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The use of mind maps related to the four operations in primary school fourth-grade students as an evaluation tool

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ABSTRACT

The aim of the study was to determine the concepts that primary school fourth-grade students reveal with their mind maps related to four operations (addition, subtraction, multiplication, division) and to compare the mind map and achievement test scores. In the study, a mixed method was used in which quantitative and qualitative data were collected and presented together. The study was carried out with a total of 14 students. There were eight girls and six boys, who studying in the fourth-grade of a primary school in Menteşe district of Muğla, in the spring semester of the 2019-2020 academic year. In the research, mind maps created for four operations and success test were used as data collection tools. The data collection process was carried out simultaneously. In the analysis of the data, qualitative data were transformed into the quantitative analysis, and quantitative analyzes were made. Concepts in mind maps created for four operations were subjected to qualitative analysis and photos were added as evidence. As a result of the research, it was determined that the majority of the students adopted the concepts of addition, subtraction, multiplication, and division. Besides, it was revealed that there was a high-level positive relationship between the scores of the students obtained from the achievement test and the scores from the mind maps they created. The evaluation made using the mind map for primary school fourth-grade students is more advantageous than the achievement test in terms of determining the conceptual understanding.

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1. INTRODUCTION

Mathematics has become a necessity for the individual to complete his/her development in today's societies [1]. Mathematics can be expressed as a system of structures and relationships created mentally by humans. Mathematics has been defined by Maddox [2] as a discipline that includes a certain way of thinking and can develop concerning more than one field. Based on this, mathematics improves the innate thinking ability of individuals. The development of mathematical thinking is possible with the acquisition of mathematical concepts. Mathematics should be learned by students by understanding, and new knowledge should be created based on experience and knowledge [3]. Conceptual understanding is important in creating this information. Conceptual understanding in mathematics is expressed as the skill of understanding mathematical concepts, discourses, and relationships [4]. Therefore, the ability to understand discourse and relationships in the formation of mathematical conceptual understanding should be developed in the best

way. Conceptual understanding plays an important role in forming the cognitive framework of the students and is necessary for the formation of knowledge [5]. Mathematical knowledge that needs to be formed based on conceptual understanding is a network of relationships that contain interrelated rules, concepts, definitions, and elements. Teaching based on visualization, which is involved in learning by doing and experiencing, has an important place in making mathematics understandable based on the network of conceptual relationships. Tools such as concept maps, mind maps, and flow maps are used in visualizing the knowledge of mathematical concepts [6]. With these visualization tools used, the cognitive structure of the learner becomes visible and provides an advantage in learning the knowledge of mathematical concepts. In the visualization of mathematical concept knowledge, mind maps provide an advantage in the education process since they support the creativity of learners more [7]. Besides, mind maps are one of the tools that make it easy to reveal students' prior knowledge.

Mind mapping was developed as a note-taking technique by Tony Buzan, a mathematician, psychologist, and brain researcher in the 1960s. A mind map is defined as an information diagram presenting correlated ideas organized around a central idea [8]. According to Buzan and Buzan [9], it is a holistic thinking tool containing visuals and graphics suitable for memory, creativity, learning, and all kinds of brain functions. According to Brinkmann [10], mind mapping is defined as a powerful technique that enables the thoughts in the mind to be expressed and reveals the potential of the brain. Kress and Van Leeuwen [11] describe the mind map as a conceptual narrative about classification. Montgomery defined mind maps as regular graphical structures that students can explain, develop and redesign what they think [12]. Tucker, Armstrong, and Massad [13] expressed mind maps as visual tools in which subjects and themes are presented regularly. Using visual elements to integrate, organize and store information, mind maps that affect a lot of senses have a common use area that helps to find great information in a small area [14], [15]. Mind map, note-taking tool, learning tool, teaching tool, thought organizer, information organizer, thought map, graphic organizer, post-reading complementary activity, pre-writing preparation activity, visual learning tool, presentation, business life, revealing prior knowledge It is used in areas such as revealing an individual's thoughts on a subject for evaluation purposes [9], [16]-[18]. The reason the mind mapping technique is so usable and serves many areas is that it enables the connection between the two hemispheres of the brain and the harmonious operation of the two hemispheres of the brain [19]. Mind maps allow students to be more creative, save time, solve problems easily, concentrate on lessons, organize and explain thoughts, achieve higher success from exams, facilitate remembering, work quickly and effectively, make it easier to work and see the subject as a whole [20]. Mind maps have two basic functions that enable children to organize information as well as remember information and can be used to achieve different purposes in many lessons.

