, to minimize distractions and ensure the students' focus. The testing process began with a brief conversation to help the student relax, followed by an explanation of the test procedure. The test included example questions to familiarize the students with the format, and instructions were repeated until the student clearly understood the tasks. The entire testing session lasted approximately 20-25 minutes per student.

By carefully executing these steps, the study aimed to collect comprehensive and reliable data to analyze the number sense skills of first-grade students and their teachers, contributing valuable insights to the field of mathematics education.

Data analysis

The data analysis for this study employed a variety of statistical techniques to comprehensively examine the number sense skills of classroom teachers and first-grade primary school students in Uşak, Turkey. The analysis aimed to explore the levels of these skills, the influence of demographic variables, and the relationships between teachers' and students' number sense abilities.

Descriptive statistics were first used to summarize the data. Measures of central tendency and variability—including means, standard deviations, minimum and maximum values—were calculated to provide an overview of the number sense scores. This step was crucial for understanding the overall distribution and characteristics of the data (Creswell, 2012). To assess the normality of the data distributions, both the Shapiro-Wilk test and the Kolmogorov-Smirnov test were utilized. The Shapiro-Wilk test was applied for sample sizes less than 50, while the Kolmogorov-Smirnov test was used for larger samples (Field, 2018). Additionally, skewness and kurtosis values were examined, with values between -2 and +2 indicating approximate normality (George & Mallery, 2010).

For the data obtained from teachers, the overall Teacher Number Sense Total Score did not meet the normality assumption (Shapiro-Wilk $p < 0.05$), indicating a non-normal distribution. However, when the teacher data were divided by gender, the number sense scores for both female and male teachers individually met the normality assumption (Shapiro-Wilk $p > 0.05$), allowing for the use of parametric tests for gender comparisons. Therefore, an independent samples t-test was conducted to compare the number sense scores between male and female teachers (Girden, 1992). For comparisons involving teachers' professional experience and number sense training, the normality assumption was not met (Shapiro-Wilk $p < 0.05$), and some groups had small sample sizes. Consequently, non-parametric tests were employed for these analyses. The Kruskal-Wallis H test was used to compare number sense scores across different levels of professional experience, and the Mann-Whitney U test was used to compare scores based on whether teachers had received number sense training (Field, 2018).

For the data obtained from students, the normality assumption was satisfied for the overall Student Number Sense Total Score and all subcomponents (Kolmogorov-Smirnov $p > 0.05$; skewness and kurtosis values within acceptable ranges), indicating that the data were approximately normally distributed. Therefore, parametric tests were used for analyses involving student data. Independent samples t-tests were conducted to compare number sense scores between male and female students (Girden, 1992). One-way ANOVA was used to examine differences in student number sense scores based on parental education levels. When significant differences were found, post-hoc Tukey tests were performed to determine which specific groups differed from each other (Field, 2018).

To investigate the relationships between the number sense skills of teachers and students, Pearson correlation analysis was conducted involving the 341 first-grade students and their 23 respective first-grade teachers. These 23 teachers were specifically those who taught the first-grade classes from which the student data were collected. Including only these teachers ensured that each student's number sense score could be directly paired with their own teacher's score, allowing for an accurate assessment of the potential influence of a teacher's number sense skills on their students. This step was essential for identifying significant correlations and understanding the interdependencies between these variables (Cohen, 1988).

Additionally, effect sizes were calculated to determine the magnitude of differences between groups. For independent samples t-tests and ANOVA, Cohen's *d* was used to measure effect sizes for significant differences based on variables such as gender and parental education levels (Cohen, 1988). Calculating effect sizes provided a clearer understanding of the practical significance of the findings.

Findings

This section presents the findings of the study, which aimed to explore the number sense skills of classroom teachers and first-grade primary school students in Uşak, Turkey. The results are organized to first address the number sense skills of teachers, including their distribution and demographic differences. Subsequently, the number sense skills of students are examined, focusing on their distribution and the influence of various demographic factors such as gender, and parental education levels. Finally, the relationship between teachers' and students' number sense skills is analyzed to provide a comprehensive understanding of the interdependencies between these variables.

