

Opinions of Teachers and Pre-Service Teachers on the Development of Number Sense

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Abstract

The aim of this research study was to examine the opinions and experiences of teachers and pre-service teachers about number sense and its development. The participants of this research were 25 teachers and pre-service teachers studying at undergraduate or graduate level in different regions and different departments of Turkey, who participated in the number sense training project prepared within the scope of teacher training. Research data were collected through

open-ended questions and activities developed by the participants. Open-ended questions developed by the researchers consisted of questions about the development and application of the number sense. The data were analyzed through content analysis. Results showed that most of the participants generally emphasized the use of materials such as number cards and ten frame cards for the development of number sense in the classroom environment and the development of number sense components such as having number talk. However, the number sense activities developed by the participants as a group at the end of the training reveal that they need to have more experience in number sense. In addition, the participants see teacher competence and the content and intensity of the objectives in the mathematics curriculum as the biggest obstacle to the use of number sense in the math classroom.

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Introduction

One of the important skills that children are expected to acquire in early childhood mathematics education is number sense. Number sense is more than the knowledge of numbers, it is the perception of the deep and relational meaning of numbers and the use of them in a fluent and flexible way. Griffin (2004) stated that number sense is difficult to define and explained this structure with an example. In his research, a 5-year-old child showed that the number 9 is 2 more than 7 by counting over 7 with his fingers in the form of 8, 9. It is stated that this statement made by this child may be a good indicator of number sense "for this age group". Similarly, according to Gersten and Chard (1999), a child with a developed number sense can develop a different strategy by using fingers or blocks to show why 8 is greater than 5. In their research, they stated that many children acquired this conceptual structure informally from their elders or family before they reached kindergarten. The view that number sense can be acquired informally without starting formal education is emphasized in many studies. (Berch, 2005; Jordan et al., 2006; Howell & Kemp, 2010). Recently, in the mathematics education literature; there is a great emphasis on the necessity of number sense in early childhood (Howell & Kemp, 2010). This need, stated in the literature, is also reflected in the curriculum of some countries. It stands out in the Nurturing Early Learners (NEL) national preschool curriculum booklet of Singapore, which is one of the countries that generally ranks at the top in international exams (Ministry of Education, Republic of Singapore, 2013). Although number sense is not emphasized in the preschool and primary school mathematics

curriculum in our country, it is seen that there are objectives aimed at improving number sense. Teachers have a great responsibility in planning activities to consider and realize these objectives in the context of number sense and develop them in the classroom environment. However, it is thought that teachers and teacher candidates generally do not have sufficient knowledge about number sense. Number sense, which is seen as a requirement for mathematics success in later periods (Andrews & Sayers, 2015; Howell & Kemp, 2010; Jordan et al., 2012; Lago & DiPerna, 2010; Sayers et al., 2016) it is very important to start its development at an early age. In order to plan activities to develop this skill in the classroom environment, pre-service teachers must first have information about the development of number sense in children. However, when the teacher training undergraduate programs for pre-school and classroom teaching in faculties of education are examined, it is noteworthy that there are no courses on number sense (YÖK, 2018). In this sense, it is thought that in order to raise students with high number sense, teachers and teacher candidates should gain knowledge and experience about the development of number sense from early childhood to the last period of primary school.

Therefore, the aim of this research was to examine the opinions and experiences of pre-service teachers and teachers about number sense and its development. The research questions developed for this purpose were as follows:

1. What are the opinions of teachers and pre-service teachers about how students' number sense can be improved?
2. What are the opinions of teachers and pre-service teachers about the obstacles in the implementation of number sense activities in the classroom?

Method

Research Design

The purpose of this research is to examine in depth the opinions and experiences of teachers and pre-service teachers regarding the development of number sense. A case study, a qualitative research type, was preferred to examine and interpret this situation in depth. The main purpose of the case studies is to describe and interpret the situation within its own environment (Seggie & Bayyurt, 2015). The aim of this study is to describe and examine the opinions, skills and

experiences of a group of pre-service teachers and teachers who have received number sense training about number sense, through their answers to open-ended questions and the activities they developed.

Research Sample

The participants of this research are the participants of the project titled "Development and support of number sense in children". This project carried out within the scope of TÜBİTAK 2237-A under the leadership of Kayhan Altay (2022). Criterion sampling method, one of the purposeful sampling methods, was used to determine the participants in the project. According to these criteria, undergraduate students studying in the 3rd and 4th grades of the Preschool Education and Classroom Education undergraduate programs of the state or foundation university's Education Faculties, as well as graduate and doctoral students in related programs, were selected to represent the whole country and from different regions. Another criterion considered in the selection of participants is the answers given to the preliminary survey. In the survey, participants were asked questions about their prior experiences with number sense. From the answers given to these questions, it is understood that all participants did not receive any training on number sense before and only took courses on mathematics education in undergraduate education programs. Information about the department and educational background of the participants is presented in Table 1.

