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Examination of pre-service teachers' perceptions of the concept of fraction using the word association test

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Abstract

In this study, it is aimed to examine the perceptions of the mathematics teacher candidates regarding the concept of fraction. 32 teacher candidates participated in the research carried out in the screening model. The word association test was used as a data collection tool and the obtained data were analyzed by content analysis method. According to the results of the analysis, it is seen that the perceptions of teacher candidates regarding the concept of fraction are mostly concentrated in the themes of meanings of fractions, operations in fractions, and representation of fractions. In addition, the themes of numbers, notation, and other mathematical topics in which it is used are other themes that emerged. It was seen that the teacher candidates expressed the quotient meaning at most, they did not mention the percent meaning. It was seen that they mostly expressed the addition operation in fractions and the type of compound fraction. As a result, it is seen that pre-service teachers' perceptions about the concept of fraction are limited. Pre-service teachers can be given a more comprehensive and relational education on the concept of fraction.

Keywords: Fractions, Meanings of fractions, Pre-service teacher, Representation of fractions, Word association test.

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Ethical: This study followed all ethical practices during writing.

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Contribution of this paper to the literature
Unlike other studies, teacher candidates studying at a small university participated in this study and the word association test was used. According to the findings, it is thought that this study will contribute to the education of teacher candidates.

1. Introduction

Mathematics is divided into five basic subject areas: numbers and operations, algebra, geometry, measurement and data analysis, and probability (National Council of Teachers of Mathematics (NCTM), 2000). The subject of fractions is one of the abstract concepts that students in the sub-learning field of numbers encounter constantly throughout their education life (Özdemir & Özçakır, 2019). Although it is a concept that is frequently used in daily life (quarter, whole, half, etc.), it is a subject where students have learning difficulties (Alkhateeb, 2019; Bentley & Bossé, 2018; Biber, Abdulkadir, & Aktaş, 2013; Charalambous & Pitta-Pantazi, 2007; Doğan & Yeniterzi, 2011; Küçük & Demir, 2009).

1.1. Literature Review

According to the studies carried out in the field of mathematics education, learning fractions is seen as difficult for all students due to their multi-faceted structure (Namkung & Fuchs, 2019; Namkung, Fuchs, & Koziol, 2018; National Center for Education Statistics, 2017; Torbeyns, Schneider, Xin, & Siegler, 2015). According to Olkun and Uçar (2007) fractions are heavier and more complex than most of the mathematics subjects in primary school. Because students perceive fractions as numbers and have difficulty in associating them with the numbers they have learned before. Olkun and Uçar (2007) stated that fractions differ from counting numbers in two ways. The first of these is that while we can represent the surrounding entities with a natural number, we need 2 natural numbers to represent fractions by quotient and measuring. The second is "How many?" in questions whose answers are natural numbers. While asking the question "How much?" is to ask the question. The fact that the rules that are valid in natural numbers are not always valid in fractions causes this subject to be difficult for students to understand.

Another reason is the different meanings fractions have (Division, processor, ratio, part-whole and measurement), and it is important for students to gain experience with these different meanings in order to fully understand fractions (Van de Walle, Karp, & Bay-Williams, 2012; Van de Walle, Lovin, Karp, & Williams, 2013). In addition, there are three different fraction models, namely area model, cluster model and number line model within the scope of part-whole meaning in fractions (Marmur, Yan, & Zazkis, 2020). In the area model, the determined part of a given whole is in question. For example, it is a model of scanning half of a triangle divided into two equal parts. In the cluster model, an amount of object is determined as a whole and the desired part is expressed as a fraction. In the number line model, the number line model is divided into the determined length units and the specified part expresses a fraction (Kamacı, 2021; Marmur et al., 2020). In addition to these difficulties, fractions are closely related to concepts such as rational numbers, decimal notation, ratio, operations and algebra (Kieren, 1988; Saxe, Gearhart, & Nasir, 2001). Kerslake (1995) stated that being successful in fractions is a criterion for success in mathematics and this situation causes students to be anxious about fractions, because fractions are related to many subject areas.