The use of mind maps in mathematics lessons was used by Entrekin [21] and stated that it was an effective and enjoyable tool in teaching subjects. Entrekin [21] stated that using mind maps in mathematics lessons enables us to completely review the main ideas, to remember them from pictures, each map makes it easier to remember, and the relationships between concepts and the importance of concepts. Mind mapping improves the ability of individuals to visualize concepts and generate ideas about concepts [22]. In this context, mind maps also enable the information in the mind to be transformed into clear knowledge [23]. With mind maps, it contributes to the awareness of the level of knowledge about the concept, to see the relationships between concepts, to identify and eliminate misconceptions [24]. Using the mind map for this purpose shows a function for evaluation.

When the Primary School Mathematics Curriculum is examined, it is expected that students will learn about four operations when they finish primary school [25]. When children leave primary school, they are expected to grasp the four operations well [26], preventing the occurrence of many problems that students will encounter throughout their lives and affect the success of the student [27]. It is important to determine the conceptual learning of primary school students regarding the addition, subtraction, multiplication, and division, which are expressed as four operations, in determining the status of children to reach their mathematical learning goals in primary school. The conceptual learning of the four operations, which is an indicator of their knowledge, can be revealed by using mind maps, as is the case with achievement tests to reveal the knowledge status of students regarding the four operations. Besides, using mind maps can be used as an evaluation tool that provides an advantage in determining misconceptions according to achievement tests. In this study, it was aimed to determine the concepts that students in the last grade of primary school reveal with the mind maps related to four operations (addition, subtraction, multiplication, division) and to compare the mind map and achievement test scores.

2. METHOD

2.1. Research method

In the research, a mixed method was preferred, in which quantitative and qualitative methods were used together. The studies in which data are collected by using quantitative and qualitative methods simultaneously, the data are analyzed, and the obtained data are presented by integration are mixed-method studies [28]. The quantitative dimension of the study consists of primary school students' achievement tests for four operations and the scoring of mind maps for four operations. It is thought that an in-depth examination of the mind maps of primary school students regarding the four operations will give detailed and in-depth information about the research situation.

2.2. Participants

The participants of the study consist of 14 primary school fourth-grade students studying at a public school in Menteşe district of Muğla province. The reason for choosing the participants from the fourth grade of primary school is that they have sufficient knowledge about the four operations and will complete primary school education. At the beginning of the research process, there were 15 students in the classroom where the application was conducted, and the research process was completed with 14 students since 1 student did not participate in the application. Eight of the fourth-grade primary school students participating in the study were girls and 6 were boys, and the class in which the students were included was determined randomly and voluntarily.

2.3. Data collection tool

The quantitative data used in the study were obtained by scoring the achievement test prepared for four operations and the mind maps they prepared. Qualitative data were obtained by detailed analysis of the concepts obtained while scoring mind maps, and photographs of the created mind maps were included. The achievement test prepared for four operations was prepared by taking expert opinions and consists of 20 questions before the pre-application. Achievement tests for four operations were applied to 132 students, and 5 test items were removed as a result of the analysis. According to preliminary application analyses of the prepared success test, it was found that the average difficulty of the substances was 67%, its distinctiveness was .62, and the kr20 value was .85. According to this result, it was revealed that the successful test has high internal consistency and reliability. The latest version of the achievement test for four operations was determined as 15 items. The mind mapping technique was used to determine primary school fourth-grade students' perceptions of the four operations concepts of addition, subtraction, multiplication, and division. The qualitative data obtained by using the mind map were transformed into a quantitative form with the graded performance evaluation tool scoring system prepared for evaluating the mind maps developed by Evrekli, İnel, and Balım [29]. This developed scoring system was developed by considering the system proposed by Novak and Gowin [30] for scoring concept maps, and the system proposed by D'Antoni, Zipp and Olson [15] for scoring mind maps. In the developed scoring system, inter-rater reliability, single rater reliability values, in-cluster correlation analysis, and variance analysis were used, and the reliability of scoring was revealed [29]. In scoring the mind maps, the criteria in Table 1 is considered, and the lowest score is zero and the highest score varies according to the branches created.

