Teaching Mathematics to Students with Hearing Loss Using Instructional Materials

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Abstract

Submission of an article implies that the work described has not been published previously except in Teaching mathematics to students with hearing loss requires special attention and care. Using materials in mathematics education is crucial in helping students concretize abstract concepts and relationships, create schemas related to the taught subject, understand the content, apply it, and develop mathematical thinking in a broader context. In mathematics classes for students with hearing loss, teachers often struggle to find ready-made materials suitable for the instructional content and the language, cognitive, and readiness levels of students with hearing loss. Teachers themselves need to prepare instructional materials for students with hearing loss. This study aims to identify and explain the types and characteristics of materials prepared and used by teachers in mathematics classes for 6th-grade students with hearing loss, and to highlight the contributions of these materials to the mathematics teaching process. Research data were collected through materials used in mathematics instruction, lesson plans and evaluations, the researcher's diary, and video recordings of lessons. The collected data were analyzed by using the content analysis method. As a result of the research, support and resources have been provided to teachers and instructional programs to create and use mathematics lesson materials suitable for students with hearing loss.

Keywords: hearing loss, mathematics education, instructional materials in mathematics teaching, schema development

1. Introduction

1.1 Mathematics Education

Mathematics holds an indisputable importance in the personal and professional lives of almost everyone today. Mathematics, their expressions, and the relationships among these concepts are all conveyed through a unique language and systematic mode of thinking (Baykul, 2009). The inherent structure of mathematics creates some challenges in both learning and teaching processes. Making abstract concepts and the relationships between them concrete proves to be a formidable task for students. Teachers are expected to design learning experiences to achieve specified instructional goals (Sapta, Hamid, & Syahputra, 2018). Consequently, teachers need various methods, techniques, and tools to assist students in creating schemas, facilitating memory retention, and fostering a positive attitude toward mathematics.

A schema represents a dynamic structure in the mind that can connect new information to existing knowledge (Siagian, Sahat Saragih, & Sinaga, 2019). As individuals experience new situations, they establish relationships with their existing mental structures, compare new information with old knowledge, and either assimilate or regulate the new information. The process of assimilation and regulation leads to learning (Schirmer, 2000). Acknowledging the importance of schemas in education is crucial (Kluen, Nixon, Agorastos, Wiedemann, & Schwabe, 2017). In creating mental schemas, teachers play a critical role in ensuring the soundness of instructional content (Qi, Zhang, & Huang, 2018). Understanding new information depends on its consistency with the existing knowledge in an individual's schema (Yu & Zhu, 2019). Many students struggle to understand a new concept because of a lack of sufficient schema knowledge (David & Jean, 2005).

On the other hand, the schemas in students' minds with different experiences vary. Teachers must prepare well-organized methods to enhance students' schemas in this situation. Using teaching materials that remind students of prior knowledge, highlight the relationship with new information, and facilitate understanding is an effective way to help students create schemas (Qi et al., 2018).

1.2 The Use of Materials in Mathematics Education

Teaching materials are tools and resources that assist teachers in managing the process of learning and teaching, made available to students (Sarpkaya Aktaş, 2022; Trianto, 2011). It can also be defined as products that include content prepared using these tools (Sarpkaya Aktaş, 2022). Teaching materials play a significant role in making the methods and techniques used by teachers more meaningful in the instructional process. Many theorists supported the use of materials in mathematics education, including Dienes and Golding (1971), Piaget (1971), and Skemp (1987).

Numerous studies have highlighted that accurate, appropriate, and effective use of materials in mathematics classes concretizes abstract concepts, supports the exploration of new concepts, facilitates learning, ensures meaningful and lasting learning, helps attract attention and create shared interest among students, increases student participation, makes lessons enjoyable, enhances student motivation, aids in developing a positive attitude towards mathematics, and saves time (Bozkurt & Şahin, 2013; Cameron & Bennett, 2010; Fidan, 2008; Gökmen, Budak, & Ertekin, 2016; Koza-Çiftçi, Yıldız, & Bozkurt, 2015). Numerous research studies have also indicated that it contributes positively to developing metacognitive skills in problem-solving activities (Siagian et al., 2019). In addition, it provides the opportunity to write and discuss mathematics. Moreover, it provides opportunities for students to enhance skills such as prediction, relationship building, knowledge transfer, mathematical deduction, and mathematical generalization (Gündüz, Emlek, & Bozkurt, 2008).

Despite teachers having a positive attitude toward using materials in mathematics classes, they often fall short of utilizing adequate materials (Fidan, 2008; Kazu & Yeşilyurt, 2008). This situation stems from teachers not having materials suitable for both the instructional content and student profile (Aksu, 1990). The concrete and attention-grabbing nature of the material does not necessarily imply a better conveyance of the relationship between the object and the concept (Baroody, 1989; Clements, 1999; Özdemir, 2008). The crucial aspect lies in the similarity and alignment between the structure and features of the material and the mathematical concept it represents (Hiebert & Carpenter, 1992). However, students cannot learn solely by using materials (Ball, 1992). Teachers need to possess skills in selecting appropriate materials, effectively utilizing the chosen materials, guiding students by establishing connections between concrete and abstract representations, and developing effective materials to ensure the successful implementation of mathematics education (Brown, McNeil, & Glenberg, 2009; Özdemir, 2008).

High-quality teaching material should possess specific characteristics. It should present the subject matter in a simple, clear, and understandable manner without unnecessary details. The material should be designed in alignment with the objectives and outcomes of the lesson. It must effectively explain the concepts planned to be taught, ensuring rapid and efficient learning towards predefined goals. In this regard, it should guide the teacher, making the methods and techniques more meaningful and facilitating effective time management (Sarpkaya Aktaş, 2022). Moreover, the material should be suitable for the students' language development and cognitive, physical, and social readiness levels. The material should encourage student participation and interaction with the teacher, allow for exercises and practical applications, and guide students to think critically with the inclusion of hints (Sarpkaya Aktaş, 2022). On the other hand, they should be visually appealing and easily readable. Additionally, the teaching material should maintain relevance to real-life situations, offering opportunities for effective learning by being connected to daily life. Another crucial aspect is that the material should have updatable and reusable features (Bozkurt & Akalın, 2010; Sarpkaya Aktaş, 2022).

1.3 Students with Hearing Loss and Mathematics

Individuals with hearing loss need to learn mathematics in order to participate effectively, independently, and successfully in society. This principle is assured in mathematics education programs under the fundamental principles of "Every child can learn mathematics" (MEB, 2018) and "No child behind" (NCTM, 2000). However, every child cannot learn mathematics in the same way and at the same pace. Indeed, hearing loss has a negative impact on children's mathematics achievements (Gottardis, Nunes, & Lunt, 2011; Traxler, 2000; Van der Straaten et al., 2021).

The deficiencies in the language development and reading comprehension skills of students with hearing loss, along with their lack of experience, restrict their abilities to construct and transfer knowledge, thereby limiting the development of their mathematical skills (Kelly, Lang, & Pagliora, 2003; Nunes & Moreno, 2002; Pau, 1995;

Swanwick, Oddy, & Roper, 2005). In this context, appropriate conditions need to be provided for students with hearing loss in the process of learning and teaching mathematics. Students with hearing loss require activities that involve concretizing academic knowledge and terminology, experiencing new information in various contexts, being directly taught instructional strategies, and undergoing more repetition than their hearing peers (Karasu, 2020). Therefore, teachers should use instructional materials when asking questions, providing explanations or definitions, and initiating educational discussions (Akay, 2021; Sharan, 2015). In this context, the use of instructional materials is crucial to support students with hearing loss in making abstract concepts concrete, reading and understanding mathematical texts, asking and answering questions about mathematical topics, engaging in discussions, solving problems, remembering topics studied in and outside of class, completing assignments, preparing for various exams, conducting research, and discussing what they have learned with other students, teachers, or parents.