However, it is one of the concepts that teachers and pre-service teachers have difficulties in teaching (An, Kulm, & Wu, 2004; Izsák, 2008). Stoddart, Connell, Stofflett, and Peck (1993) in his study with pre-service teachers, determined that pre-service teachers had a good procedural accuracy rate (37-98%) on fractions, while they could only achieve an accuracy rate of 5-10% in a conceptual sense. In another study, Faulkenberry (2003) determined that pre-service mathematics teachers' procedural knowledge about rational numbers is high, conceptual knowledge is medium, and pedagogical content knowledge is low. In the study of Dede and Argün (2004) it was determined that the participants were not even aware that there was a relationship between the concept of fractions and the concept of rational numbers. As a matter of fact, the existing mental schemas of the pre-service teachers, who are on the way to becoming a teacher, about the concept of fraction, which has an important place in numbers and operations, and difficulties in learning and teaching, are important.

In this study, it was aimed to determine the perceptions of the third grade students studying in the primary school mathematics teaching department about the concept of fractions by using the word association test.

2. Methods

In the research within the scope of the screening model, the Word Association Test (WAT) was preferred as the measurement tool. The Word Association Test is widely used in studies to investigate cognitive structure (Timur & Taşar, 2011). In such studies, the answers to the key concepts are used to define the concepts in the cognitive structure of the participants, to determine the relationships between the concepts and to reveal the thoughts about the concepts (Doğan, Yücel, & Güngör, 2018). Word Association Test has been widely used in the fields of educational sciences recently (Akyurt, 2019; Balbag, 2018; Bostan & Çelik, 2021; Kaya, Aladağ, & Akkuş, 2021).

There are two types of assessment in the word association test. In the first type of assessment, points are awarded according to the correct answers of the student. Second assessment; It is aimed to create a frequency table regarding the number of repetitions of the words associated with the given concept and to see the cognitive structure and conceptual relationships of the test group according to the frequency table (Tokcan & Yiter, 2017). The second evaluation method was used in this study.

2.1. Research Sample

In this study, easy sampling method, which is one of the non-random sampling methods, was used in order to collect data faster, less costly and easier (Çeliköz & Erişen, 2017; Gülertekin, Genç, & Gümüş, 2016). In this context, 32 pre-service mathematics teachers studying at a university in Anatolia participated in the research.

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2.2. Research Instrument and Procedures

The word association test (WAT) was used in data collection. Before the word association test was applied, the participants were informed about the test. During the application of the word association test, the participants were asked to form groups of 2, and then they were asked to write down the words that came to mind about the concept of "Fraction" for about 15 minutes.

2.3. Validity and Reliability

In order to ensure validity in this study, data analysis was expressed in detail and the words stated by the participants were used as data sources. In the Findings section, detailed information about these findings is presented together with the evidence. As a matter of fact, it is an important criterion to present and explain the data obtained from the research in detail in order to ensure the validity of the research in qualitative research (Yıldırım & Şimşek, 2016).

In order to determine the reliability process of the research, the opinions of 2 experts were taken and then the consensus coefficient between the experts was calculated. In this direction, Miles and Huberman (1994) formula Reliability = Consensus / (Agreement + Disagreement) X 100 was used for reliability. İt was found to be 94%.

2.4. Data Analysis and Process

The words expressed by the pre-service teachers were coded by researcher and next the opinions of 2 experts were taken. Content analysis method was used to analyze the obtained data. Content analysis method is the organization and interpretation of the obtained data under certain concepts and themes (Yıldırım & Simşek, 2011). With the content analysis, it was ensured that the words expressed by the students in the WAT about the concept of fraction were collected in themes and presented in a more meaningful and understandable way. In the analysis phase, first of all, the words expressed by the students were examined one by one and coded taking into account the mathematical concepts, and frequency Tables were created. Then, themes were created by combining similar codes and frequency values of the themes were calculated. Then, the analyzes obtained were examined by two mathematics educators and expert opinion was taken.

2.5. The Role of the Researcher

Before the test was administered, a brief information about the word association test and how to fill it was given by the researcher to the participants. There was no intervention by the researcher during the application. After the application, the application papers were collected.

2.6. Ethical Information

Pre-service teachers were given detailed information about the analyze to be made before the study and the outputs of the results, and signed informed consent forms were obtained from them.

3. Results

In this study, WAT was used to see the perceptions and conceptual relationships of prospective teachers about the concept of "fraction". The word cloud composed of the most frequently repeated words related to the concept of "fraction" is in Figure 1.