Table 1. Scoring criteria of mind maps

Criteria	Score to be received
First-level valid concept connections	2 points
Second-level valid concept connections	4 points
Third-level valid concept connections	6 points
Fourth-level valid concept connections	8 points
Valid cross links	10 points
Valid examples	1 points
Valid relationships	3 points
Invalid item	0 points

2.4. Data collection process

The data of the study were collected between February 10 and February 17 in the spring semester of the 2019-2020 academic year. Before starting the data collection process, the necessary permissions were obtained from the school, the teacher in the classroom, and the students, and the necessary information about the study was given to the participating students on February 10. The teacher was informed about how the study will be carried out, what its purpose is and how long it will take. As the first step of the research, the achievement tests for four operations, whose validity and reliability were tested with another group, were

applied in one class hour on February 10th. As the second stage, on February 11, primary school students were informed about the mind mapping technique during two lesson hours, examples of mind maps were shown, and activities were carried out to prepare a mind map for various concepts. Then, primary school fourth-grade students who participated in the study were provided with creating mind maps on the concepts of addition, subtraction, multiplication, and division on February 12-13-14-17. For each concept, students were given one lesson every day, during this time, the instructions required in the process of preparing a mind map were applied by the researchers. Research process; The application of the achievement test in one lesson on the first day, the introduction of the mind mapping technique in two lesson hours on the second day, and the preparation of mind maps for the concepts related to four operations in one lesson each day, were carried out by the researchers in a total of six days and seven lesson hours.

2.5. Data analysis

2.5.1. The analysis of quantitative data

The scores obtained from the achievement test and mind maps from the quantitative data obtained were entered into the SPSS program. While analyzing the mind maps made by the students for the concepts of four operations, the codes Ö1, Ö2, Ö3,… were given to the data of each student. The mind maps prepared by the students for the concepts of addition, subtraction, multiplication, and division were scored using the specified score system, and the average of the scores obtained by each student regarding the concepts of addition, subtraction, multiplication, and the division was calculated. The mind map scores of the students for the four operations were determined by taking the average of the scores of the four operations. The average of the scores they get from the mind map is the lowest zero, and the highest average score varies according to the branches created in the mind map. The distribution of the data was examined to determine the relationship between the scores obtained from the achievement test of the students participating in the study and the scores they obtained from creating a mind map, and Pearson Product Moments Correlation analysis was performed because it was normally distributed.

2.5.2. The analysis of qualitative data

While obtaining the qualitative data of the study, the mind maps they created were examined in-depth and the concepts and expressions revealed by each student were analyzed. Scoring was made in line with the concepts introduced by the participating students and qualitative data were converted into quantitative data. Besides, to validate the qualitatively obtained data, concepts and photographs from mind maps created by students are presented in the findings section. Coding qualitative data in scoring concepts in the analysis of qualitative data was done separately by two researchers and reliability was determined as .87 using the encoder reliability formula put forward by Miles and Huberman [31].

3. RESULTS

The scores obtained by primary school fourth-grade students from the mind maps they formed regarding the addition and the findings regarding the concepts created are given in Table 2.

Table 2. Mind maps scores and concepts created by primary school students regarding the addition

Average score ($\bar{x}$)	Associated concepts generated *(f)*	Unrelated concepts generated *(f)*
19.42	Plus sign (7), subtract (5), operation (5), add (5), math (3), overcount (2), addend (2), reproduce (2), multiply (2), step (1), combine (1), raise (1), increase (1), sum (1)	Multiplication (4), division (4), teacher (3), school (3), equals (3), problem (2), education (2), difficulty (2), lesson (1), subtract (1), tree (1), candy apple (1), money (1), knowledge (1), book (1), ruler (1), questions (1), desk (1)

When Table 2 is examined, the average of the scores obtained by primary school fourth-grade students from their mind maps related to the concept of addition ($\bar{X}$=19.42) was determined to be. Primary school fourth-grade students specified the concepts related to the addition, such as a plus sign, add, subtract, addend, overcount, reproduce, and multiply. It is observed that the concepts introduced by the students such as multiplication, division, teacher, and school are not related to the addition. Besides, elementary school fourth-grade students stated once, the concepts of "lesson, subtraction, tree, apple, money, knowledge, book, ruler, questions and desk", which are not related to the addition. The mind maps prepared by the students coded Ö2 and Ö5 regarding the addition by primary school fourth-grade students are displayed in Figure 1.

