African Educational Research Journal
Vol. 8(1), pp. 57-69, March 2020
DOI: 10.30918/AERJ.81.19.011
ISSN: 2354-2160
Full Length Research Paper

The effect of 'volume of concept' on the level of identifying concepts and understanding of relationships between concepts for 7th grade students

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Accepted 18 March, 2020

ABSTRACT

The main purpose of this research is to determine the effect of the volume of concept on the level of understanding the relationship between concepts. The mixed method was used in the research. Volume of concept form, concept map form and puzzle scales were used to collect quantitative data. Qualitative data was collected through a fully structured interview form. A homogeneous sample was used in the study. A total of 54 students participated in the study (there are 27 students in both experimental and control groups). The data was analyzed with the help of SPSS and Microsoft Excel program. T-test, Wilcoxon, frequency and percentage techniques were used for descriptive analysis. According to the findings, it was determined that volume of concept had a positive effect on relationship between concepts. No significant relationship was found between the experimental and control groups in regards to concept knowledge. In addition, according to the quantitative findings, concept map was found to be more successful in determining the relationships between concepts. On the other hand, according to the qualitative findings, the volume of concept form and concept map was equally effective in determining the relationship amongst different concepts. In line with the results, volume of concept can be used to determine the relationship between concepts.

Keywords: Concept, concept map, relationship between concepts, volume of concept.

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INTRODUCTION

Concepts are the names given to beings, events and thoughts according to their similar and distinctive features. They are the basic units used in the formation of information. Concepts have a definite definition, usage area, quality, quantity or intellectual value (Yeşiltaş et al., 2017). They can be abstract, concrete, singular or plural. In short, concepts are the basic building blocks of knowledge (Demirkuş, 2019; Kaptan, 1998). It is important to learn, understand and use the concepts in the formation of knowledge (Coştu and Ünal, 2005). In particular, understanding the relationships during the use of concepts is very important for learning (Fredriksson and Pelger, 2018; Karslı and Ayas, 2013). Indeed, learning a subject depends on understanding the relationships between concepts (Atapattu et al., 2017). In the education environment, concept-related tools are generally used in determining the relationships between concepts.

The tools used in concept association are important values in understanding and connecting concepts (Phanphech et al., 2019). In concept association, many more tools such as mind map, concept map, concept network, concept tables, and concept set are used (Alkan, 2011; Kaptan, 1998; MoNE, 2018; Tokcan, 2015). Also, the volume of concept developed by Gülen (2015) is used. Author claims that the volume of concepts such as the volume of atoms can also exist. There are layers of electrons of atoms. They settle in layers according to their energy level. Furthermore, the number of layers of each atom is directly proportional to the number of

electrons. Similarly, a subject in science can symbolize an atom. The concepts within the subject can be symbolized as an electron. The main concepts of the subject can be located near the center. Intermediate concepts can be located in the distant layers. As the concepts of the subject increase, the number of layers increases. Thus, the volume of concept of a subject can be formed (Gülen, 2015).

The volume of concept is a circular visual tool showing the relationships between concepts of subject. The volume of concept and the distribution of all the concepts of a subject around the main concepts are shown circularly. It is also stated in the relations between concepts. This tool, which is developed especially for use in science education, is recommended in many disciplines.

As seen in Figure 1, the name of the unit in the center is a circular structure with a growing volume starting from the basic concepts. Firstly, after the unit name, the main concepts and then the other concepts related to the main concepts are determined. Concepts are placed in such a way that relationships between them are determined (Gülen, 2016). Here, first-order concepts related to the main concept are placed on the first layer. Then, second order concepts are placed on the second layer. Due to this association, the number of layers is increased as the number of concepts increases. The number of concepts in a layer is connected with subjects and to associate. It also shows the relationships between the concepts between the layers. Studies have shown that visualization has an important place in concept education (Demirkuş et al., 2018). The basic principle in volume of concept is to show the relationships between concepts with a visual relationship. This research was conducted on the availability of a tool to help concept training.

While preparing the volume of concept, the following steps are followed: (a) determination of the subject, (b) determination of concepts, (c) classification of concepts (main concepts, intermediate concepts, related concepts), (d) drawing, (e) placement of concepts, (f) specifying relationships between concepts (Examples are attached). The volume of concept will assist learners see all the concepts of the subject and their relations. The volume of concept tool is a circular visual representation of the concepts of the subject. With this tool, the individual acquires in-depth knowledge and sees the summary of the topic and visualizes the subject.