Table 1

Distribution of participants by department and educational status

Department	Education Level					
	Undergraduate		M.S.		Ph.D.	
	Early Childhood Education	Elementary Teacher Education	Early Childhood Education	Elementary Teacher Education	Early Childhood Education	Elementary Teacher Education
	6	13	1	2	-	3
Total	25					

As seen in Table 1, most of the participants consist of pre-service teachers studying in the department of elementary teacher education. The number of participants who are teachers is 6. The names of the participants were presented by coding as P1, P2, ..., P25.

Research Instrument and Procedure

The data of the research consists of documents of the answers given individually by the participants to open-ended questions and the activities they developed as a group. Since TÜBİTAK-supported number sense training was conducted online, it was preferred to collect opinions with open-ended questions in the last session of the project in the online environment. Open-ended questions were developed by the researchers of this study who conducted theses and academic studies in the field of number sense (Alkaş Ulusoy, 2020; Kayhan Altay, 2010; Kayhan Altay & Umay, 2013; Özer et al., 2022). These experiences and research results were used while developing the questions. The questions were prepared to reveal the participants' views on number sense, its definition, importance, components and development. In the first part of the form, there are questions about the importance of number sense, in the second part, there are questions about the development of number sense, in the third part, there are questions about the obstacles in applying number sense in the classroom environment. Examples of questions developed for each section are as follows:

1. What comes to your mind when number sense is mentioned? What do you think are the characteristics of someone with a high sense of numbers?
2. What can be done to develop number sense in the classroom environment?
3. What might be the difficulties or possible limitations of developing children's number sense in preschool and primary school?

Participants answered the open-ended questions in the form individually in writing in approximately 30 minutes in the last session of the project training

Within the scope of the project training, participants received a total of 23 hours of theoretical and practical training for five days by expert trainers in the field of number sense. In the theoretical part of the training, it was aimed for the participants to gain awareness about number sense, and in the practical part, it was aimed to provide them with information on how to use different teaching

techniques and tools (such as number line, concrete materials, children's literature) in the classroom environment for the development of number sense. In addition, the activities they developed aimed to help them gain skills and experience to develop in-class number sense activities. For this reason, number sense has been addressed in education starting from early childhood, and education has been given at each education level about the definition of number sense, its components, and basic mathematical ideas and structures that may be important in its development. Additionally, application examples using different teaching techniques and tools that can be effective in the development of number sense and its components in the classroom environment are presented. In order for the participants to gain experience in the application, they were asked to develop a number sense-based activity as a group on the fourth day of the training. The groups were created by the project team, with Elementary Teacher Education and Early Childhood Education participants as separate groups. A total of 6 groups were formed, including two early childhood groups and four elementary teacher education groups. In the activity template developed by the project team, the groups were asked to develop an activity by choosing an outcome for preschool children and elementary school students. The developed activities were evaluated by the project team and participants through discussions on the last day of the training. These developed activities are another data source used to examine participants' opinions and experiences about number sense.

Data Analysis

The research data consists of the answers given to the open-ended form filled out by the participants and the activities developed as a group on the last day of the training. The data obtained was analyzed using the content analysis method. The participants' answers to the form were first transferred to a word document. Then, the codes were determined by the first three researchers, considering the research questions separately, and transferred to the tables. These codes transferred to the tables were discussed with all researchers together and placed in appropriate themes according to their similarities. An attempt was made to achieve consensus in the analysis of the data. Explanations and sample answers regarding the created codes and themes are discussed in the findings section.

Results

Views on Enhancing Number Sense

The opinions on how to enhance number sense activities were gathered from the participants within the scope of the first sub-problem of the research. The codes and themes that emerged within this sub-problem are presented in Table 2.

Table 2.