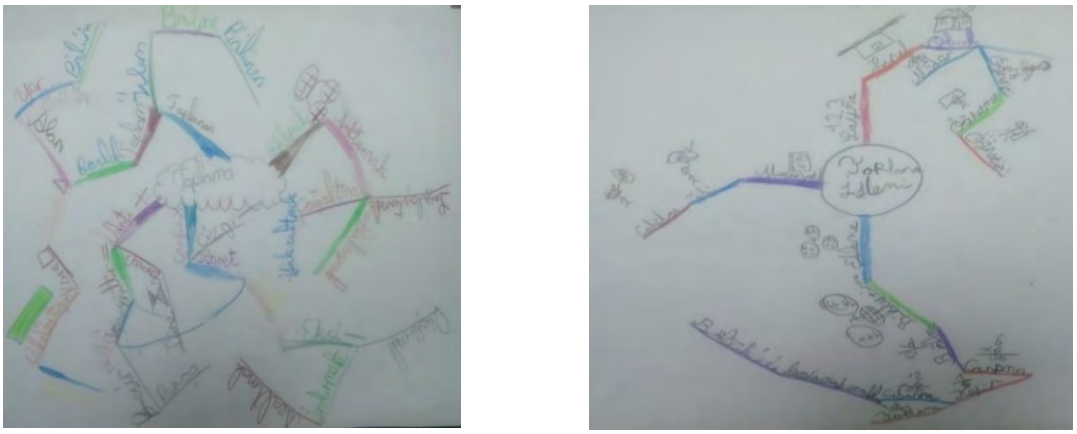

Figure 1. Mind maps of Ö2 and Ö5 students regarding the addition

The scores obtained by primary school fourth-grade students from the mind map they have formed regarding the subtraction and the findings regarding the concepts created are given in Table 3.

Table 3. Mind maps scores and concepts created by primary school students regarding the subtraction

Average score ($\bar{x}$)	Associated concepts generated *(f)*	Unrelated concepts generated *(f)*
19.64	Subtrahend (8), summation (7), operations (6), descending (6), minus (6), residual (6), math (3), spare (2), decrease (2), difference (2), lower (1), subtract (1), abandon (1), give points (1)	Multiplication (5), division (5), school (4), teacher (3), class (2), game (2), lesson (1), zero (1), take (1), result (1), plus (1), multiplier (1), quotient (1), divisor (1), numeral (1), problem (1), education (1), math book (1), smartboard (1)

In Table 3, the average of the scores obtained by primary school fourth-grade students from the mind map created for the concept of subtraction ($\bar{x}$=19.64) appears to be. The students included concepts that explain the conceptual aspects of subtraction, such as subtrahend, descending, minus, spare, decrease, and summation. It has been determined that concepts such as multiplication, division, school, teacher presented by primary school fourth-grade students are not related to subtraction. Concepts of "lesson, zero, take, result, plus, multiplier, quotient, divisor, numeral, problem, education, math book and smartboard" regarding subtraction are concepts that are not related to the subtraction, which are presented once. The mind map prepared by the Ö5 coded student regarding the subtraction by primary school fourth-grade students is shown in Figure 2.

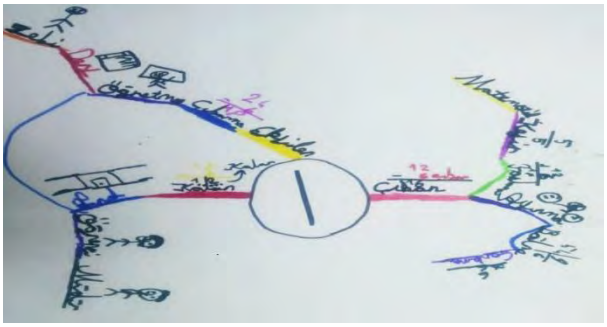

Figure 2. Mind maps related to subtraction of Ö5 student

The scores obtained by primary school fourth grade students from the mind maps they have formed regarding the multiplication and the findings related to the concepts created are given in Table 4.