Overview of teacher number sense skills

The distribution of the number sense test scores among first-grade teachers is presented in Table 3. This table shows the minimum, maximum, mean, and standard deviation of the scores obtained by the teachers.

Table 3 Distribution of teacher number sense scores

n	Min.	Max.	$\bar{x}$	SD
102	4	17	12.24	± 3.41

Note: The lowest possible score is 1, and the highest possible score is 17.

Table 3 provides an overview of the number sense test scores for the teachers in the sample. The mean score was 12.24 with a standard deviation of ±3.41, indicating that the average number sense ability among the teachers is moderate. The range of scores (4 to 17) suggests a considerable variation in number sense skills among the teachers. These findings imply that while some teachers possess strong number sense skills, others may need further development in this area. The variation in scores highlights the importance of targeted professional development programs to enhance the number sense skills of teachers, which can ultimately benefit student learning outcomes.

Demographic differences in teacher number sense skills

Gender differences in number sense scores

The gender differences in number sense scores among first-grade teachers are presented in Table 4. This table shows the results of the t-test conducted to examine whether there is a significant difference in number sense scores based on gender.

Table 4 Teacher number sense scores by gender

Test Name	Gender	n	$\bar{x}$	SD	t	df	p	Cohen's d
Number Sense	Female	50	11.48	3.309	0.089	100	0.028*	0.444
	Male	52	12.96	3.378				

*p < .05

Table 4 shows that there is a statistically significant difference in number sense scores between male and female teachers ($p = 0.028 < 0.05$). The mean score for male teachers ($\bar{x} = 12.96$) is significantly higher than that for female teachers ($\bar{x} = 11.48$). The effect size, as indicated by Cohen's d, is 0.444, suggesting a moderate effect of gender on number sense scores. These findings indicate that gender is a factor influencing number sense skills among first-grade teachers, with male teachers demonstrating higher number sense skills on average compared to their female counterparts. This suggests a need for further investigation into the underlying causes of these differences and potential interventions to support female teachers in developing their number sense skills.

Differences based on professional experience and number sense training

The differences in number sense scores based on professional experience and number sense training among first-grade teachers are presented in Table 5. This table shows the results of the Kruskal-Wallis H test conducted to examine whether there are significant differences in number sense scores based on the years of professional experience and number sense training.

Table 5 Teacher number sense scores by years of professional experience and number sense training

Test	Professional Experience	n	Mean Rank	SD	χ^2	df	p	Cohen's d	Source of Difference
Number Sense	Less than 10 years	56	44.93	1.92	9.633	3	0.022*	0.079	1-4
	10-15 years	16	64.13						-
	16-20 years	12	46.00						-
	More than 20 years	18	64.39						4-1

*p < .05

Table 5 indicates that there is a statistically significant difference in number sense scores based on the professional experience of teachers ($\chi^2 = 9.633$, $p = 0.022 < 0.05$). The mean rank scores suggest that teachers with more than 20 years of experience have the highest number sense scores, while those with less than 10 years of experience have the lowest scores. The effect size, as indicated by Cohen's d, is 0.079, suggesting a low effect of professional experience on number sense scores. These findings imply that professional experience influences number sense skills among first-grade teachers, with more experienced teachers demonstrating higher number sense skills. This suggests that experience contributes positively to the development of number sense skills, highlighting the importance of continued professional development and training for teachers to enhance their mathematical competencies.

The differences in number sense scores based on professional experience and number sense training among first-grade teachers are presented in Table 6. This table shows the results of the Mann-Whitney U test conducted to examine whether there are significant differences in number sense scores based on whether teachers have received number sense training.

Table 6 Teacher number sense scores by training status

Test Name	Training Status	n	Mean Rank	SD	Mann-Whitney U	p	Cohen's d
Number Sense	Yes	10	78.7	0.299	188.000	0.002*	0.458
	No	92	48.54				

*p < .05

Table 6 shows that there is a statistically significant difference in number sense scores between teachers who have received number sense training and those who have not ($p = 0.002 < 0.05$). Teachers who received number sense training have higher scores (mean rank = 78.7) compared to those who did not receive training (mean rank = 48.54). The effect size, as indicated by Cohen's d, is 0.458, suggesting a moderate effect of training on number sense scores. These findings indicate that receiving number sense training has a positive impact on teachers' number sense skills. This suggests the importance of providing targeted training programs to enhance teachers' numerical competencies, which could ultimately benefit their students' learning outcomes.