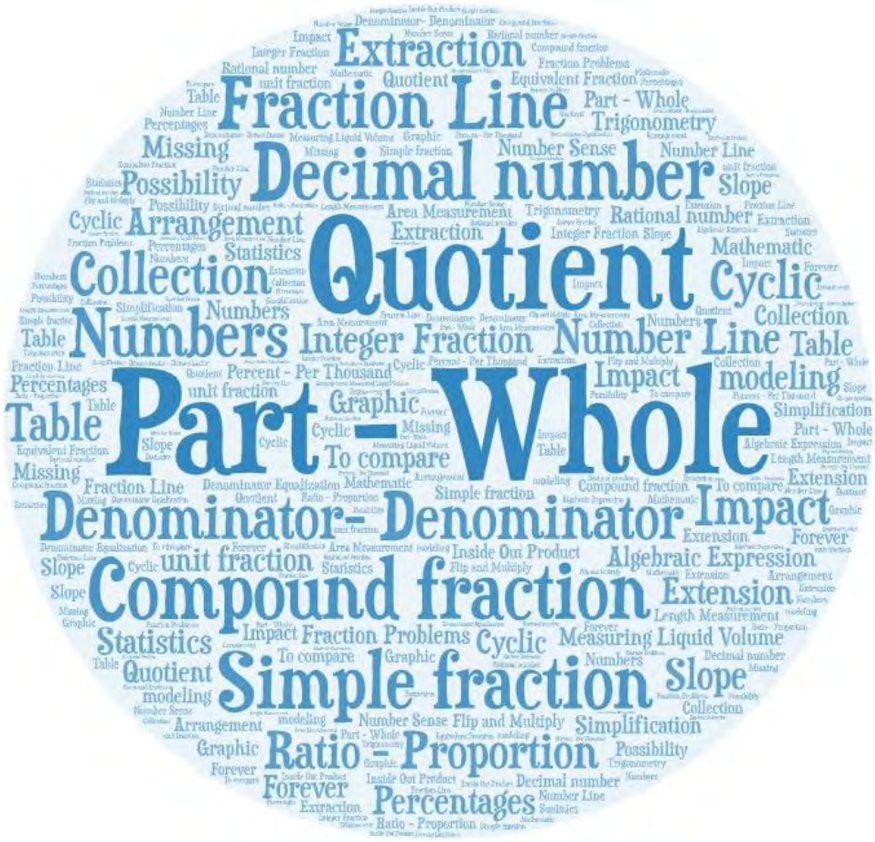

Figure 1. The most frequently repeated words related to the concept of fraction.

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According to the data obtained, the most frequently repeated words among teacher candidates' answers to the concept of "fraction" are quotient (f=16), numerator-denominator (f=13), compound fraction (f=11), quarter (f=10), half (f=10), decimal (f=10), simple fraction (f=10), ratio-proportion (f=9), part-whole (f=9), fraction line (f=9), percentages (f=9), whole (f=8), number line (f=7), numbers (f=7), addition (f=7), subtraction (f=7), ordering (f=7), exact was determined as a numbered fraction (f=7).