Table 4. The scores and concepts of the mind maps created by primary school students regarding the multiplication

Average score ($\overline{x}$)	Associated concepts generated *(f)*	Unrelated concepts generated *(f)*
16.07	Division (7), math (6), multiplier (5), summation (5), operations (3), multiplication (3), cross (3), plus (2), series counting (1), fold (1), reproduce (1)	Subtraction (5), school (3), teacher (3), lesson (2), student (2), mind (2), hard (2), notebook (2), book (2), education (2), number (1), numeral (1), problem (1), class (1), minus (1), quotient (1), homework (1), worry (1), uneasiness (1), need (1), table (1), book (1), pencil (1)

In Table 4, the average of the scores obtained by primary school fourth-grade students from the mind map created for the concept of multiplication ($\overline{x} = 19.64$) appears to be. The students included concepts related to multiplication, such as division, math, multiplier, multiplication, and summation, that reveal the conceptual aspects of the multiplication operation. It was determined that concepts such as subtraction, school, teacher, lesson revealed by primary school fourth-grade students are not related to multiplication. The concepts of "number, numeral, problem, class, minus, quotient, homework, worry, uneasiness, need, table, book and pencil" related to the multiplication are concepts that are not related to the multiplication operation, which are presented once. Figure 3 shows the mind map prepared by the student coded S6 about multiplication by primary school fourth-grade students.

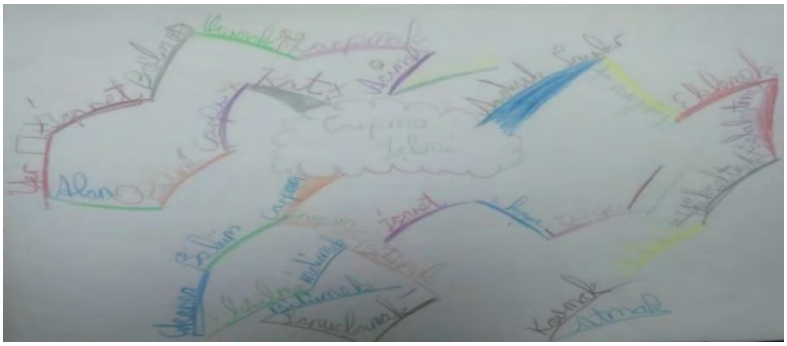

Figure 3. Ö6 student's mind maps related to multiplication

The scores obtained by primary school fourth-grade students from the mind maps they formed regarding the division and the findings regarding the concepts created are given in Table 5.

Table 5. Mind maps scores and concepts created by primary school students regarding the division

Average score ($\overline{x}$)	Associated concepts generated *(f)*	Unrelated concepts generated *(f)*
16.50	Residual (7), quotient (6), dividend (5), subtraction (5), multiplication (4), math (3), apportionment (3), operations (3), divisor (2), spare (2), fragmentation (2), subtrahend (2), go to pieces (1), split it evenly (1), subtraction (1), nondividing (1)	Summation (3), school (2), teacher (2), knife (2), watermelon (2), lesson (1), half (1), asked (1), fraction (1), hard (1), problem (1), cutting (1), plate (1), person (1), cake (1), pencil (1)

When Table 5 is examined, it is seen that the average of the scores obtained by primary school fourth-grade students from their mind maps regarding the concept of division ($\bar{x}$= 16.50) was determined to be. Primary school fourth-grade students included concepts related to the division, such as remainder, division, division, subtraction, equal sharing, multiplication, etc. indicating the conceptual aspect of division. It is seen that concepts such as addition, school, teacher put forward by the students are not related to the division. Besides, elementary school fourth-grade students stated once, not related to the division, the concepts of "remaining incomplete, desired, fraction, difficult, problem, cutting, plate, person, cake and pencil". The mind maps prepared by the students coded Ö5 and Ö6 regarding the division by primary school fourth-grade students are given in Figure 4.

Figure 4. Mind maps related to the division for Ö5 and Ö6 coded students

The findings obtained as a result of the Pearson Product Moment Correlation analysis, which was conducted to determine the relationship between the scores of primary school fourth-grade students in achievement tests for four operations and the scores obtained from the mind maps created for four operations are shown in Table 6.

Table 6. Pearson product moment correlation analysis results performed to determine the relationship between the achievement test of primary school fourth-grade students and the mind map scores for four operations

	Mind map of the four operations
Four operations success tests	.57*

p<.05

In Table 6, as a result of the correlation analysis conducted to determine whether there is a relationship between the four operations achievement test scores and the mind map scores of primary school fourth-grade students, it was determined that there was a high level of positive correlation between the four operations achievement scores and the mind map scores of the four operations ($r = .57$; $p < .01$). In line with this finding, it is seen that when the mind map scores increase, the achievement test scores will also increase. It has been determined that students with high success analyze the concepts related to four operations better.