Demographic differences in student number sense skills

Distribution of student number sense scores

The distribution of the number sense assessment scores among first-grade students is presented in Table 7. This table shows the minimum, maximum, mean, and standard deviation of the scores obtained by the students in different subcomponents of number sense.

Table 7 Distribution of student number sense scores

Number Sense Subcomponent	n	Min.	Max.	$\bar{x}$	SD
Counting Skills	323	0	5	2.76	± 0.738
Number Recognition	323	0	4	2.72	± 1.149
Number Comparisons	323	0	7	5.69	± 1.380
Nonverbal Calculations	323	0	4	3.16	± 1.067
Story Problems	323	0	6	3.25	± 1.444
Number Combinations	323	0	6	3.92	± 2.001
Number Sense Screener	323	2	30	21.44	± 5.465

Note: The lowest possible score is 1, and the highest possible score is 29.

Table 7 provides a comprehensive overview of the number sense scores for the students in the sample. The mean scores for different subcomponents, such as Counting Skills ($\bar{x} = 2.76$, SD = ±0.738), Number Recognition ($\bar{x} = 2.72$, SD = ±1.149), and Number Comparisons ($\bar{x} = 5.69$, SD = ±1.380), indicate moderate proficiency levels among the students. Nonverbal Calculations ($\bar{x} = 3.16$, SD = ±1.067), Story Problems ($\bar{x} = 3.25$, SD = ±1.444), and Number Combinations ($\bar{x} = 3.92$, SD = ±2.001) also show a wide range of abilities. The overall Number Sense Assessment scores range from 2 to 30, with a mean score of 21.44 (SD = ±5.465), reflecting a generally high proficiency in number sense skills among the students. The variation in scores across different subcomponents suggests diverse levels of number sense skills, indicating areas where students excel and areas that may require additional support and instructional focus.

Gender differences in number sense scores

The gender differences in number sense scores among first-grade students are presented in Table 8. This table shows the results of the t-test conducted to examine whether there is a significant difference in number sense scores based on gender.

Table 8 Student number sense scores by gender

Number Sense Subcomponent	Gender	n	$\bar{x}$	SD	t	p	Cohen's d
Counting Skills	Female	135	2.76	0.766	0.029	0.977	-
	Male	206	2.76	0.721			
Number Recognition	Female	135	2.38	1.203	-4.291	0.000*	0.049
	Male	206	2.94	1.060			
Number Comparisons	Female	135	5.45	1.500	-2.409	0.017*	0.027
	Male	206	5.84	1.280			
Nonverbal Calculations	Female	135	2.99	1.167	-2.320	0.021*	0.025
	Male	206	3.27	0.985			
Story Problems	Female	135	3.15	1.530	-1.008	0.314	-
	Male	206	3.32	1.387			
Number Combinations	Female	135	3.74	2.118	-1.333	0.183	-
	Male	206	4.04	1.919			
Number Sense Screener	Female	135	20.12	6.038	-3.349	0.001*	0.039
	Male	206	22.27	4.906			

*$p < .05$

Table 8 shows that there are statistically significant differences in number sense scores between male and female students in several subcomponents. Specifically, significant differences were found in Number Recognition (t = -4.291, p = 0.000, Cohen's d = 0.049), Number Comparisons (t = -2.409, p = 0.017, Cohen's d = 0.027), Nonverbal Calculations (t = -2.320, p = 0.021, Cohen's d = 0.025), and the overall Number Sense Assessment (t = -3.349, p = 0.001, Cohen's d = 0.039). In these subcomponents, male students demonstrated higher number sense skills on average compared to their female counterparts. However, no significant differences were observed in Counting Skills, Story Problems, and Number Combinations. These results suggest that while gender plays a role in certain aspects of number sense, it does not affect all areas equally. Further research may be needed to explore the underlying causes of these gender differences and to develop strategies to support female students in enhancing their number sense skills in the areas where they lag behind.