However, teachers often struggle to find ready-made materials appropriate for the language, cognition, and readiness levels of students with hearing loss. In such cases, teachers of students with hearing loss find themselves in the position of having to create their own materials tailored to the levels of their students in mathematics class.

The Hearing-Impaired Children Education Research and Application Center (ICEM) at Anadolu University in Turkey implements Balanced Mathematics Teaching for students with hearing loss across all levels, from preschool to secondary education (Tanrıdiler, Uzuner, & Girgin, 2015). Teachers take an active role in developing and utilizing instructional materials that guide their mathematics lessons. This study aims to introduce and describe the characteristics and usage of materials prepared and used by teachers during a 6th-grade unit in ICEM. Additionally, it seeks to provide examples illustrating the features and application methods of these materials and to explain their significance in mathematics education. The study addresses the following questions.

1.4 Research Questions

What materials are used in mathematics classes for students with hearing loss?

What are the characteristics of the materials used in mathematics classes for students with hearing loss?

How are instructional materials prepared for mathematics classes of students with hearing loss utilized?

What contributions have the materials used in mathematics classes for students with hearing loss made to mathematics education?

2. Method

This case study aims to conduct an in-depth examination of the materials prepared and used by teachers in mathematics lessons for 6th-grade students with hearing loss. A case study involves an in-depth exploration of a subject or phenomenon within its natural context and conditions without any interventions (Yin, 2012).

2.1 Educational Environment

This research was conducted at the Hearing-Impaired Children Education Research and Application Center (ICEM) at Anadolu University. At ICEM, a student-centered and interdisciplinary approach is adopted to provide communication and academic skills to children with hearing loss through an auditory-oral approach. A balanced mathematics education program is implemented from preschool to secondary education levels. The teaching materials thoroughly examined during the research process were prepared and used by the mathematics lesson teacher during the 2016-2017 academic year.

2.2 Participants in the Research

The participants in the research are seven students with hearing loss attending the 6th grade at ICEM. Among the students, one is female, and six are male. All students have severe or profound bilateral sensorineural hearing loss. The hearing loss of all students was identified early, and they received early device intervention. None of the students have any additional disabilities. Students do not experience significant problems in communication. Students understand and use a simple, clear mathematical language appropriate to the context.

The author of the research is the teacher who conducted 40 weeks of group mathematics lessons (10 hours per week) for the participating students during the 2016-2017 academic year. The author completed undergraduate and graduate education in mathematics and doctoral education in teaching individuals with hearing loss. The teacher has 21 years of experience in mathematics education for individuals with hearing loss and has participated in various qualitative studies.

2.3 Research Process

The diversity of data collection tools is crucial for validity and reliability in case studies (Yin, 2012). This study primarily utilized the instructional materials used in classes as the main data source. Additionally, data were collected through mathematics teaching programs, video recordings of mathematics classes, lesson plans, evaluation records, reflective journals, and student products.

The research data were collected during the "Decimal Representations" unit, taught between 27.03.2017 and 08.05.2017. Since there has been no change in the mathematics curriculum and teaching methods for students with hearing loss since the data collection process, the study remains up-to-date.

All materials used during the research process were prepared by the teacher before the lessons. In the preparation process, the appropriateness of the materials to the instructional content was consulted with a mathematics specialist. Feedback regarding the suitability of language and content presentation to meet the needs of students with hearing loss was obtained from an expert in educating individuals with hearing loss. Photographs of all teaching materials were taken before and after the instructional process. The documented photographs were used as the primary source of data.

2.4 Data Analysis

In this research, content analysis, one of the qualitative data analysis methods, was employed to analyze the obtained data. Content analysis aims to describe the data and extract what is hidden within the data. Similar data are categorized based on specific concepts, organized in a way that the reader can easily understand, and interpreted (Yıldırım & Şimşek, 2013).

In line with the purpose of the research, transcripts of the materials were written, the transcripts were examined by comparing them with other data, and general themes and categories were determined by taking into account recurring situations. At the same time, lesson video recordings and teacher evaluations were used as support resources. Consequently, the study identified recurring scenarios such as materials utilized in mathematics classes for students with hearing loss, characteristics of these materials, how they are utilized, and their contributions to mathematics teaching

2.5 Trustworthiness and Validity

Trustworthy and reliable studies should meet the criteria of objective, valid, reliable, systematic, and peer-reviewed data. In order to ensure the reliability of the research, various data sources were utilized. Long-term and in-depth data were collected. Data collection and analysis were systematically conducted. Opinions were obtained from experts in the education field of students with hearing loss and mathematics education. The researcher described all materials used in the research process and created transcripts. Coding and theme analysis were performed. An expert in mathematics education reviewed codes and themes. It was observed that 100% agreement was reached in the reliability assessment.

2.6 Ethics

Parents are informed, upon enrolling their children in ICEM, that the school is not only an educational and application center but also a research center where various research studies are conducted. They are assured that their children can participate in research while their rights are protected, and this participation will not have a negative impact on their educational and social lives. Permission for this study was obtained by sharing the necessary information with the school administration in line with the research objectives. In this study, the participating students did not experience any negative issues.

Since the main focus of this study is on examining instructional materials, these materials form the primary data. Other data were used as supplementary information. Accordingly, the camera angles during video recordings were adjusted to focus on the teacher and the board, and the students' faces were not visible in the footage. Additionally, the names of the students were not used in the research report.

3. Results

In line with the purpose of the research, instructional materials used in mathematics classes are presented under the following headings:

3.1 What Are the Materials Used in Mathematics Classes for Students with Hearing Loss?

Mathematics classes for students with hearing loss are divided into two sections: group and individual studies. These

two sections also influence the type, preparation, and usage of materials employed in the classes. The materials used in each section are presented in Table 1.

Table 1. Educational Materials Used in the Mathematics Classes for Students with Hearing Loss during the Research Process

Lesson No/Date	The topic of the lesson	Group materials	Individual materials
1st Lesson: March 27, 2017	Decimal Representation of Fractions	2 Group Tables Titled "Decimal Representations"	Informative Text and Worksheet Titled "Decimal Representations"
2nd Lesson: March 30, 2017	Association of the Division Operation with the Concept of Fractions	2 Group Tables Titled "Fraction and Division"	Informative Text and Worksheet Titled "Fraction and Division"
3rd Lesson: April 3, 2017	Analysis of Decimal Representations	3 Group Tables Titled "Analyzing Decimal Representations Given Numbers"	Informative Text and Worksheet Titled "Analyzing Decimal Representations of Given Numbers"
4th Lesson: April 10, 2017	Rounding Decimal Representations	4 Group Tables Titled "Rounding in Decimal Numbers"	Informative Text and Worksheet Titled "Rounding in Decimal Numbers"
5th Lesson: April 13, 2017	Comparing and Ordering Decimal Representations	2 Group Tables Titled "Comparing Decimal Representations"	Informative Text and Worksheet Titled "Comparing Decimal Representations"
6th Lesson: April 20, 2017	Addition and Subtraction Operations with Decimal Representations	4 Group Tables Titled "Decimal Addition and Subtraction"	Informative Text and Worksheet Titled "Decimal Addition and Subtraction"
7th Lesson: April 24, 2017	Problem Solving Activities with Decimal Representations	4 Group Tables Titled "Let's Solve Problems"	Informative Text and Worksheet Titled "Let's Solve Problems"
8th Lesson: April 27, 2017	Multiplication Operation with Decimal Representations	3 Group Tables Titled "Decimal Multiplication Operation"	Informative Text and Worksheet Titled "Decimal Multiplication Operation"
9th Lesson: May 4, 2017	Division Operation with Decimal Representations	3 Group Tables Titled "Decimal Division"	Informative Text and Worksheet Titled "Decimal Division"
10th Lesson: May 8, 2017	Problem Solving Activities with Decimal Representations	4 Group Tables Titled "Let's Solve Problems"	Informative Text and Worksheet Titled "Let's Solve Problems"

As shown in Table 1, during the research process, a total of 10 sessions of mathematics classes were conducted. In the group mathematics sessions, 31 group tables were utilized, while informative texts and worksheets were used for individual studies.