Conceptual and theoretical structure

Many studies have been done on the subjects such as acquiring concepts and gaining relations between concepts. Some of the most important of these studies are Piaget and Montessori (Aydoğan and Şen, 2011). In particular, the steps that Piaget calls schema, assimilation and adaptation are important in concept training. According to this, the child forms a schema in the mental structure of the status, objects, or events. According to this, the child forms a schema in the mental structure of the status, objects, or events. According to Piaget, the individual is in balance. When it creates imbalance, it tends to mentally adapt. If the scheme fits, new schemes are created by assimilating or not sleeping (Gao et al., 2018; Piaget, 2010).

In the educational environment, it is important to develop tools that will help to increase or develop the schemas of concepts. Therefore, it is important to determine the concept knowledge and the relationship between concepts in existing schemas of students (Yetim, 2019). In this study, concept map, puzzle, fully structured interview form and volume of concept were used. Concept map shows the relationship between concepts and information about concepts. It enables visual and concrete information in the mind (Kaptan, 1998; Liu and Lee, 2013).It is known that puzzle is used in the determination and evaluation of the concept with given tips. Especially, it is used in the general review at the end of the subject, in strengthening what students have learned and in the field of concept training (Kaymakçı, 2012; Gürdal and Arslan, 2011). It has also been used in educational entertainment or evaluations (Gültekin et al., 2014; Yılmaz, 2015). Fully structured interview forms are advantageous in that they provide an opportunity to clarify the situation and complete the answers by asking in-depth questions on a specific subject (Tekbıyık and Akdeniz, 2008). In many studies, this form is used to reach information (Uğraş and Zengin, 2019; Vural and Yıkmış, 2008). It can also be used to validate concepts and relationships between concepts (Yıldırım and Şimşek, 2013). In general, it is a data collection tool in which take place students thinks and answers (Taşdemir and Demirbaş, 2010). Although some researchers use fully structured interview forms under different names, they use different names mainly for the purpose of determining the relationships between concepts and concepts information (Canpolat and Ayyıldız, 2019). The volume of concept is a circular visual tool that is presented in such a way that all the concepts related to the subject are clear in their relations (Gülen, 2018). The task of all these tools is to help the schema-assimilation-adaptation in student's mental structure (Dias et al., 2017). Therefore, in this study, these tools are used as a measuring tool in determining the relationship between concepts and concept information.

It is possible to find studies on concept education in the literature review. Some studies focus on concept training (Hamadi et al., 2018), misconceptions (Slapničar et al., 2018), and conceptual change (Gao et al., 2018). On the other hand, other studies focus on concept-related tools such as the concept map (Koponen and Nousiainen, 2018; Lachner et al., 2018; Llinás et al., 2018). It has been proven that concept maps are effective in identifying concepts and identifying relationships between concepts, and they are used to identify any conceptual mistakes and to eliminate those errors (Novak, 2002;

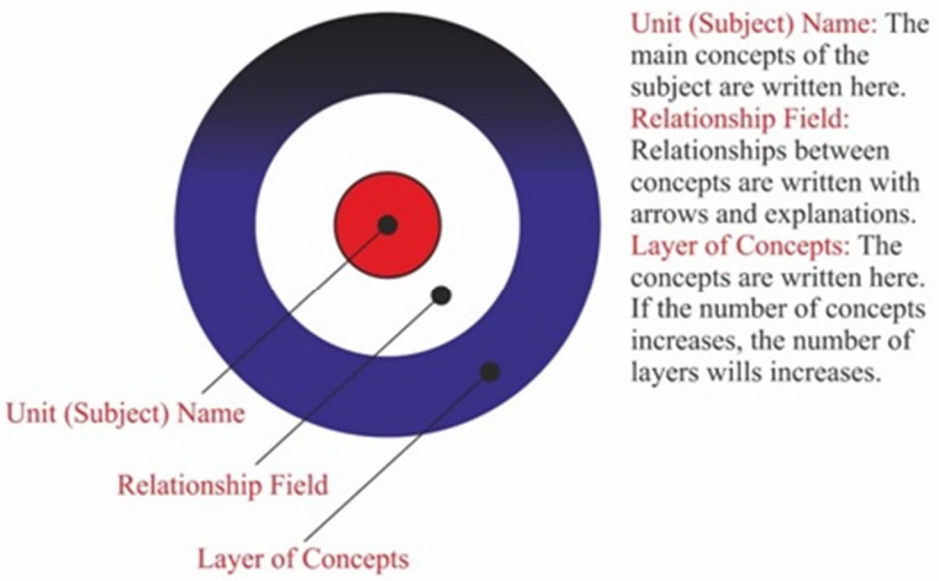

Figure 1. The template volume of concept (Gülen, 2016).