Differences based on parental education levels

The differences in number sense scores based on the mother's education level are presented in Table 9, and those based on the father's education level are shown in Table 10.

Table 9 Student number sense scores by mother's education level

Education Level	n	$\bar{x}$	SD	df	F	p	Cohen's d	Source of Difference
Counting Skills								
Primary/Secondary	208	2.72	0.813	2	0.843	0.432	-	-
High School	80	2.84	0.550	320				
University	53	2.81	0.647	322				
Number Recognition								
Primary/Secondary	208	2.64	1.177	2	2.177	0.115	-	-
High School	80	2.76	1.083	320				
University	53	3.02	1.093	322				
Number Comparisons								

Primary/Secondary	208	5.67	1.358	2				
High School	80	5.72	1.380	320	0.051	0.950	-	-
University	53	5.72	1.499	322				
Nonverbal Calculations								
Primary/Secondary	208	3.03	1.097	2				
High School	80	3.36	0.930	320	4.418	0.013*	0.037	1-3 3-1
University	53	3.43	1.058	322				
Story Problems								
Primary/Secondary	208	3.11	1.443	2				
High School	80	3.45	1.416	320	2.641	0.073	-	-
University	53	3.55	1.442	322				
Number Combinations								
Primary/Secondary	208	3.61	2.083	2				1-2
High School	80	4.34	1.690	320	7.172	0.001*	0.049	1-3 2-1
University	53	4.62	1.824	322				3-1
Number Sense Screener								
Primary/Secondary	208	20.60	5.409	2				1-2
High School	80	22.62	5.082	320	6.676	0.001*	0.038	1-3 2-1
University	53	23.17	5.647	322				3-1

*p<.05 1 = Primary/Secondary, 2 = High School, 3 = University

Table 10 Student number sense scores by father's education level

Education Level	n	$\bar{x}$	SD	df	F	p	Cohen's d	Source of Difference
Counting Skills								
Primary/Secondary	168	2.66	0.850	2				1-2
High School	106	2.95	0.411	320	5.088	0.007*	0.097	2-1
University	67	2.70	0.782	322				-
Number Recognition								
Primary/Secondary	168	2.61	1.217	2				-
High School	106	2.84	0.982	320	1.508	0.223	-	-
University	67	2.82	1.204	322				-
Number Comparisons								
Primary/Secondary	168	5.65	1.325	2				-
High School	106	5.80	1.303	320	0.529	0.590	-	-
University	67	5.59	1.637	322				-
Nonverbal Calculations								
Primary/Secondary	168	3.04	1.158	2				-
High School	106	3.28	0.753	320	2.342	0.098	-	-
University	67	3.31	1.218	322				-
Story Problems								
Primary/Secondary	168	3.04	1.491	2				1-2
High School	106	3.51	1.275	320	3.822	0.023*	0.033	2-1
University	67	3.41	1.510	322				-
Number Combinations								
Primary/Secondary	168	3.57	2.100	2				1-2
High School	106	4.22	1.738	320	5.365	0.005*	0.052	1-3
University	67	4.38	1.993	322				2-1

								3-1
Number Sense Screener								
Primary/Secondary	168	20.35	5.548	2	6.692	0.001*	0.045	1-2 1-3 2-1 3-1
High School	106	22.61	4.195	320				
University	67	22.41	6.500	322				

*p<.05 1 = Primary/Secondary, 2 = High School, 3 = University

Tables 9 and 10 present the results of the ANOVA tests conducted to examine whether there are significant differences in number sense scores based on parental education levels. Table 9 shows the differences in student number sense scores based on the mother's education level. Statistically significant differences were found in Nonverbal Calculations (F = 4.418, p = 0.013, Cohen's d = 0.037), Number Combinations (F = 7.172, p = 0.001, Cohen's d = 0.049, 0.051), and the overall Number Sense Assessment (F = 6.676, p = 0.001, Cohen's d = 0.038, 0.046). In these subcomponents, students whose mothers have higher education levels (high school and university) demonstrated higher number sense scores compared to those whose mothers have primary or secondary education. For example, students whose mothers have a university degree had a significantly higher mean score in Nonverbal Calculations ($\bar{x}$ = 3.43) compared to those whose mothers have primary or secondary education ($\bar{x}$ = 3.03).