3.2 What Are the Characteristics of the Materials Used in Mathematics Classes for Students with Hearing Loss?

The materials employed in the mathematics teaching process for students with hearing loss are categorized into two groups: group materials and individual materials. Group materials include group tables, while individual materials consist of informative texts and worksheets.

The general characteristics of group tables are presented in Table 2.

Table 2. The Capitals, Assets, and Revenue in Listed Banks

Quantitative Features of the Group Table	Paper type, pen type, writing style, illustrations pre and post-lesson blanks and their completion
Sections of the Group Table:	
Title	Simple, understandable, explanatory
Introduction	Prior knowledge, use of models
Development	Use of models, establishing a connection between old and new information
Conclusion	Application examples
Language Use	Simple, straightforward language use
Use of Mathematical Language	Writing and reading of symbols, terms, rules
Transfer of Mathematical Knowledge	From model usage to rule
	From simple to complex
	Use of everyday examples
	Representation methods of mathematical knowledge

As shown in Table 2, these characteristics are explained under themes such as quantitative features, sections, language use, use of mathematical language, and transfer of mathematical knowledge.

Figure 1. Before the First Lesson, the Group Tables Used

Quantitative Features of Group Tables: The teacher prepared all group tables using white paper with dimensions of 50 cm by 70 cm. The writings on the group tables are of a size that all students can easily see in the class. Legible and neat handwriting was used. As shown in Table 1, depending on the scope of the topic, 2, 3, or 4 sheets of paper were used for some lessons. The group table was completed in two stages. Before the lesson, the title and main outlines of the topic were written with red and blue blackboard markers. If a model was needed to explain the mathematical concept, the appropriate model was drawn on the group table, or a pre-prepared drawing was used. Some sections of the topic explanation were left blank. During the teaching process, the activities were written in the

blank spaces on the group table using a blackboard marker. Photographs of all the group tables were taken before (Figure 1) and after (Figure 2) the lesson.

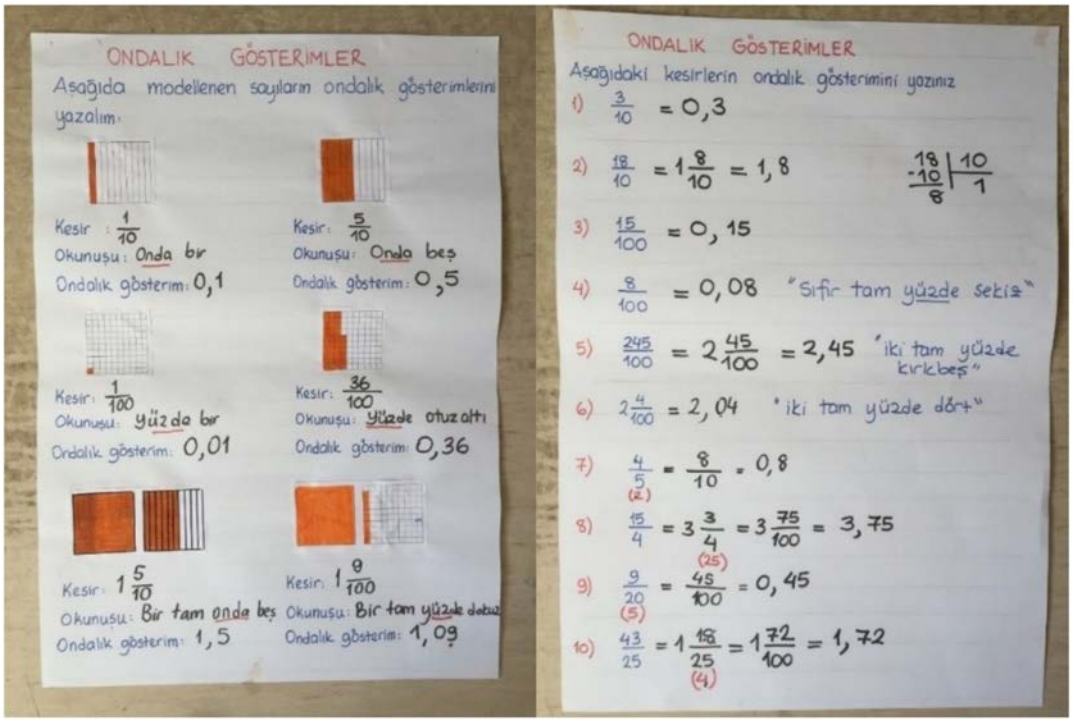

Figure 2. After the First Lesson, the Group Tables Used

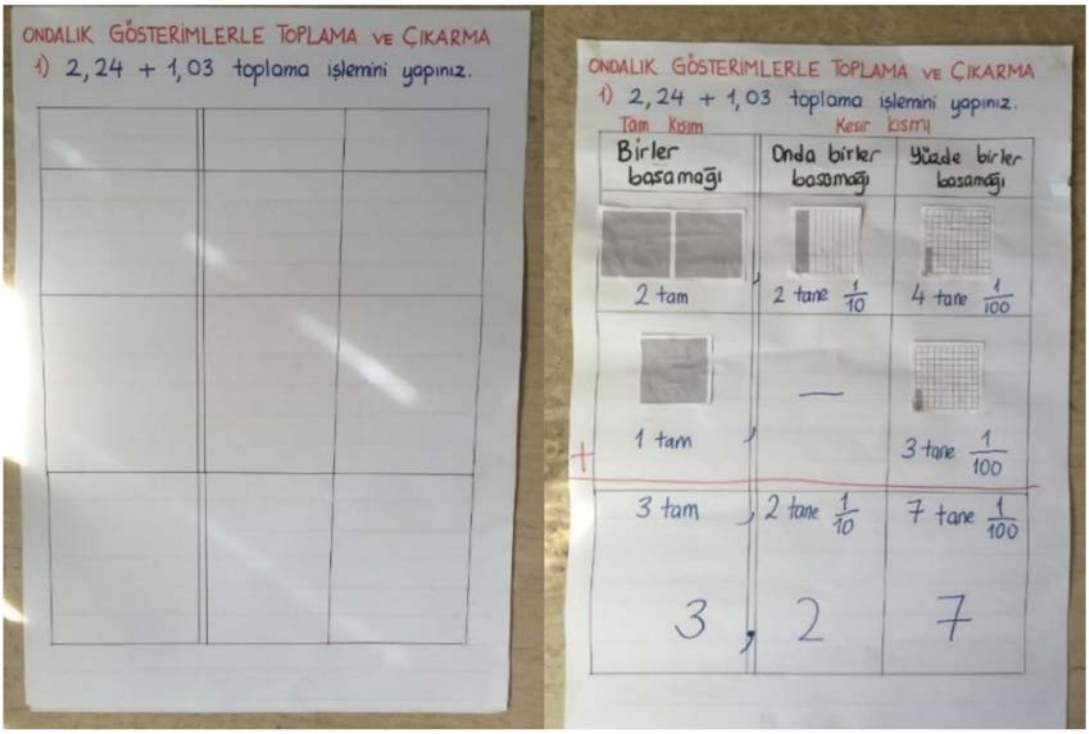

Figure 3. The Introduction Section of the Group Table Used in the Sixth Lesson before and after the Lesson

The sections of the group tables: All group tables have a simple title expressing the topic and include introduction, development, and conclusion sections. In the introduction section, there are reminders of prior knowledge about the topic, activities designed to capture students' attention, and questions intended to illustrate the connections between previously learned material and new concepts. For example, Figure 3 shows the introduction section of the topic "Decimal representation of addition and subtraction operations".

Students already knew how to read, write, represent with fraction models, and solve decimal numbers. They begin the topic with prior knowledge. ... At the same time, it reminds them that in addition, quantities of the same type need to be brought together. ... It also reminds them to write 0 (zero) for parts not given in the place value table. ... In the place value table, they add quantities of the same type one below the other. ... They align the commas in the same line in this writing style (Transcript of Lesson 6 Group Table).