Ozdemir, 2005). Computer-aided preparation or use of the concept map in the virtual environment is very popular (Koponen, and Nousiainen, 2018; Lachner et al., 2018). Liu, (2011), Liu and Lee (2013), Tseng et al. (2007) emphasized the role of e-learning by adjusting the concept map into the computer environment. Dias et al. (2017) have worked on computer-aided concept maps. Similarly, Falloon (2019) and Su (2018) showed that simulations could be used in concept training with appropriate teacher support for children. They also concluded that simulations could be effective in providing opportunities to participate in higher-order thinking processes. Apart from these studies, concept maps have long been seen as an appropriate alternative assessment tool (Ruiz-Primo and Shavelson, 1996). Llinás et al. (2018) have proven that concept maps can be used in the assessment of engineering students. In addition, Koponen and Nousiainen (2018) have used the concept maps in their study to analyze the students' knowledge better than traditional methods.

In the study of Yetim (2019), she used concept map, and then interview technique to determine the concepts and their relations. She showed the concept map to the students, then left blank some places in the concept map and measured the knowledge of concepts and the relations between the concepts. Later, interviews were made with students who had mistakes. The aim of the researcher here is to identify misconceptions. Although the purpose of the study by Yetim is different from this study, the methods and the tools used are similar. According to Gürdal et al. (1999), the relationships between science concepts should be learned. Therefore, the tool which is developed in terms of determining the relations between concepts, concepts information and strengthening of these relations are important for science subjects. Although studies on concept mapping have been identified in the literature review, only Gülen (2015, 2016, 2018) has conducted studies on the volume of concept.

Gülen (2015), in his first work, developed the theoretical structure, preparation and promotion of the volume of concept. In a later study (Gülen, 2016), some examples about volume of concept were offered. Finally, Gülen (2018) conducted a single-group study on the use of the volume of concept at the level of 6th and 7th grades in the unit of materials and properties. In this study investigates whether the volume of concept is as effective as the concept map in the education process. He also asked the opinions of the students about the volume of concept. Concept maps were used with pre-post tests to compare experimental and control groups'. Use of these mixed methods also increased the objectivity of the data. Apart from all these studies, in this study was conducted to determine the effect of volume of concept on the level of understanding the relationship between concepts.

Purpose of the research

The main purpose of this research is to determine the effect of the volume of concept on the level of understanding the relationship between concepts. For this purpose, a comparative study was carried out with the concept map through the experimental design.

In this context, the answers to the following questions were sought.

1. Does the volume of concept have an impact on determining the relationship between concepts?

2. Is there a significant relationship between the concept knowledge of the groups according to the puzzle test?
3. Is there a significant difference between the quantitative data of the experimental (volume of concept) and control (concept map) groups in determining the relationship between concepts?
4. Is there a significant difference between the scored qualitative data of the experimental (volume of concept) and control (concept map) groups in determining the relationship between concepts?

Importance of research

In this research, the degree of effectiveness of the volume of concept is determined comparatively. As determined by literature review, puzzle, volume of concept, concept map and fully structured interview form are used in identifying and determining the relationship between the concepts. Quantitative data were collected by measurement tools such as puzzle, volume of concept, concept map in experimental and control groups. Qualitative data was collected with a fully structured interview form. The aim was to increase the number and type of data collection tools and to increase the accuracy of the results in both directions. In addition, single group pre-post test method was used to determine the effect of volume of concept on the relationship between concepts. The concept map was used in the control group in terms of its effectiveness compared to volume of concept. In addition, the data in both groups using the puzzle have been diversified. Apart from this, with the help of the fully structured interview form, the volume of concept has been applied to identify and to determine the effect on the relationship between concepts.

Limitations of research

The study is limited to 54 students in a small district of Eastern Anatolia Region. The research is limited to the topic "*Matter and Mixtures*" of the seventh grade science (This topic was selected randomly).

MATERIALS AND METHODS

The mixed method was used in the research. In the quantitative aspect of the study, pre-posttest experimental design with experimental and control group was used. The experimental and control groups were randomly determined. In the qualitative aspect, a fully structured interview form consisting of questions, which indicate clarity and precision, was used. Both qualitative and quantitative data were used to increase the objectivity of the answers to research problems. Qualitative data were collected together with quantitative data (Büyüköztürk, 2009; Creswell, 2013; Çepni, 2010). Table 1 shows the steps and explanations of the processes followed in this study.