Teacher and Pre-Service Teachers Views on Enhancing Number Sense

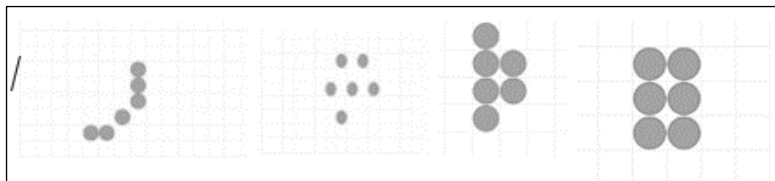
Themes	Codes	Participants	F
Use of Materials	Ten frame cards, Dominoes, Number cards, Base ten blocks, Dot cards, Digital tools, Counters	P2,P3,P6,P7,P9,P12,P14,P17, P22,P24	10
Activities for Components of Number Sense	Subitizing, Part-Whole Relationship, Estimation, Meanings of Numbers (examples of number talks)	P1,P5,P6,P9,P10,P16,P18,P20	8
Supporting Strategies	Discussing Different Student Strategies in the Classroom	P5,P6,P19,P20,P21,P24	6
Making Connections	Everyday Life Integration, Interdisciplinary Integration	P2,P8,P19,P22	4
Different Techniques	Games, Children's Literature, Fingerplays, Videos	P3,P14	2

According to Table 2, it can be observed that participants' responses are categorized into five different themes: material usage, activities related to number sense components, support for strategies, making connections, and different techniques. Many participants provided various examples within the first theme, material usage. Some of the participant opinions included in this theme are as follows: "*Games can be developed and played with materials such as dominoes, ten frame cards, counters, etc.*" (P14), "*In elementary school, the use of materials corresponding to*

numbers can be important in terms of developing number sense" (P24). When the lesson plans prepared by the participants as part of the study were examined, it was observed that the materials they mentioned as examples were also included in the activities they prepared. In this context, for instance, the ECE2 (Early Childhood Education 2) group activity included the use of subitizing cards and counters as follows: *"The teacher distributes counting counters to the students. The teacher shows subitizing cards one by one. Students are asked to create the number 6 they see using the counters."*

Figure 1.

Activity for the ECE2 Group (Counting Counter Example)



The responses related to the theme of activities for the components of number sense indicate a focus on subitizing, part-whole relationship, meanings of numbers, and estimation components. P5 presented the opinion regarding the meanings of numbers, stating, *"Creating more number discussion environments with less focus on a single topic is possible."* In the same theme, participant P20 mentioned about the part-whole relationship, saying, *"introducing and using numbers to students with different combinations ($6=1+5=2+4=3+3$)."*

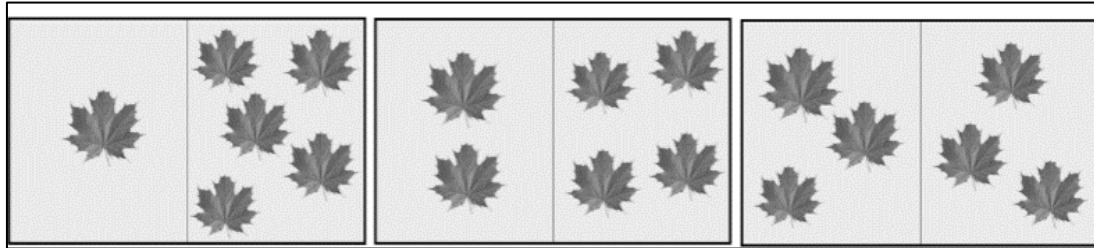
The participants in the ECE2 group used the following expressions in their activities aimed at developing the part-whole relationship in the representation of the number 6:

"The teacher asks parents to have conversations with their children involving the number 6 the day before, and when the children come to school the next day, they are asked to bring sentences related to the number 6. When the children arrive in the classroom, the child responsible for the week is asked to make the number 6 on the number board for that week. Then, a discussion about the number 6 is conducted with all the children. The teacher asks: 'What did you discover about the number 6 today on your way to school? How many things related to the number 6 are there in our classroom? What do you think could be related to

the number 6 at your home? Do you think you can have 6 cars? How many boys are there in our class?"

Figure 2.

Activity of the ECE2 Group (Part-Whole Relationship)

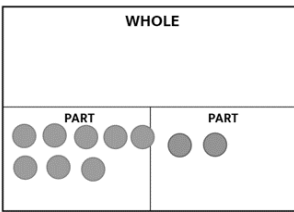
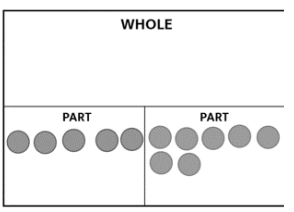
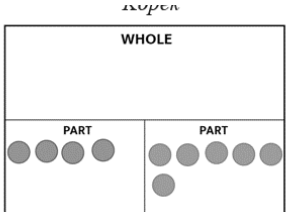


An excerpt from the activity prepared by the ETE4 group, demonstrating the use of part-whole relationship with different numbers, is presented in Figure 3.