In the development section of the group table, questions and activities are included where the meanings of the planned concepts can be discussed, and definitions and rules can be reached together with the students. Mathematical rules have been structured with the students through these questions and activities. Mathematical rules are not directly given to the students. For example, in Figure 4, the development section of the same topic is shown.

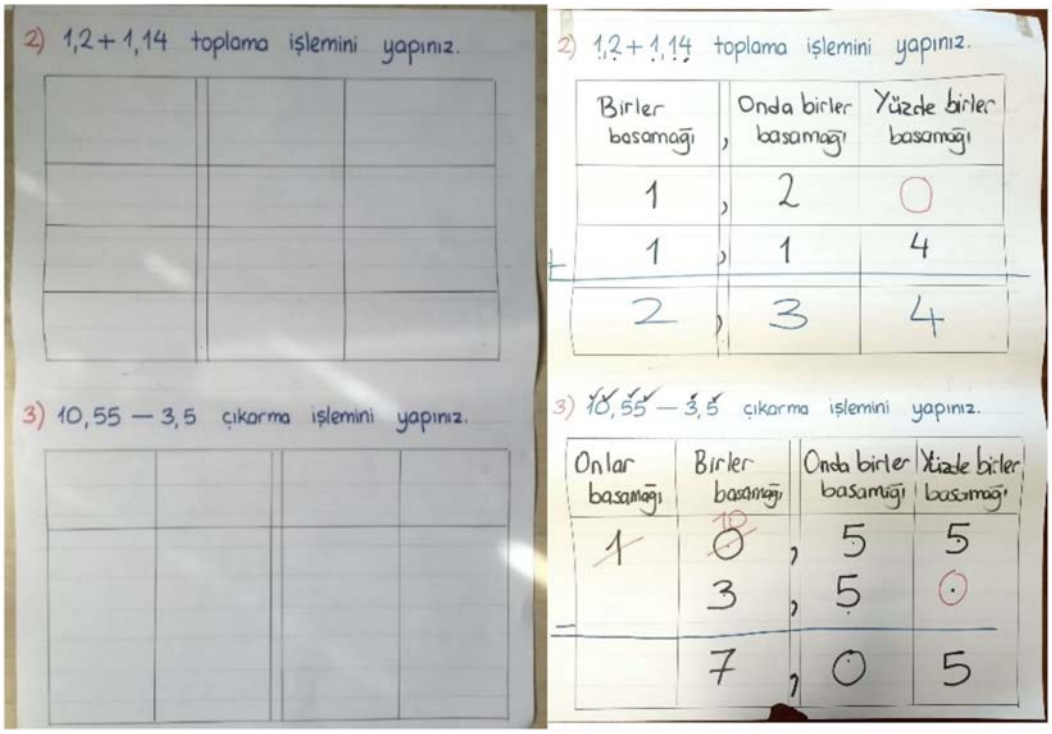

Figure 4. The Development Section of the Group Table Used in the Sixth Lesson before and after the Lesson

This time, students are not using the fraction model but only the place value chart. They are deemphasizing the use of the model. ... Without using the fraction model, they perform subtraction using the place value chart. ... Each time, they write the whole parts and the commas separating the whole parts and the fractional parts in a column, aligning them at the same level. ... In different examples, it is observed in the group table that the rule is to write the commas below each other and complete the empty spaces in the fractional part with 0 (zero), then calculate the sum or remainder (Transcript of 6th Lesson Group Table).

The results section of the group tables provides examples of the application of mathematical rules that were reached collaboratively with the students. For instance, Figure 5 shows the development section of the sixth lesson.

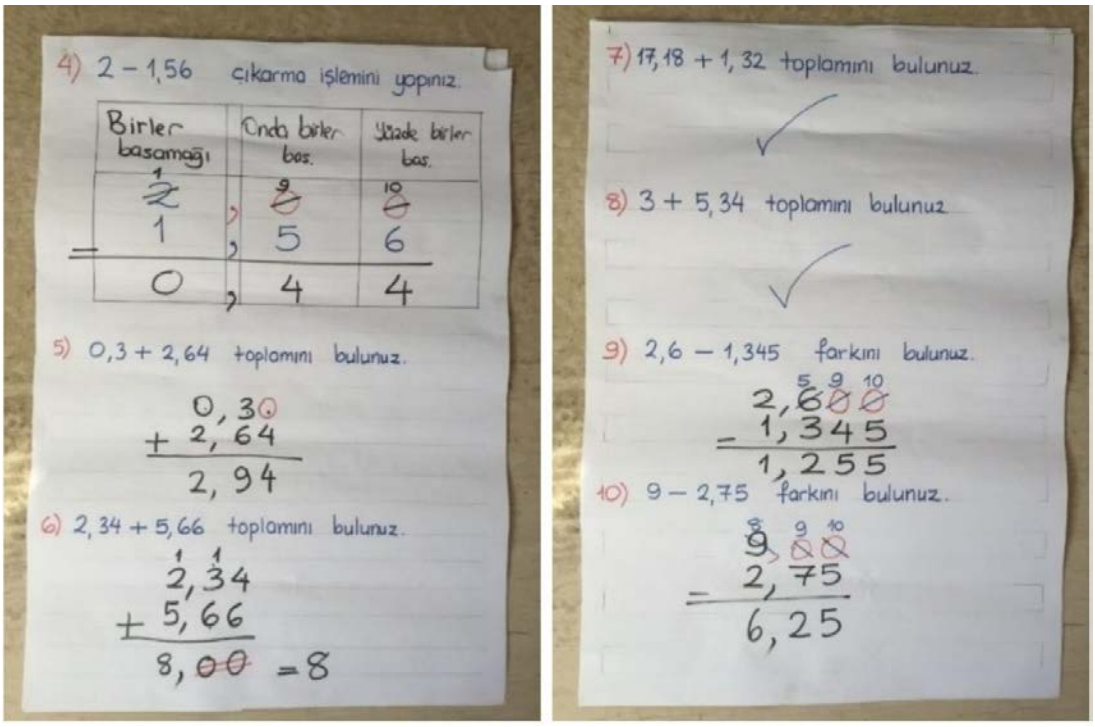

Figure 5. The Conclusion Section of the Group Table Used in the Sixth Lesson after the Lesson

Starting from the fifth question in the table, they do not use the fraction model or the place value chart; instead, they apply the rule directly. They repeat the rule by working on six examples (Transcript of the 6th Lesson Group Table).

Language Usage: Throughout all group tables, a simple and clear language that is understandable by students with hearing loss has been employed. Avoiding lengthy and complex sentence structures and using compound and complex sentences has been prioritized. The written content has been supported with visuals whenever possible. The language used has been confirmed by an expert in the field of hearing loss education to be suitable for the language level of students with hearing loss in the classroom.