Participants

Homogeneous (analogous) samples were used in the study. The aim in the analogous sample is to determine the status of groups of similar characteristics in a subject in order to collect the data effectively (Yıldırım and Şimşek, 2013). As a matter of fact, the research was conducted with 7th grade students in a public school in Eastern Anatolia Region during the 2018-2019 academic years. A total of 54 students (experimental and control groups consists of 27 students each) participated in the study. Although 54 students participated in the pre-tests, a total of 50 students participated in the post-tests. Two students, both in the experimental and the control groups, could not attend because they were in the school football team during the lesson hours when the posttests were applied. The socio-economic statuses of the participants were similar. All students lived in the same neighborhood. There were no social activities outside the school.

Data collection tools

Volume of concept form (Appendix 1), concept map form (Appendix 2), puzzle (Appendix 3) scales were used for collecting quantitative data. The volume of concept and concept map forms were created with demo versions of the CorelDRAW, while the puzzle form was made with Eclipse Crossword programs. Qualitative data was collected through a fully structured interview form.

Volume of concept form

Volume of concept form, developed by researcher, was prepared to show the relations between the concepts in accordance with the gains of the unit. In this form, the concepts and the relations between the concepts are mentioned in detail. Then, 15 of the concepts in the form were deleted and presented to the students in the lower part of the form. The students filled the gaps by establishing a relationship between the concepts given in the form and the concepts under the form. It is applied as pre-post test.

Concept map form

The concept map given in the textbook of the students is prepared by making the necessary arrangements. Then, 15 of the concepts in the form were deleted and presented to the students in the lower part of the form. The students filled the gaps by establishing a relationship

Table 1. Steps followed in the study.

Order	Steps	Explanation
A	Topic	Subject was selected randomly
B	Examination	The course curriculum and book have been reviewed.
C	Measuring tools	The tools used in finding the answers to the research questions were selected.
D	Application	1. Determination of groups: Classes were determined randomly as experimental and control groups. 2. Pre-test: Volume of concept, concept map and puzzle forms were applied. 3. Use of concept maps and volume of concept: In this section, volume of concept is used in the experimental group and concept map is used in the control group under the guidance of the teacher. In the application process, the relations between the concepts should be indicated and these tools are shown the students. The students were informed about concept map and volume of concept at the beginning of the application. 4. Post test: Volume of concept, concept map and puzzle forms have been applied. In addition, the fully structured interview form was applied only as a post-test to qualitatively collect the data. 5. Duration: The application took a total of four weeks.
E	Analysis	Data obtained from measurement tools were analyzed.
F	Results	The findings were determined and presented.

between the concepts given in the form and the concepts under the form. It is applied as pre-post test.

The volume of concept and concept map tools were used to understand and learn the relationships between groups better. Both tools have deleted the same number of same words. Accordingly, a total of 29 concepts related to substances and their properties were determined in these instruments. 15 of these concepts were deleted from the place, and they were intricately presented to the students in the lower part of the form. The participants were asked to place the concepts given in the lower section towards the empty places. In order to do this, participants needed to analyze the relationship between the given concepts well. Thus, experimental and control group students' levels of determining the relationships between concepts with different tools were investigated.

Puzzle form

It is designed to recognize and strengthen unit concepts and the relationships between concepts. The students identified the concepts from the clues given. A total of 13 concepts were used. It is applied as pre-post test. This tool was used to question the recognition status of the subject concepts of the participants. It was applied in both groups. In this tool, 13 concepts, which can be defined from the information on the subject, were questioned. There is no reason for the difference in the number of concepts in other tools.

Full structured interview form

It was prepared for supporting data measured by quantitative instruments. Both data types are intended to complement each other. In addition, it was prepared for students to learn and understand the relationships between the concepts. This form was applied only as a post test. The fully structured interview form includes the following questions:

1. Write the basic particles granules in the maps of the atom?
2. Specify pure substances with samples.
3. Specify the types of mixtures with examples.
4. Which is solvent and solute in sugary water solution?
5. Write examples of separation methods.
6. Which substances are recycled? Give examples from daily life.

A fully structured interview form was used to determine the volume of concept and concept map levels of the groups after the application. In this form, based on the questions asked and the answers given, which participants better understood the relationship between concepts was determined. Thus, it is determined which tool is more effective in which group.

Analysis of data

The data of the measurement tools used in the study were analyzed with the help of SPSS and Microsoft Excel program. T-test, Wilcoxon, frequency and percentage techniques were used for descriptive analysis.