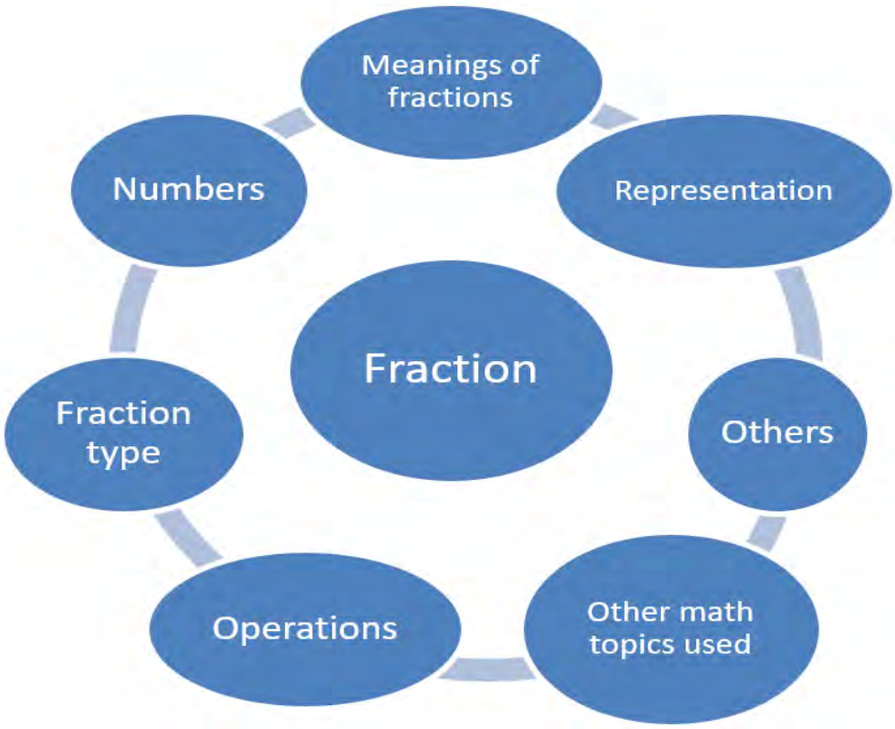

Figure 2. Themes determined according to the concepts obtained from the word association test.

As seen in Figure 2, according to the answers obtained, 6 themes were determined from the words specified for the concept of "fraction": Meanings of Fractions, Numbers, Fraction Types, Operations, Other Mathematics Subjects Used and Notation. In addition, the other theme was created for the concepts that do not fall into these themes. The words that emerged as a result of the word association test WAT, the themes that these words included and their frequencies are given in Table 1.

Table 1. Words, themes and frequencies resulting from the word association test.

Main theme	Main theme frequency (f)	Main theme percent (%)	Concept	Frequency (f)	Percent (%)
Meanings of fractions	72	29.26	Quarter (Part-whole meaning)	10	4.06
			half (Part-whole meaning)	10	4.06
			full (Part-whole meaning)	8	3.25
			Missing	1	0.40
			Proportion	9	3.65
			Part whole	9	3.65
			Volumetric analysis	6	2.43
			Length measurement	1	0.40
			Measuring area	2	0.80
			Quotient	16	6.50
Impression	57	15.04	Fraction line	9	3.65
			Numerator-denominator	13	5.28
			Modelling	3	1.21
			Number line	7	2.84
			Fraction problems (Verbal notation)	5	2.03
Numbers	26	10.56	Numbers	7	2.84
			Decimal number	10	4.06
			Natural number	2	0.80
			Cyclic	2	0.80
			Rational number	4	1.62
			Number sense	1	0.40
Transactions	49	19.91	Impact	5	2.03
			Divide	5	2.03
			Collection	7	2.84
			Extraction	7	2.84
			Flip it over	1	0.40
			Denominator equalization	3	1.21
			They exclude	1	0.40
			0/Number=0	1	0.40
			Sort (Big, Small, Even)	7	2.84
			Extension	5	2.03
			Simplification	5	2.03

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Main theme	Main theme frequency (f)	Main theme percent (%)	Concept	Frequency (f)	Percent (%)
			To compare	2	0.80
Fraction type	55	14.22	Unit fraction	5	2.03
			Compound fraction	11	4.47
			Integer fraction	7	2.84
			Simple fraction	10	4.06
			Equivalent fraction	2	0.80
Other math topics used	26	10.16	Possibility	3	1.21
			Statistics	2	0.80
			Graphic	1	0.40
			Percentages	9	3.65
			Chart	1	0.40
			Slope	1	0.40
			Trigonometry	2	0.80
			Algebraic expression	6	2.43
Other	2	0.81	Maths	1	0.40
			Forever	1	0.40
Total	246	100	28 Part-whole meaning 1 Missing 9 Proportion 9 Part whole 6 Volumetric analysis 1 Length measurement 2 Measuring area 16 Quotient 9 Fraction line 13 Numerator-denominator 3 Modelling 7 Number line 5 Fraction Problems (Verbal notation) 7 Numbers 10 Decimal number 2 Natural number 2 Cyclic 4 Rational number 1 Number sense 5 Impact 5 Divide 7 Collection 7 Extraction 1 Flip it over 3 Denominator equalization 1 They exclude 1 0/Number=0 7 Sort (Big, Small, Even) 5 Extension 5 Simplification 2 To compare 5 Unit fraction 11 Compound fraction 7 Integer fraction 10 Simple fraction 2 Equivalent fraction 5 Possibility 2 Statistics 1 Graphic 9 Percentages 1 Chart 1 Slope 2 Trigonometry 6 Algebraic expression 1 Maths 1 Forever	246	100