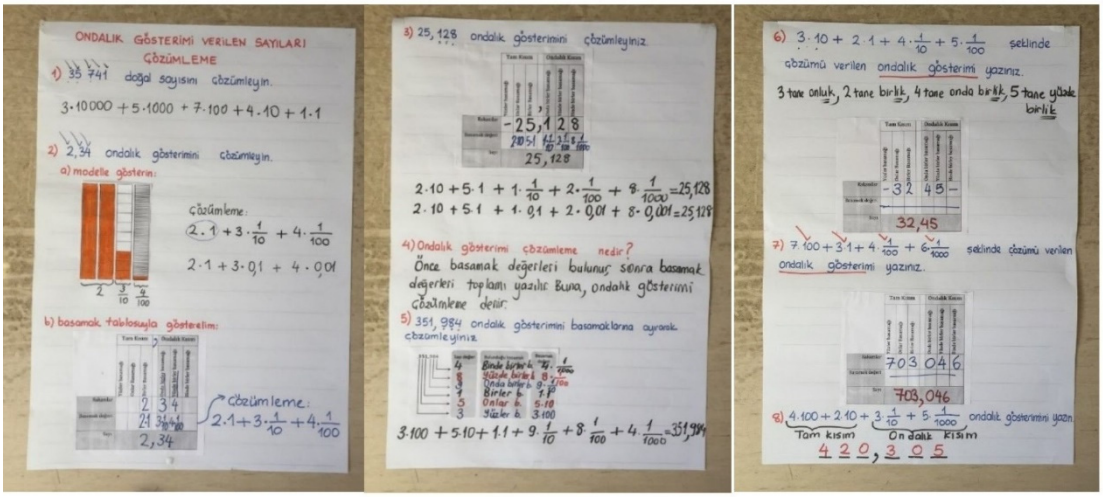

Figure 6. After the Third Lesson, The Group Tables Used

Use of Mathematical Language: All group tables include the writing, definition, representation with symbols if applicable, and pronunciation of all mathematical terminology related to the planned topic of instruction.

In the "Introduction to Decimal Representations" lesson, mathematical concepts related to the topic, such as "decimal representation," "fraction," "whole," "tenth," and "percent," are written in the group table. The same mathematical information, conveying the same meaning, is presented with text, symbols, and visual models. The pronunciation of symbolic representation is written in the fourth, fifth, and sixth questions: "8/100=0.08" is accompanied by the pronunciation "Zero point zero eight." (Transcript of the 1th Lesson Group Table).

In the fourth question, the process of mathematically performing the operations is described as "First, place values are determined, then the sum of place values is written. This is called analyzing the decimal representation." ... In the sixth question, information equivalent in meaning is presented through writing, symbolic representation, and a table (Transcript of the 3rd Lesson Group Table).

Transfer of Mathematical Knowledge: In six of the group tables, the rules of the topic discussed in the lesson were explained by writing them in the table. For example, in Figure 7, in the results section of the group table used in teaching the topic "Multiplication Operation with Decimal Representations," the rule reached in the lesson was written in the table.

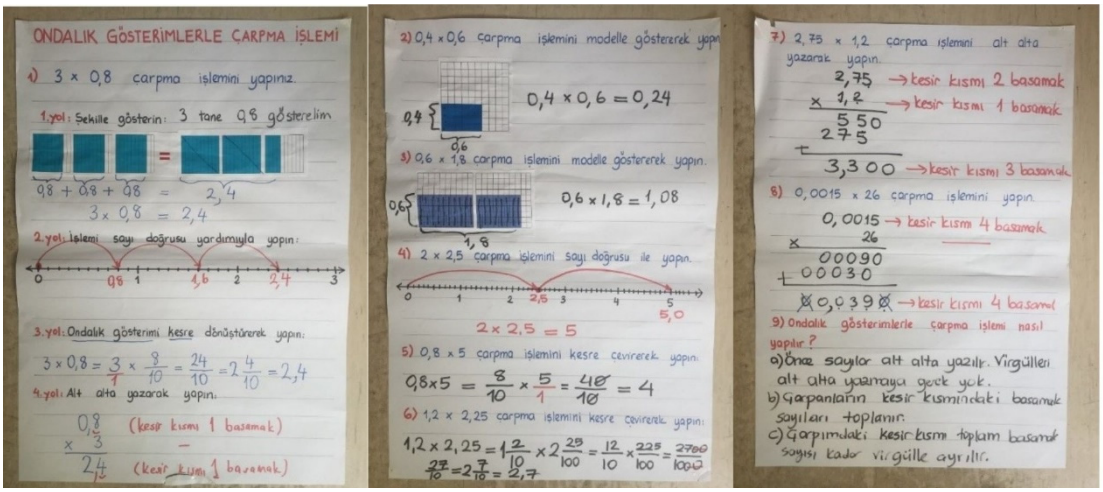

Figure 7. After the Eighth Lesson, the Group Tables Used

In the introduction section of the lesson, students are reminded of their prior knowledge related to the topic. In the first question, they use the fractional model, and the multiplication is calculated through the model. … Then, multiplication is calculated on the number line. … Subsequently, the same process is executed by converting decimal representations to fractions. Finally, the multiplication of numbers is calculated, similar to the multiplication process with natural numbers. … The relationships between the products are noted in red next to the operations. The use of models gradually diminishes. … In the ninth question, the mathematical rule derived during the course of the topic is written (Transcript of the 8th Lesson Group Table).

In the transfer of mathematical knowledge within the group tables, there is a progression from simple to complex. Upon analyzing the questions used in all group tables, a transition is observed from small to large numbers, from fewer to more operations, and from model usage to symbolic representation. Additionally, everyday situations encountered in daily life are utilized as teaching tools in the initial examples (Figure 8).

The instruction begins by introducing situations encountered in daily life, using examples of dividing objects that capture the child's interest. ... The progression of the topic moves from simpler to more complex. First, there is a division with a whole. Then, there is a division with a non-whole part, requiring the use of decimal representation. ... The relationship between fractions and division is presented without a problem scenario in the fourth, fifth, and sixth questions. ... The numbers used become progressively more complex (Transcript of the 2nd Lesson Group Table).

Informative texts and worksheets were used in individual studies in mathematics classes of students with hearing loss.