Table 10 shows the differences in student number sense scores based on the father's education level. Statistically significant differences were found in Counting Skills (F = 5.088, p = 0.007, Cohen's d = 0.097), Story Problems (F = 3.822, p = 0.023, Cohen's d = 0.033), Number Combinations (F = 5.365, p = 0.005, Cohen's d = 0.052, 0.057), and the overall Number Sense Assessment (F = 6.692, p = 0.001, Cohen's d = 0.045, 0.052). In these subcomponents, students whose fathers have higher education levels (high school and university) demonstrated higher number sense scores compared to those whose fathers have primary or secondary education. For example, students whose fathers have a high school education had a significantly higher mean score in Counting Skills ($\bar{x}$ = 2.95) compared to those whose fathers have primary or secondary education ($\bar{x}$ = 2.66).

These findings suggest that higher parental education levels are associated with higher number sense scores among students, highlighting the influence of parental education on the development of children's numerical competencies.

Correlation between teacher and student number sense skills

The relationship between the number sense skills of teachers and their students is presented in Table 11. This table shows the correlation coefficients between teacher number sense test scores and student number sense assessment scores across different subcomponents.

Table 11 Correlation between Teacher and Student Number Sense Scores

Number Sense Test (Teacher Form)	Counting Skills	Number Recognition	Number Comparisons	Nonverbal Calculations	Story Problems	Number Combinations	Number Sense Screener
r	0.278	-0.091	0.079	0.247	-0.163	-0.147	0.131
p	0.199	0.681	0.720	0.256	0.456	0.503	0.551
n	341	341	341	341	341	341	341

Table 11 shows the correlation coefficients between teacher and student number sense scores. While some positive correlations were observed, such as between teacher number sense scores and student counting skills (r = 0.278) and nonverbal calculations (r = 0.247), none of these correlations were statistically significant (p > 0.05).

These findings indicate that there is no significant direct relationship between the number sense skills of teachers and their students across the various subcomponents measured. This suggests that other factors may play a more substantial role in influencing student number sense skills and that further research is needed to explore these factors.

Discussion

This study aimed to investigate the number sense skills of classroom teachers and first-grade primary school students in Uşak, Turkey, and to explore the influence of various demographic factors on these skills. The findings reveal significant insights into the number sense abilities of both teachers and students, highlighting areas for improvement and potential strategies for enhancing mathematical education in early childhood.

Overview of teacher number sense skills

The distribution of number sense test scores among first-grade teachers indicates a moderate average proficiency level, with considerable variation in scores. The mean score of 12.24 out of 17 suggests that while some teachers possess strong number sense skills, others may need further development in this area. These findings align with the research by Bayak (2016), which also found variability in the number sense skills of classroom teachers. The significant variation in scores highlights the need for targeted professional development programs to enhance teachers' number sense skills, ultimately benefiting student learning outcomes. This supports the idea proposed by Sowder (1992) that effective teaching strategies and a strong understanding of mathematical concepts by teachers are crucial for enhancing students' number sense.

Demographic differences in teacher number sense skills

Gender differences

The study found a statistically significant difference in number sense scores between male and female teachers, with male teachers demonstrating higher scores on average. This finding aligns with previous research indicating that males tend to outperform females in mathematical achievement. For instance, Li et al. (2018) reported small gender differences favoring males among Grade 8 students in Beijing, suggesting that males scored higher than females in mathematics achievement. Similarly, Reilly et al. (2014) found small but stable mean sex differences favoring males in mathematics and science achievement among 12th-grade students in the United States.

In the context of teacher education, Yaman (2015) also found differences in number sense performance among teacher candidates based on gender, with male candidates outperforming female candidates. However, other studies, such as those by Gülbağcı Dede and Şengül (2016), found no significant gender differences in number sense skills among teacher candidates. This discrepancy suggests that gender differences in number sense skills may be context-specific and influenced by various factors, including cultural and educational contexts.