Figure 3.

Activity of the ETE4 Group (Part-Whole Relationship)

"What was the number of roosters?
What was the number of cats?
What was the number of dogs?"

Rooste	Cat	DOG
<p>WHOLE</p> <hr/> <p>PART PART</p> 	<p>WHOLE</p> <hr/> <p>PART PART</p> 	<p>WHOLE</p> <hr/> <p>PART PART</p> 

In the theme of supporting strategies, P24 expresses *“the need for asking thought-provoking questions to enable children to reach the same solutions through different methods.”* In the theme of making connections, within the scope of daily life integration, P19 emphasizes *the need for activities that will develop children's number sense using examples from daily life.* In addition to all these themes, there are participants who emphasize the development of number sense through

different techniques. Here are some opinions from these participants: *"Number sense development can be achieved interactively with children through children's books, fingerplays, and videos"* (P14).

Classroom Barriers to Implementing Number Sense Activities

Within the scope of the second sub-problem of the research, the participants' views on the barriers to implementing number sense activities were collected. The opinions gathered resulted in the codes and themes presented in Table 3.

Table 3.

Teacher and Pre-Service Teachers Views on Barriers to Implementing Number Sense Activities

Themes	Codes	Participants	F
Teacher Competence	Lack of material usage, Lack of pedagogical content knowledge	P5,P6,P7,P11,P15,P16,P18,P19	8
Curriculum Contents and Intensity	Outcome Deficiencies, Class Hour Duration, Curriculum Intensity	P4,P5,P6,P7,P10,P18,P19	7
Individual Differences	Families' Number Sense, Age	P10,P12,P13,P22,P23,P24	6
Physical Conditions	Socioeconomic Status, School Infrastructure, Class Size, Limited Educational Materials	P3,P4,P7,P12,P13,P19	6
Student Readiness	Prior Experience in Mathematics Class, readiness	P1,P8,P15,P20,P21	5
Affective	Teacher's Attitude and Experience	P9,P15	2

Possible difficulties and limitations have been categorized under six themes. Participants who emphasize teacher competence, like P11 supports this statement by stating, *"I also do not really know how it should be taught because I cannot put myself in their shoes, and I do not know where they struggle to make sense of it."* Regarding the theme of curriculum content and intensity, P6

comments, *"The intensity of the curriculum also poses difficulties for teachers."* P7 emphasizes *"the necessity of increasing the class hour duration to a sufficient extent."* Within the theme of individual differences, P22 emphasizes individual learning differences and expresses their opinions as follows:

"I don't think it's too difficult for children who are at a normal learning level. The progress can be tailored according to the students' inclinations. For example, for a student inclined towards literature, learning can be facilitated through children's books, while for more social and active students, using drama methods may lead to more lasting and meaningful learning."

Within the theme of student readiness, P20 says that *"Since every child's readiness is different and number sense is a more personal perception, trying to cater to all of them can be somewhat limiting."* Another theme created regarding limitations and challenges related to number sense is the theme of physical conditions. Participants use expressions like *"class sizes"* (P12), *"physical conditions"* (P7), and *"limitations in technology usage"* (P19) concerning physical conditions. Participant P3, on the other hand, mentions socio-economic conditions and states, *"Geographically and socioeconomically, there may be difficulties. In rural areas, there may not be preschool education institutions, so it is not very possible to develop number sense."* Within the scope of the affective theme, participants express their views on teachers' negative experiences and attitudes towards mathematics. P15 mentions that *"Teachers' negative experiences and attitudes towards mathematics"* can be a constraining factor for the development of number sense.

Conclusion

The acquisition of number sense is a developmental process acquired long before the school age begins. Despite evidence of the acquisition of number sense at an early age, advancing years do not guarantee the development of number sense (Kayhan Altay, 2010). In this context, it can be said that preschool and early education teachers, who are responsible for the education of the early age group, play a significant role in the development of number sense. Therefore, studies on the views and awareness of preschool and early education teachers regarding number sense constitute a foundation for the development of children's number sense. Despite numerous studies examining

students' number sense from various perspectives (Yang et al., 2007; Kayhan Altay & Umay, 2011), it can be observed that studies related to teachers and pre-service teachers who play an effective role in developing number sense tend to focus more on teachers' number sense performance and the strategies they use (Tsao, 2004; Yang et al., 2009; Şengül 2013, Almeida et al., 2016; Aktaş & Özdemir, 2017). In addition to studies attempting to uncover how pre-service teachers utilize their number sense and this skill, some research also investigates the impact of training given to teacher candidates on the development of their number sense. These studies have determined that training has a positive effect on the number sense performance of teacher candidates (Kaminski, 2002; Tsao, 2005). Given the critical importance of teachers with developed number sense and awareness of this skill in the development of number sense in children, in a project that was designed, pre-service teachers' and teachers' opinions regarding number sense were obtained following a five-day training on number sense.