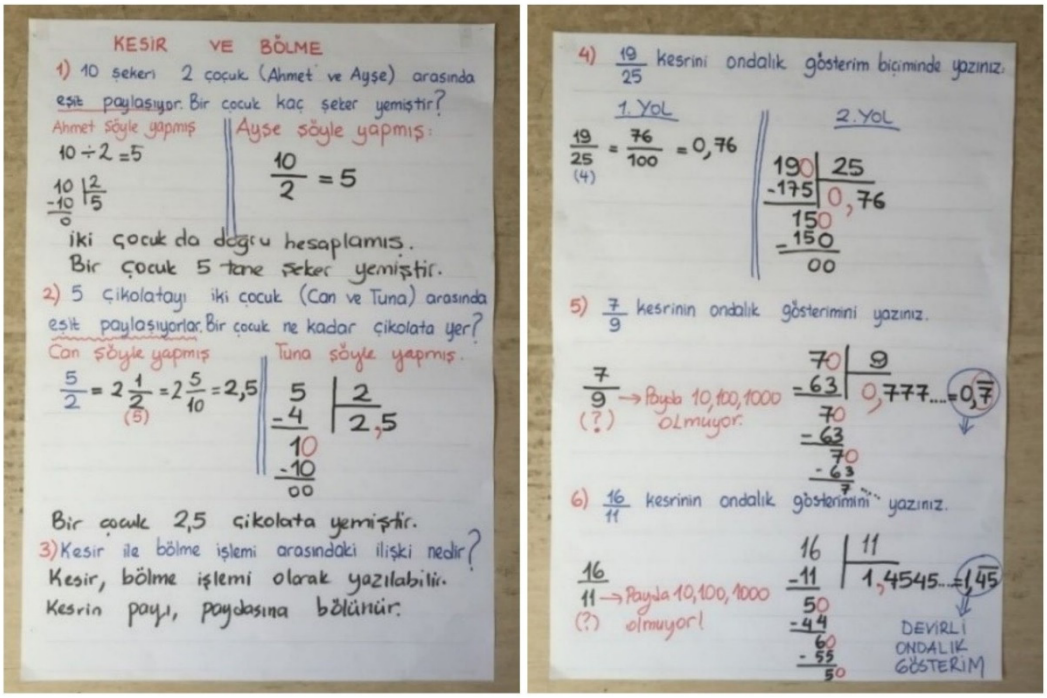

Figure 8. After the Second Lesson, the Group Tables Used

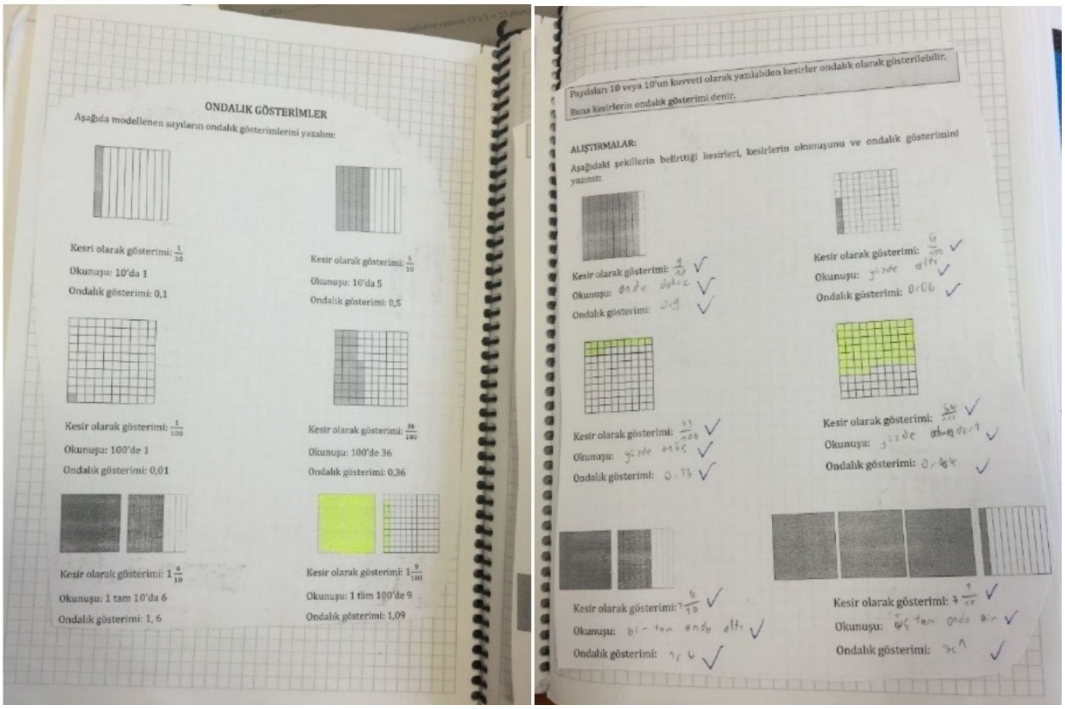

Figure 9. The Informative Text and Worksheet Used in the First Lesson

Informative texts and worksheets: All informative texts and worksheets were prepared in the form of mathematics textbooks using the Word program on a computer. Prints in A4 size were obtained for each student in the class. As seen in Figures 9, 10, and 11, each student pasted the assigned informative texts and worksheets into their math notebooks in the order of subjects. Informative texts contain explanations related to the topic taught in the class, while the worksheets include practical exercises. The informative texts contain the same content as the group tables,

including text, models, visuals, and examples. The difference is in their size and usage. Group tables are large enough for everyone to see, and they are worked on collectively as a group. On the other hand, informative texts are smaller, notebook-sized, provided individually for each student, offering the opportunity for individual work. Additionally, what is written on the group table is completed in two stages. There are guidelines, hints, and examples for exercises and activities on the group table, and the blanks are filled in by working together with the students in the classroom. In contrast, the informative texts provided contain all exercise and activity examples, accompanied by their respective solutions. Additionally, as seen in Figure 9, definitions and rules related to the topic not found on the group table are included in the informative texts.

The six examples used in the first lesson and found in the group table are included in the informative text, along with their solutions. Additionally, the text contains a framed definition that is not present on the group table, stating: "Fractions whose denominators are 10 or powers of 10 can be represented as decimals. This is called a decimal fraction." (Transcript of the 1st Lesson Informative Text).

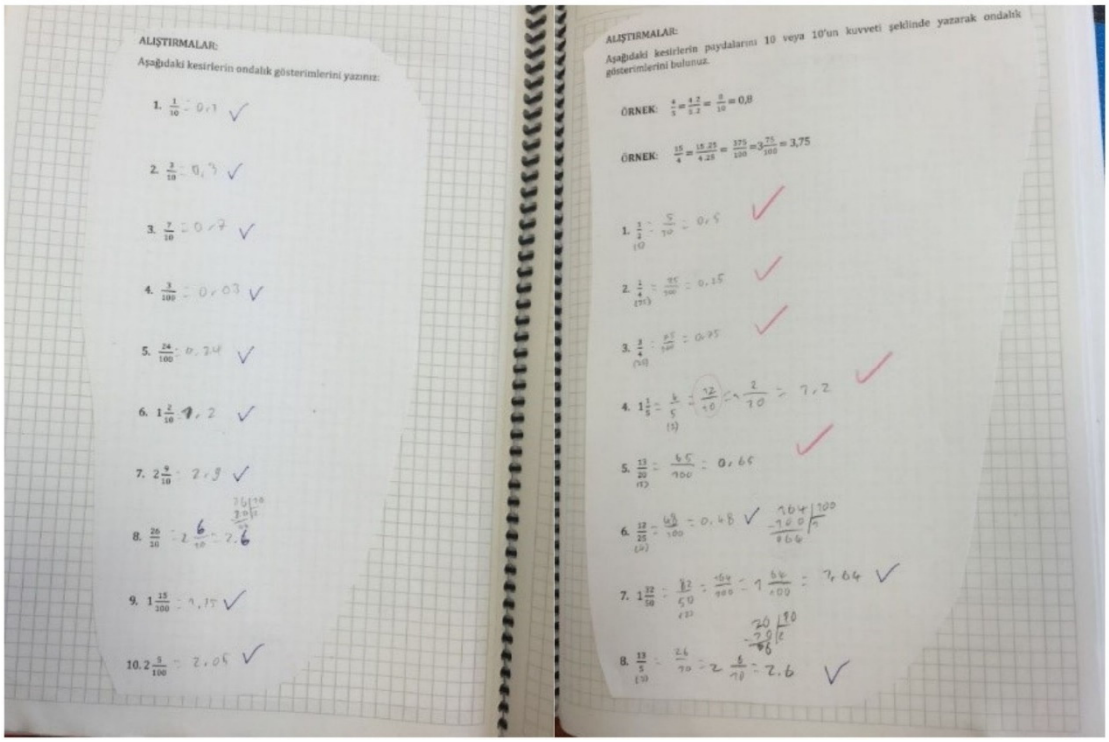

Figure 10. The Worksheet Used in the First Lesson

The distinction between informative texts and pre-made textbooks lies in the fact that informative texts are structured in a language and at a level of information that allows students with hearing loss to read and comprehend them independently. The features found in the group tables are also present in informative texts. Informative texts consist of introduction, development, and conclusion sections. They begin by recalling previous knowledge, explaining the topic with mathematical models and visuals, establishing relationships between existing and new information, providing an adequate number of examples related to the topic, and presenting definitions and rules in writing. Additionally, they include the written forms, pronunciations, and definitions of mathematical terms and symbols. The transfer of mathematical knowledge follows a flow from simple to complex, explaining mathematical rules with models, and presenting equivalent mathematical information through writing, visuals, and symbols.