According to Table 1, it is seen that the concept of fraction is mostly formed in the minds of teacher candidates as the meanings of fractions (29.26%), operations (19.91%) and notation themes. The most striking part about the theme of fraction meanings was the part-whole (51.38%) and quotient (22.22%) meanings. While the concepts of the meaning of ratio (12.50%) and the meaning of measurement (12.50%) were in question, the meaning of processor was not encountered. Pre-service teachers mostly mentioned operations between fractions themselves. As a matter of fact, the other most used theme was transactions. The most striking thing here is that although addition and subtraction are the operations that come to mind the most (14.28%), the denominator equalization, which is important in these two types of operations, occurs to a much lesser extent (6.12%). It is seen that comparison occurs less between sorting (14.28%), expansion (10.20%), simplification (10.20%) and comparison (4.08%) compared to other operations.

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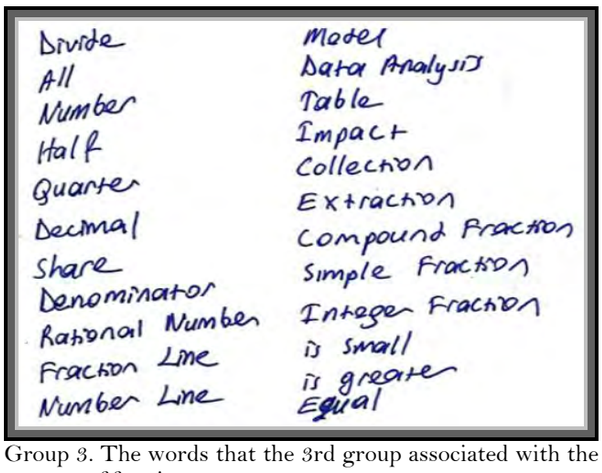
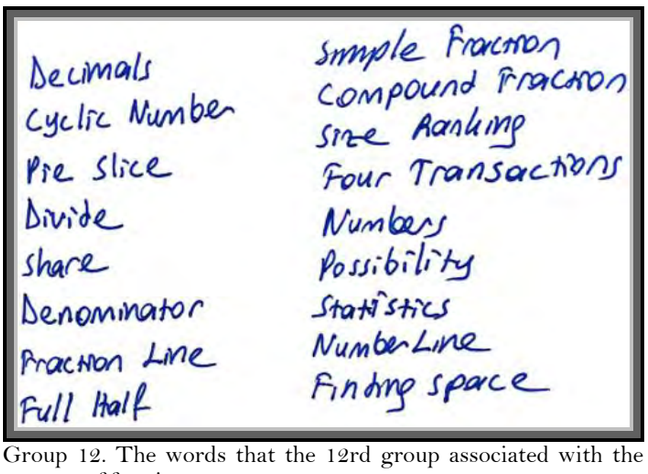


Group 3. The words that the 3rd group associated with the concept of fraction



Group 12. The words that the 12rd group associated with the concept of fraction

Figure 3. Word examples associated with the concept of fraction by teacher candidates.

In Figure 3, there are words written by 2 groups in the word association test related to the concept of fraction.

While the emphasis on the numerator-denominator (35.13%) stands out in the theme created about the representation of fractions, the fraction line (24.32%) maintains its importance. Modeling (8.10%) was the least used display format. In the fraction type theme, the most frequently mentioned words were compound fraction (31.42%) and simple fraction (28.57%), while equivalent fraction (5.71%) was much less expressed. In the theme of numbers, the number most associated with fractions was decimals (38.46%). It is noteworthy that in this theme, rational numbers (15.38%) are encountered less frequently than decimal numbers. Number sense (3.84%) was the least used word.

When its relationship with other mathematics subjects is considered, it is seen that the subject it is most related to is percentages (36%), while the other most frequently used subject is algebra (24%). Graph, table and slope (4%) were the least expressed words. Since the words mathematics and infinity could not be associated with any category, they were considered in the other category.