The participants were asked how activities related to number sense can be developed. They emphasized the importance of using materials in activities related to number sense. They mentioned various materials such as ten frame cards, dominoes, base ten blocks, dotted cards, digital tools, and counters as examples of materials that can be used. Participants were able to include these materials in the sample lesson plans they prepared at the end of the training. Preschool and elementary school teachers, as well as pre-service teachers, emphasized the need to develop activities related to number sense based on the components of number sense. When the lesson plans prepared by the participants at the end of the training were examined, it was found that activities based on components were included. In addition, participants emphasized that activities related to number sense should include different strategies of students and should make use of daily life and interdisciplinary connections. They also mentioned that different techniques such as videos, children's literature, and games can be used in the development of activities related to number sense. As a reflection of the knowledge and experiences gained from the project, teachers and teacher candidates used the mentioned methods and techniques in their lesson plans. However, when the prepared plans were examined, it was observed that the plans remained superficial. Although the participants could include multiple components of number sense in their activities, they generally focused on one component. They also had limited diversity in the materials they

used in the activities, and they often planned activities using a single material. Additionally, they provided limited opportunities for dialogues with students in the classroom for the development of number sense, and they did not fully exploit the potential of using different materials and techniques to enrich the activities. The reason for this might be the short duration of the training, which took place in just 5 days, making it challenging for teachers and teacher candidates to fully grasp the concepts related to number sense. Therefore, it would be beneficial to offer these types of training regularly as part of in-service education or to make necessary additions related to number sense in the courses that pre-service teachers take during their undergraduate studies. This approach would allow for the development of more detailed content and a deeper understanding of number sense.

Discussion

The quality of the created activities and their feasibility in implementation are important factors in developing students' number sense. At the end of the training, the views of participants on the barriers to implementing number sense activities were obtained. In this context, the majority of participants saw the lack of teacher competence as an obstacle to implementing activities. They perceived the inadequacy of teachers in using materials and pedagogical content knowledge as a hindrance to implementing number sense activities, and some participants mentioned feeling inadequate in this area. Studies in the literature also show that teachers and teacher candidates often have a low level of number sense (Yang et al., 2007; Almeida, 2013; Aktaş & Özdemir, 2017; Er & Dinç Artut, 2021). This situation can be explained by teachers and teacher candidates not considering themselves competent due to the content of the undergraduate education they received. Participants also mentioned the content and intensity of the curriculum as one of the obstacles to implementing activities. Consistent with the views of the participants, Çetin and Öztürk (2020) noted that the curriculum lacked explicit and sufficient content related to number sense components. Therefore, it can be suggested that the content of the curriculum should be updated to include more explicit content related to number sense. Regarding individual differences, factors such as families' number sense and age were discussed as barriers to implementing activities. Some studies have shown that as students get older, they tend to move away from using number sense strategies and shift towards using standard algorithms (Kayhan Altay, 2010). However, other

studies have observed that as students' progress in grade levels, their number sense also improves (Takır, 2016). Furthermore, participants mentioned that students' prior experiences with mathematics, their readiness for the activities, physical conditions, and teachers' attitudes and experiences could also be barriers to implementing activities.

Recommendations

The observations of improved responses to open-ended questions and the analysis of the activities and lesson plans prepared by participants after the training indicate that the training had a positive impact on them. However, it was noticed that the participants tended to create more superficial applications in their activity plans. This may be due to the limited duration of the 5-day training program. Therefore, the continuity of in-service training programs for developing number sense is crucial. To foster the development of number sense, the content of in-service training programs needs to be organized, sample activities that can enhance number sense should be prepared, and the curriculum should be updated accordingly. This way, teachers and teacher candidates can gain more experience and awareness related to number sense. Studies have shown that training programs aimed at improving number sense among teacher candidates have positively contributed to their development (Kaminski, 2002; Tsao, 2005). In addition to teacher and teacher candidate training, it's essential to enhance the number sense aspect of textbooks and curriculum standards used in mathematics classrooms. In this context, activity books and online resources can be developed, and teachers can be encouraged to use these materials

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