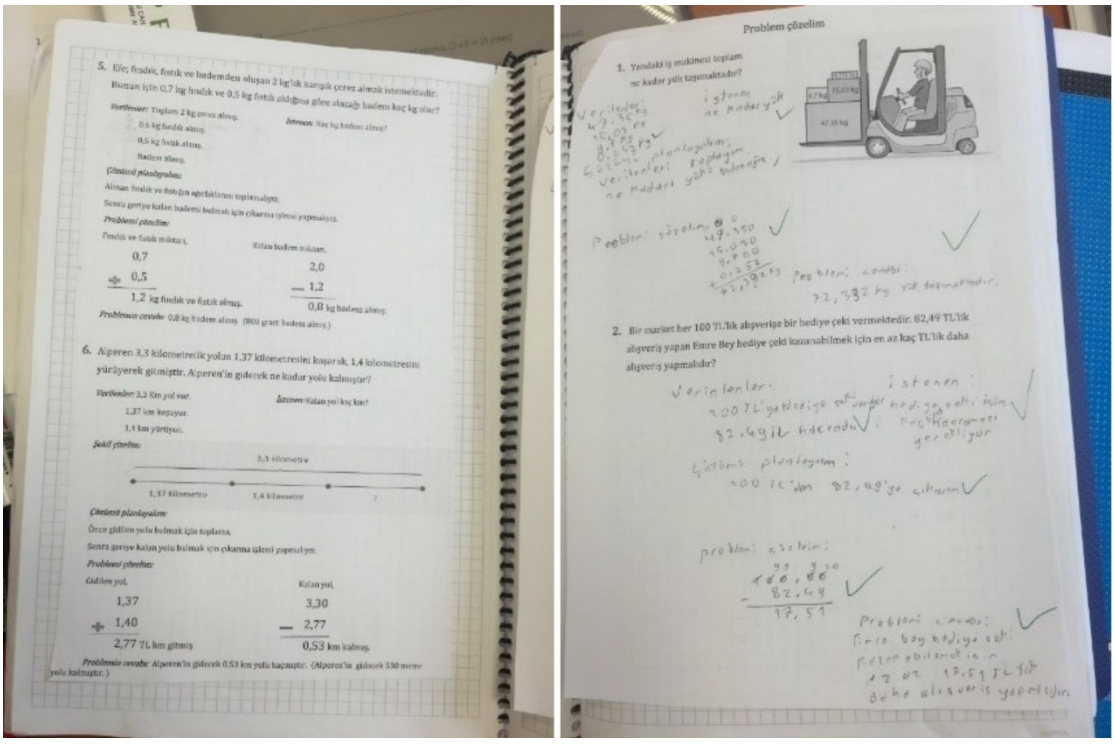

Figure 11. The Informative Text and Worksheet Used in the Sixth Lesson

In the worksheets, questions parallel to the activities in group mathematics studies have been written to allow individual practice for the students. Questions related to the taught topic have been formulated, leaving blanks for the students to write answers. Various question types have been included, such as exercises, problem-solving (Figure 10), making definitions, fill-in-the-blanks, and multiple-choice questions. A sufficient number of questions have been presented to cover the topic comprehensively. Students write the solutions to the questions in the provided blanks.

3.3 How Are the Instructional Materials Prepared for Students with Hearing Loss Used in Mathematics Classes?

Mathematics classes for students with hearing loss are conducted in two parts: group work and individual work.

In group activities, students with hearing loss are seated in a U-shaped formation at an equal distance from the teacher and the writing board. The group table is displayed at the beginning of the lesson on the writing board at a distance visible to all students with hearing loss. The teacher is responsible for writing during group activities. In this section of the lesson, students with hearing loss are not assigned writing tasks. When preparing the group table, the teacher considers the students' prior knowledge and language skills. To facilitate students' participation in planned mathematical activities, encourage them to think about the targeted new topic and establish connections between prior knowledge and new information, the teacher prepares some parts of the material before the lesson. Some sections are left blank to be filled collaboratively by students during in-class interactions. During the lesson, the teacher asks questions related to the activities on the group table. Students listen to each other and the teacher, answer the teacher's questions, and share their thoughts on the questions. The teacher asks students to express their thoughts, discusses similar and different ideas, approves correct answers, asks other students to repeat correct answers, and facilitates oral repetitions. The information written and the models drawn on the group table provide hints for answering the questions. The teacher points out the written hints to draw attention. At the end of the activity, the teacher writes the correct answer on the group table in a way that matches the students' language level and reads the written content aloud to the students. The teacher also writes out the mathematical symbols on the table and provides written pronunciation for mathematical expressions when necessary.

After the group mathematics activity, individual work sessions were conducted. In this section, the teacher distributed informative texts and worksheets to each student. In individual work sessions, students with hearing loss read the worksheet questions and wrote the solutions in the designated spaces. They revisited the informative texts or the group table displayed on the board when needed. The teacher moved around the students, carefully observing

their progress. The teacher also encouraged students to read the questions aloud and explain their problem-solving approaches. Correct solutions were reinforced with positive feedback, while incorrect solutions prompted the teacher to ask clarifying questions. Additionally, the teacher guided students toward the correct answers by encouraging them to revisit examples covered in the group table.

Sequentially, the teacher provided individual feedback to each student, fostering a supportive learning environment. At the end of the mathematics class, the group table was displayed on the classroom wall for all students to see.

3.4 What Contributions Have the Materials Used in Mathematics Classes Made for Students with Hearing Loss?

The group tables have contributed to visualizing and concretizing mathematical concepts for students with hearing loss. Visual mathematical models were employed in the group tables during the research process in 7 out of 10 lessons. Additionally, it was observed that the teacher and students engaged in discussions related to the topic during the instructional process. The teacher wrote the mathematical representations of these discussions on the group tables. This approach allowed students the opportunity to listen to discussions and express their thoughts without being occupied with writing, facilitating more oral repetition. Simultaneously, it enabled students to see the mathematical expressions in written form. This practice supported students in establishing a connection between oral, written, and various model-based representations of mathematical language.

The language used in group tables, completed with the participation of students, was prepared at a level suitable for the students with hearing loss, thereby providing support for the students' reading comprehension. It was observed that group tables were beneficial in facilitating the teacher's shared focus during the lesson, guiding students in the questions asked, and providing hints. Additionally, the same mathematical task was presented in at least two different ways in all lessons. This situation contributed to students' critical thinking. As stated in the teacher's lesson evaluations, tables assisted in effectively utilizing the lesson time. The students' reading and solving of questions in the worksheets helped to apply and reinforce the subject matter by facilitating a review of the language and concepts covered. The variety of question types in the worksheets allowed students to encounter different question formats related to the topic. The way students approached and solved the questions in the worksheets provided the teacher with insights into whether the student understood the topic and identified the strengths and weaknesses of the learner.

Explanatory texts include examples and explanations of activities worked on together during the lessons. Therefore, these texts provide students with hearing loss an accessible resource they can read and understand, enabling them to review and retain the lesson topics later.

In the group mathematics work of students with hearing loss, providing informational texts related to the topic and worksheets for applying what they have learned serves as a means for them to review and recall the subject when needed.

4. Discussion

Studies related to the learning and achievements of students with hearing loss generally indicate that these students tend to lag behind their hearing peers (Gottardis et al., 2011; Traxler, 2000; Van der Straaten et al., 2021). However, the challenges faced by students with hearing loss in learning mathematics are often explained in terms of specific concepts (Nunes & Moreno, 2002; Pagliaro, 2006; Swanwick et al., 2005; Tanrıdiler, 2013). In this context, in teaching mathematics to students with hearing loss, it is essential to focus on methods, techniques, and strategies that are tailored to their individual needs by carefully analyzing the reasons for their difficulties. The effective use of teaching materials in mathematics instruction is considered a crucial tool in this process (Bozkurt & Akalın, 2010; İnan, 2006). However, the current situation where teaching materials for students with hearing loss are limited (Mumba, Kasonde-Ngandu, & Mandyata, 2022; Onojah & Okoro, 2023) and teachers often adhere to standard textbooks makes it challenging for students with hearing loss to receive an education that meets their needs.

At this point, teachers may need to develop their own materials. This study emphasizes the importance and characteristics of materials prepared by teachers for students with hearing loss in mathematics classes. The materials used in the study included group tables for group activities, informative texts, and worksheets for individual work. All materials used aimed to overcome difficulties by considering the features that should be present in high-quality materials (Sarpkaya Aktaş, 2022) and the challenges faced by students with hearing loss in mathematics education.