One possible explanation for these differences is the influence of socio-cultural factors and gender stereotypes that associate mathematical ability more strongly with males. Boaler (1997) argued that societal expectations and classroom practices often reinforce gender stereotypes, which can affect students' engagement and performance in mathematics. Reilly et al. (2014) suggested that these stereotypes may encourage males to engage more with mathematics, leading to higher confidence and performance in this domain. Furthermore, Hyde et al. (1990) conducted a meta-analysis and concluded that gender differences in mathematics performance are generally small and declining over time, suggesting that socio-cultural influences play a significant role. In some contexts, female teachers have been found to outperform male teachers in mathematical knowledge. For example, Haroun et al. (2016) found that female teachers in Saudi Arabia significantly outperformed their male counterparts in mathematical knowledge for teaching in single-sex classrooms. This indicates that when educational opportunities and encouragement are equitable, gender differences may diminish or even reverse. Additionally, Geary et al. (2022) reported that while boys exhibited advantages in spatial abilities, girls were more attentive in classroom settings, and there were no significant sex differences in overall mathematics performance among students. This highlights that gender differences may be more pronounced in specific cognitive domains rather than in general mathematical ability.

The influence of gender on mathematical abilities has been a topic of debate, with some studies suggesting inherent differences (Hyde et al., 1990) and others pointing to socio-cultural influences (Boaler, 1997). The findings of this study suggest that in the Turkish context, male teachers may have higher number sense skills due to a combination of factors such as societal expectations, educational practices, and potential differences in professional development opportunities. Addressing these disparities requires targeted interventions to promote gender equity in mathematics education, challenge existing stereotypes, and provide equal opportunities for professional growth among teachers.

Differences based on professional experience and number sense training

The analysis revealed that professional experience significantly influences number sense skills, with more experienced teachers demonstrating higher scores. This finding is consistent with the literature, which suggests that teaching experience positively impacts mathematical skills and instructional effectiveness (Harris & Sass, 2011). Additionally, teachers who received number sense training had significantly higher scores than those who did not, underscoring the importance of targeted training programs. This aligns with the findings of Yang (2003), who emphasized the role of teacher training in enhancing number sense skills. Professional development programs that focus on number sense can help bridge the gap in teachers' numerical competencies, as suggested by studies on effective mathematics instruction (Ball et al., 2008).

Overview of student number sense skills

The distribution of number sense assessment scores among first-grade students indicates moderate to high proficiency levels across various subcomponents. The mean scores suggest that while students generally possess a good understanding of number sense, there is room for improvement, particularly in areas such as number combinations and nonverbal calculations. These findings are consistent with previous research, which has shown that early number sense skills are critical for later mathematical achievement (Jordan et al., 2009; Lipton & Spelke, 2003). The observed variation in scores highlights the need for differentiated instruction to support students with diverse levels of number sense proficiency. Research by Aunio et al. (2004) and Dyson et al. (2013) also emphasizes the importance of early number sense development for long-term mathematical success.

Demographic differences in student number sense skills

Gender differences

The study found statistically significant gender differences in several subcomponents of number sense, with male students demonstrating higher scores on average. This finding is consistent with previous research by Yenilmez and Yıldız (2018), which found that male students had higher number sense skills than female students. However, other studies, such as those by Harç (2010) and Takır (2016), found no significant gender differences in number sense skills. These mixed findings suggest that gender differences in number sense skills may be influenced by various factors, including cultural and educational contexts.

Research on gender differences in mathematics achievement has shown conflicting results. Some studies have reported small gender differences in favor of either girls or boys (Gibbs, 2010; Krinzinger et al., 2012; Robinson & Lubienski, 2011), while others have failed to document significant gender differences (Hyde, 2005; Hyde & Linn, 2006; Hyde et al., 2008). The origins of these differences have been extensively discussed, with a range of biological and socio-cultural causes proposed (Geary, 1996; Robinson & Lubienski, 2011; Spelke, 2005). For instance, societal expectations and gender stereotypes may play a role in shaping mathematical abilities (Anaya et al., 2017; Barbaresi et al., 2005; Pina, 2021; Reigosa-Crespo et al., 2012;).