4. Discussion, Conclusion, and Suggestions

In this study, primary school mathematics teacher candidates' perceptions of the concept of "fraction" and their conceptual relationships were examined through the Word Association Test. The fact that there are a wide variety of themes that emerged as a result of the research showed that the pre-service teachers who practiced structured the concept of fraction under many concepts in their minds and they reached a rich mental structure about fractions. However, there are concepts that do not appear or that occur more or less than other concepts in a similar category.

It is seen that the perceptions of the pre-service teachers who applied regarding the concept of fraction are mostly concentrated in the themes of meanings of fractions, operations in fractions, and representation of fractions. It was seen that the pre-service teachers who applied mostly presented words about the meaning of fractions, quotient and part-whole. This situation shows that although the concept of fraction has 5 different meanings, they restrict it to the meaning of part and whole and perceive fraction as conceptually limited. Similarly, Marmur et al. (2020) in their study with pre-service teachers found that the meaning they have the most is the part-whole meaning of the fraction, similar to this study. In the study carried out by Taştepe and Yanık (2021) it is seen that one of the meanings most used by 9th grade students when writing equations for algebraic fractional expressions is the part-whole meaning. Starting from pre-school, teaching focused on the part-whole meaning of fractions rather than other meanings may cause limited learning in students (Behr, Harel, Post, & Lesh, 1992; Haser & Ubuz, 2002; Okur & Cakmak, 2016; Toluk-Uçar, 2009). As seen in this study, this situation also manifests itself at the university level. The reason why the part-whole meaning is encountered more intensely at many levels may be related to the fact that students learn the part-whole meaning more easily or that teachers tend to teach the part-whole meaning of fractions more (Simon, Placa, Avitzur, & Kara, 2018). In this regard, the curriculum or textbooks may also be one of the situations that should be examined separately. The meaning of the processor, on the other hand, is not expressed at all. Similarly, Özçakır (2022) observed in the research she conducted with primary school students that they had deficiencies in percent meaning.

Another remarkable result obtained from this research is that although addition and subtraction are the most frequently expressed operations, less emphasis is placed on equating the denominator, which is a fraction-specific operation. Looking at the operations between the fractions themselves, comparison was the least expressed operation. Although there is no study on this subject, it can be examined how longitudinally and in what intensity these acquisitions are included in the curriculum. In addition, students' attitudes towards operations such as simplifying, expanding, ordering and comparing fractions can be effective in this regard.

Although decimal numbers are the number type with which fractions are most associated in this study, it is remarkable that rational numbers are rarely mentioned. As stated by many researchers, fractions are closely related to concepts such as decimal notations, ratio, operations and algebra, especially rational numbers (Kieren, 1988; Saxe et al., 2001). It is noteworthy that the least number that comes to mind when talking about fractions is the rational number, especially for students who encounter rational numbers intensively in mathematics courses at university level. The subject that the fraction is most associated with was determined as percentages and especially algebra. While the reasons for algebra to come to the fore are various, it is thought that the most important one is related to the fact that the pre-service teachers are at the university level.

As a result, pre-service teachers who applied have a rich perceptions about the concept of "fraction". However, there are deficiencies in the meaning of fractions, especially in percent meaning. Comparison of fractions and

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equivalent fractions were the operations that came to mind the least about operations in fractions. There are also deficiencies in the relationship of fractions with rational numbers. It is noteworthy that one of the subjects they associate fractions most with is algebra. It is thought that investigating these deficiencies or remarkable situations at different levels and with different methods can be effective in terms of both learning and teaching.

In the continuation of this research, the word association test for different concepts in mathematics can be applied. Or, the perceptions difference between the two applications can be investigated by applying a word association test in the form of a pre-test and a post-test to the pre-service teachers who applied and applying a well-planned training aimed at improving conceptual knowledge between these two applications. In addition, the perceptions of students in different age groups or teachers with different experiences regarding the concept of fraction can be investigated by applying the word association test.

5. Limitations

This research was limited to primary school mathematics teacher candidates. Another limitation of the study is that only the fraction concept was discussed. In addition, the perceptions of pre-service teachers were tried to be determined only by applying the word association test.

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