The fundamental challenges experienced by students with hearing loss in mathematics instruction are typically identified as limited language development due to hearing impairment, as well as difficulties in comprehending spoken content and communication skill deficits caused by this limitation. (Nunes, 2004; Pagliaro, 2006; Swanwick

et al., 2005). In teaching mathematical concepts and their relationships, using language and comprehending what is being conveyed are crucially important for these students. In this context, students with hearing loss often require more visual support (Nunes & Moreno, 2002). In the materials used in this study, clear and straightforward language that students with hearing loss could easily read and understand was preferred. It was written avoiding lengthy and complex sentence structures, the use of compound and complex sentences, and unnecessary details. Written expressions were supported with visuals wherever possible. Additionally, emphasizing the use of mathematical language and the development of communication skills, which are among the goals of mathematics education programs (MEB, 2018), the study's planned mathematical topics were associated with situations that children with hearing loss may encounter in daily life. This allowed mathematical concepts to be used within meaningful contexts. Detailed explanations were provided for representing mathematical concepts through models, their notation, definitions, the symbolic representation of concepts, and the pronunciation of symbols.

In the study, the sections intentionally left blank by the teacher before the lesson in the group tables were collectively discussed with students in the classroom, and they were completed through joint decisions and active student participation. Not requiring written tasks from students during group activities has contributed to more effective listening, oral repetition of spoken content, expression of thoughts and problem-solving approaches, as well as facilitating discussions among students about the subject. This has positively impacted the mathematical language development of students with hearing loss.

Additionally, completing group tables with the participation of students with hearing loss during the instructional process has helped them create texts that they can read and understand independently. Considering that students with hearing loss are weaker than their hearing peers in reading comprehension (Pau, 1995), the informative texts and worksheets used have provided them with a resource they can read and understand independently and revisit whenever they want.

From the teacher's perspective, it has provided the opportunity to ensure student participation and shared interest, increase motivation, explain the subject more efficiently, and effectively utilize time.

The inadequate experiences of students with hearing loss from the preschool years onwards (Kritzer, 2009; Pagliaro & Kritzer, 2013) and their inability to complete the curriculum because of teachers' emphasis on language development in instructional programs (Kelly et al., 2003) result in some deficiencies in these students' prior knowledge in mathematics compared to their peers. In this context, determining the prior knowledge of students with hearing loss is crucial. Mathematical knowledge builds upon prior knowledge, and instructional materials must align with students' prior knowledge. Therefore, if a student lacks sufficient prior knowledge related to the planned subject, reaching the intended instruction level is impossible. In this context, teachers of students with hearing loss are the best equipped to understand these students, knowing the extent of their prior knowledge. Hence, it is essential for teachers of students with hearing loss to prepare instructional materials.

Schema theory, representing a dynamic structure that connects new information in the mind with existing knowledge, is considered an appropriate instructional method for mathematics teaching (Xia, Chen, Zhang, Lou, & Duan, 2022). The materials used in this study were prepared by the teacher, taking into consideration the prior knowledge and schema development of 6th-grade students with hearing loss. In all the materials, there is an introductory section tailored to the students' level, which serves to remind them of the relevant prior knowledge and illustrates the connections between this knowledge and the topic to be taught. Subsequently, the focus is on questions and activities that allow discussion of the meanings of mathematical concepts related to the topic and that enable students to reach new definitions and rules collaboratively. In the transfer of mathematical knowledge, a transition from simpler to more complex mathematical knowledge, from small to larger numbers, from fewer operations to more operations, and from using models to symbolic representation has been made. It is believed that this approach helps students develop their schemas.

Mathematical problem-solving skills are becoming increasingly important in mathematics education and are often used interchangeably with engaging in mathematics. However, research indicates that teachers need to provide students with hearing loss sufficient opportunities for problem-solving in mathematics class; instead, they tend to concentrate on exercises focusing on operations (Kelly et al., 2003; Pagliaro, 1998; Pagliaro & Ansel, 2002). This situation leads to the conclusion that students with hearing loss experience negative effects on their problem-solving skills and, consequently, cognitive development (Güldür, 2005; Pagliaro & Ansel, 2002). Currently, it is known that students with hearing loss have weaker problem-solving skills compared to their hearing peers (Pau, 1995; Traxler, 2000).

However, the group tables used in this study demonstrate the implementation of problem-based instruction for

students with hearing loss. Regarding the topic, problem situations that students might encounter in their experiences were selected, and the problem statements used language structures that students with hearing loss could understand. In this context, the materials used in this study have positively contributed to the problem-solving skills of students with hearing loss.

The compatibility of instructional materials with the mathematical concepts they represent in the mathematics teaching process can only be understood in conjunction with how the teacher uses these materials (Ball, 1992; Stein & Bovalino, 2001). In this context, not only the characteristics of the materials but also their effective use in the teaching process is essential. This study provides detailed explanations of how the materials were used in the teaching process, along with their characteristics. In group activities, mathematical concepts and the relationships between concepts were explained to students, an interaction was facilitated using cues on the materials, students were encouraged to think and express their thoughts, and the results were written on the materials. In individual work, the materials used provided students with hearing loss the opportunity to review, practice, receive feedback, and reinforce the topic and the use of mathematical language.

Students with hearing loss have a greater need than their hearing peers for the concretization and repetition of academic knowledge and terminology in different contexts (Karasu, 2020; Kyle, Campbell, & MacSweeney, 2016). The individual materials used in the study have provided students with hearing loss with the opportunity to review in different settings and at different times, as well as the chance to encounter different types of questions. Additionally, they have enabled teachers to assess how well students understand the subject and their ability to perform operations independently.

Good teaching material should be durable, reusable, and updatable (Bozkurt & Akalın, 2010; Sarpkaya Aktaş, 2022). However, significant differences in the prior knowledge and language levels of students with hearing loss hinder the use of the same material for different times and different students with hearing loss. The existing materials need to be revised and adapted to make them suitable for teaching students with hearing loss, for whom the instruction will be conducted. The materials used in this study were initially prepared for single use. However, the informative texts and worksheets prepared in parallel with the group table were created using computer-based word processing programs. This allowed the same topic to be reorganized and reused for different students with hearing loss at different times. This, in turn, has increased the adaptability of the materials for a broader range of students.

5. Conclusion

In conclusion, the effective use of materials in mathematics classes for students with hearing loss enriches the learning process and provides them with the opportunity to establish a stronger connection with mathematics. Since finding ready-made materials suitable for the current language and knowledge level of students with hearing loss is quite challenging, teachers who know these students best should prepare their own materials for mathematics instruction. Group tables supporting the teaching of mathematical concepts, symbols, and relationships between concepts through activities, worksheets supporting the application and reinforcement of what they have learned, and informative texts allowing them to review and recall what they have learned later can be used as instructional materials in mathematics teaching. When preparing these materials, the current language and knowledge level of students with hearing loss should be taken into account, and simple, understandable language should be used. Mathematical terms and symbols should be written and pronounced and represented with mathematical models, and relationships between mathematical concepts should be clearly expressed. Attention should be paid to providing explanations on the mathematical topic using everyday problem examples, allowing students to think about and discuss the mathematical topic, express their thoughts, and engage in discussions. Teachers should organize the teaching process to ensure students with hearing loss actively participate in mathematical activities, enabling them to read, write, listen, repeat, and discuss different thoughts using mathematical language. At the same time, opportunities should be provided for them to practice independently, write using mathematical language, explain what they have written, receive feedback, and solve mathematical problems. Teachers should prepare instructional materials with these purposes in mind.

The materials described in this study are a good example for professionals working in the field of mathematics education for students with hearing loss. However, more efforts are needed to increase research and support for teachers to develop suitable materials for students with hearing impairments. This study is limited to units, topics, number of participants, and materials used in mathematics classes. Studies examining materials used by different classes, different topics, and materials used by different students with hearing impairments in mathematics classes can be conducted to enhance the contribution of this research.

The current study aims to examine and explain the instructional materials used by teachers in-depth. Within this scope, the case study method, one of the qualitative research methods, was used. However, various research methods can be used to investigate the effects of materials used in mathematics instruction and establish cause-and-effect relationships.

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