Gender differences in mathematics have been most consistently reported in older children, but such differences have also been observed earlier in development, although not consistently (Lachance & Mazzocco, 2006; Stoet & Geary, 2013). For example, Krinzinger et al. (2012) found a male advantage in writing multi-digit Arabic numerals, subtraction, and multiplication among second graders from Germany, Austria, Belgium, and France. Conversely, Hutchison et al. (2017) found evidence for gender equality in early numerical tasks among Dutch children, suggesting that gender differences might only emerge in more complex mathematical tasks.

The findings of this study align with research indicating that gender differences in mathematical abilities, particularly in early numerical competencies, may stem from both biological and socio-cultural factors (Geary, 1996; Hutchison et al., 2017). For instance, Jordan et al. (2006) reported small but significant effects of gender in favor of boys on overall number sense, nonverbal calculation, and estimation among children from low and middle socioeconomic backgrounds.

Differences based on parental education levels

The analysis revealed significant differences in number sense scores based on both the mother's and father's education levels. Students whose parents had higher education levels demonstrated higher number sense scores, which is consistent with the findings of Singh (2009) and Can (2019). This suggests that parental education plays a crucial role in the development of children's number sense skills, likely due to the provision of a more enriched and stimulating home environment (Aikens & Barbarin, 2008).

Research indicates that high-SES children (i.e. children from high socio-economic status families) tend to have more advanced number skills, including counting, ordering, and comparing numbers, than their low-SES peers, even before kindergarten (Starkey et al., 2004). These foundational number skills may mediate the relationship between SES and math achievement during kindergarten and first grade (Jordan et al., 2007). SES differences in numeracy skills are particularly pronounced in verbal tasks such as story problems, whereas low-SES kindergarteners do not differ significantly from their more affluent peers in non-verbal and non-symbolic tasks (Jordan & Levine, 2009; Jordan et al., 1992).

Moreover, SES disparities in early numeracy are evident in number representation skills. Throughout early and middle childhood, children's mental representations of numbers shift from a logarithmic perception, where smaller numbers are perceived as further apart than larger numbers, to a linear perception, where numbers are equally spaced along the number line (Case & Okamoto, 1996; Dehaene, 1997). More linear representations are associated with enhanced arithmetic skills (Gunderson et al., 2012). However, low-SES children typically have less linear representations of numbers on average (Siegler & Ramani, 2008). These difficulties with both language and visuo-spatial representations may partially underlie SES disparities in numeracy.

The importance of parental education in supporting children's mathematical development is well-documented in the literature (Jordan et al., 2009; Park & Brannon, 2014). Higher parental education levels are often associated with greater involvement in children's education and more frequent engagement in educational activities at home, which can positively influence children's academic performance (Hill & Tyson, 2009). This enriched home environment likely provides children with more opportunities to engage with mathematical concepts and develop their number sense skills, reinforcing the critical role of parental education in early childhood numeracy development.

Correlation between teacher and student number sense skills

The correlation analysis revealed no significant direct relationship between the number sense skills of teachers and their students. One possible explanation for this finding is the limited time the first-grade students had spent with their teachers at the point of data collection. As the participants were first-grade students who had recently begun formal schooling, their experience with their teachers may have been limited to only a few months, depending on when the research was conducted during the academic year. This limited interaction period might not have been sufficient for the teachers' number sense skills and instructional practices to have a measurable impact on their students' number sense development.

This suggests that other factors, such as the home environment, parental involvement, and individual student characteristics, may play a more substantial role in influencing student number sense skills at this early stage. This aligns with the research by Gözüm et al. (2024), which found that various factors contribute to the development of number sense skills in young children. While the direct influence of teachers on students' number sense skills was not significant in this study, the importance of teacher quality and instructional practices in supporting mathematical development should not be underestimated (Yang, 2003). Indeed, the cumulative effect of effective teaching practices may become more pronounced over a longer period (Desimone et al., 2002; Garet et al., 2001).