4. DISCUSSION

When the mind maps created by primary school fourth-grade students for the concept of addition were examined, they stated the concepts of the plus sign, operation, add, overcount, reproduce, multiply, combine, raise and increase related to the concept. The concepts stated regarding the addition show that the conceptual structure of the addition has been formed in children. The fact that children present concepts such as subtraction, multiplication, division, teacher as well as these concepts related to the addition can be expressed as concepts that do not take part in the formation of the conceptual perception of the addition. It can be said that the conceptual understanding of subtraction has developed since the students participating in the study stated the concepts related to subtraction such as subtrahend, operation, descending, residual, spare, decrease, and difference. The students introduced concepts such as summation, multiplication, division, school, and teacher, which do not contribute to the development of the conceptual understanding of subtraction. In this context, the development of these concepts negatively affects the formation of a conceptual understanding of addition and subtraction in children. Since there is a relationship between the development of the conceptual understanding and the development of computational skills of children in primary school [32]-[34], children may make operational mistakes. Besides, not gaining a conceptual understanding of addition and subtraction will lead to an inability to comprehend the relationships between problem situations and to provide learning without interpretation [35], [36]. Considered in this context, in the primary school education process, children are required to make addition and subtraction meaningfully, to acquire and apply conceptual knowledge to understand and solve problems.

Using the mind map of the students in the fourth grade of primary school, they created related concepts such as a multiplier, summation, operation, multiplication, cross, fold and plus. The expression of these concepts by the students shows that conceptual learning about multiplication has taken place. The realization of a learning-based on conceptual learning will prevent the teaching of multiplication based on memorization and will enable the operations to be interpreted in line with the basic concepts [37]. Besides, the concepts related to the concept of multiplication such as division, subtraction, school, teacher and lesson that are not related to the concept of multiplication were introduced by the students. It is seen that the concepts related to multiplication are difficult to learn by students [38], [39]. The reason why it is difficult to teach the concepts of multiplication by students is that the teacher performs the teaching process based on memorization [40]. As a result, primary school students cannot have conceptual knowledge in learning more by rote than meaningful learning about multiplication. The fact that students do not have conceptual learning in multiplication makes it difficult to understand and solve problems involving multiplication. Using the mind map, the students formed concepts related to the division such as residual, quotient, dividend, subtraction, apportionment, spare, and fragmentation. These concepts created by students are important in providing conceptual learning and establishing relationships regarding the division. Students have a lot of difficulty and problems with the concepts of division [41]. Primary school fourth-grade students in the study stated some concepts that are not related to the concept of division, such as addition, school, teacher, knife, and watermelon. It can be said that these concepts are not concepts that will enable students to relate to the division, and based on these concepts, errors may occur in the development of conceptual learning and there will be rote learning.

It was found that the relationship between the average of the scores obtained by primary school fourth-grade students in the achievement tests related to the four operations and the average of the scores they obtained from the mind maps they formed was found to be positive and at a high level. This finding is an expected result, and it is seen that the use of mind maps provides more advantages in developing the conceptual understanding in the evaluation of students and revealing the conceptual mistakes they make. Haiyue and Khoon Yoong [42] evaluated students' connections to the concept of "triangle" by using a concept map. At the end of this research, it was concluded that students made effective connections. Besides, Davies [43] thinks that pictures and structured diagrams are more understandable than words and a clearer way to show understanding of complex issues. Considering these studies, it can be thought that the use of teachers' mind maps and various mapping methods, and flow diagrams in evaluating the teaching process in primary school will provide an effective and efficient evaluation process. Mind maps, concept maps, flow charts, and various mapping methods provide teachers with a versatile evaluation opportunity in the performance evaluation of students [6], [44]. Mapping and diagramming tools show detailed information and errors on the concepts. In line with these results, it can be said that primary school students need to carry out studies to provide conceptual learning about four operations and that teachers should use mind maps to determine conceptual learning in the evaluation process.

5. CONCLUSION

When the mind maps created by primary school fourth-grade students for the concept of addition were examined, they stated the concepts of the plus sign, operation, add, overcount, reproduce, multiply, combine, raise and increase related to the concept. The students introduced concepts such as summation, multiplication, division, school, and teacher, which do not contribute to the development of the conceptual understanding of subtraction. Using the mind map of the students in the fourth grade of primary school, they created related concepts such as a multiplier, summation, operation, multiplication, cross, fold and plus. It was found that the relationship between the average of the scores obtained by primary school fourth-grade students in the achievement tests related to the four operations and the average of the scores they obtained from the mind maps they formed was found to be positive and at a high level.

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