Research by Chen et al. (2013) and Major and Berger (2014) also underscores the critical role of effective teaching practices in enhancing students' mathematical abilities. Therefore, the lack of a significant correlation in this study may reflect the early stage of the teacher-student relationship rather than an absence of teacher influence altogether. Future research could benefit from longitudinal designs that track students' number sense development over a more extended period to more accurately assess the impact of teachers' number sense skills on their students.

In summary, this study provides valuable insights into the number sense skills of classroom teachers and first-grade primary school students in Uşak, Turkey. The findings highlight the importance of targeted professional development for teachers and the significant influence of parental education on student number sense skills. The limited correlation between teacher and student number sense skills may be attributed to the short duration of the teacher-student interaction at the time of the study. Further research is needed to explore the underlying factors influencing gender differences in number sense skills and to develop effective interventions to support students with diverse levels of proficiency. By addressing these areas, educators and policymakers can implement strategies to enhance mathematical education and support student success from an early age.

Conclusion

This study examined the number sense skills of classroom teachers and first-grade primary school students in Uşak, Turkey, highlighting the influence of various demographic factors. The findings revealed significant differences in number sense skills based on gender, professional experience, and training among teachers, and based on gender and parental education levels among students. The study underscores the importance of targeted professional development for teachers and the critical role of parental education in shaping children's numerical competencies. These insights contribute to a deeper understanding of the factors influencing number sense skills, providing a foundation for developing effective educational strategies and interventions.

The findings of this study have several important implications for educators, policymakers, and researchers. The significant variation in number sense skills among teachers, particularly based on professional experience and training, suggests a need for targeted professional development programs. Enhancing teachers' numerical competencies can positively impact their instructional practices and, consequently, student learning outcomes. Training programs should focus on developing teachers' understanding of number sense and effective strategies for fostering these skills in students. The influence of parental education on students' number sense skills highlights the critical role of the home environment in early mathematical development. Educational initiatives should encourage parental involvement in children's learning and provide resources to support parents in creating a stimulating and supportive environment for numerical development. The observed gender differences in number sense skills among both teachers and students indicate a need for further investigation into the underlying causes of these disparities. Educational interventions should be designed to address these differences and support female students and teachers in developing their number sense skills. Given the importance of number sense skills in predicting later mathematical achievement, early intervention programs should be implemented to support students with diverse levels of proficiency. These programs can help identify and address gaps in students' numerical understanding, ensuring a strong foundation for future mathematical success.

Limitations and future research directions

Despite the valuable insights provided by this study, several limitations should be acknowledged. The sample size was limited to 102 teachers and 341 students from Uşak, Turkey, which may restrict the generalizability of the findings. Future studies should include larger and more diverse samples to enhance the robustness and applicability of the results. The cross-sectional design of the study provides a snapshot of number sense skills at a single point in time, which limits the ability to draw conclusions about the development and progression of these skills. Longitudinal studies are needed to examine changes in number sense skills over time and the long-term impact of various factors. Some of the data, particularly regarding teachers' professional experience and training, were self-reported, which may introduce bias. Future research should incorporate objective measures and observational data to validate the findings. The study was conducted in a specific cultural and educational context, which may influence the results. Comparative studies across different cultural settings are necessary to understand the broader applicability of the findings.

Building on the findings and limitations of this study, several directions for future research are suggested. Future research should adopt longitudinal designs to track the development of number sense skills over time and examine the long-term effects of demographic factors and educational interventions. Experimental studies evaluating the effectiveness of targeted interventions for improving number sense skills among teachers and students are needed. These studies can provide evidence-based recommendations for educational practice and policy. Comparative studies across different cultural and educational contexts can provide insights into the universality and variability of factors influencing number sense skills. This can help identify best practices and inform the development of culturally responsive educational strategies. Indepth qualitative studies exploring the experiences and perceptions of teachers, students, and parents regarding number sense can provide a deeper understanding of the factors shaping these skills and inform the design of effective interventions. Future research should explore additional demographic factors, such as socio-economic status, language proficiency, and regional differences, to provide a more comprehensive understanding of the influences on number sense skills. By addressing these research gaps, future studies can build on the current findings to further enhance our understanding of number sense skills and their development, ultimately contributing to improved mathematical education and student outcomes.

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