The correct filling of each space in volume of concept and concept map forms was scored with 1 point. A total of 15 points are taken. Similarly, 1 point was given for each correct answer on the puzzle scale. However, a

total of 13 points are taken. Since these scales were used as both pre-test and post-test, independent sample T-test was used to determine the significance between groups and the tests (Generally, T-test was preferred because the data were found to have parametric values). In addition, the percentage values of the scores obtained from all scales are also given.

The fully structured interview form data were analyzed descriptively. Frequency and percentage values were preferred in descriptive analysis. In addition, by analyzing in the light of the criteria mentioned in Table 2, the significance of the points obtained between the experimental and control groups were questioned. For this purpose, independent sample T-test was used.

Table 2 was used to score the answers of the students to the questions in a fully structured interview form. This table is designed to identify students' interrogated concepts and to determine the relationships between them. The concepts in the table are the concepts that should be in student responses. In addition, the concepts that were questioned in other measurement tools were also questioned here. The answers of the fully structured interview form questions were scored by the help of the teacher. As a result of the separate scoring of the researcher and the teacher of the course, it was finalized with consensus. For the ratings, reliability was calculated by using Miles and Huberman's (1994) formula. According to this calculation, 95% confidence coding was performed throughout the study. In fact, according to Miles and Huberman (1994) 80% and above has been accepted as reliable (Arik and Yilmaz, 2017).

Table 2. Scoring criteria for full structured interview form.

Questions	Concepts	Score
1. Question	Proton	1
	Neutron	1
	Electron	1
2. Question	Element	1
	Compound	1
3. Question	Homogeneous	1
	Heterogeneous	1
4. Question	Solvent	1
	Soluble	1
5. Question	Elimination	1
	Distillation	1
	Density difference	1
	Filtration	1
	Magnets	1
	Evaporation	1
6. Question	Paper waste	1
	Glass bottles	1
	Plastic bottles	1
	Metal	1

Reliability and validity

In the study, the situation of the sample group was explained in detail within the scope of the reliability studies; also, data collection and analysis were presented with conceptual framework. In addition, these data were supported by descriptive analysis (Glesne, 2013; Merriam, 2013). The fully structured interview form, concept map form, volume of concept form and the puzzle prepared by expert opinion were used. In the analyses, support from branch teachers was received. In the preparation of the scales, subject gains were taken into consideration and the scope validity of the scales was ensured. In addition, the validity of the structure and appearance were taken with expert opinion. Research experts were science professors and doctoral students.

RESULTS

The data obtained in the research are presented in Table 3. In order to understand the research questions, quantitative data are presented firstly, and then, qualitative data are described. Accordingly, the quantitative data obtained are presented in Table 3.

In Table 3, the mean scores of the quantitative measurement tools used in the research and the reflections of these scores on the percentage system are given. This table shows the data of both groups. According to this, the puzzle pre-test average of the control group was 7.81 (60.11%) and the average of the post test was 11.40 (87.69%). The pre-test average of the concept map test applied in the control group was 13.96 (93.09%), and the average of the post test was 14.00 (93.33%). In the experimental group, the mean pre-test average of puzzle was 11.29 (86.81%), and the average of post-test was 11.24 (86.46%). In addition, the pre-test average of volume of concept in the experimental group was 7.18 (47.86%) and the average of post-test was 11.08 (73.87%). In addition to these data, the significance level of these mean scores in experimental group students was examined.

Table 4 shows the significance of the experimental group students' scores in the puzzle test. According to the results of the Wilcoxon Signed Ranks Test, the p value was 0.965. In addition, the significance between the volume of concept scores is given in Table 5.

Table 5 shows the meaningfulness between the volume of concept scores of the experimental group students.

Table 3. Average and percentage values of pre-post test results of measurement tools.

Groups	Tests	Puzzle	Percent (%)	C. Map	Percent (%)	C. Volume	Percent (%)
Control group	Pre test	7.81	60.11	13.96	93.09		
	Post test	11.40	87.69	14.00	93.33		
Experiment group	Pre test	11.29	86.81			7.18	47.86
	Post test	11.24	86.46			11.08	73.87

Note: C. Map = Concept Map, C. Volume = Volume of Concept.

Table 4. Puzzle pre-post Wilcoxon signed ranks test in experimental group.

Puzzle		N:25	Mean rank	Sum of ranks	Z	p
Pre-Post	Negative ranks	9[a]	9.39	84.50	-0.44	0.965
	Positive ranks	9[b]	9.61	86.50		
	Ties	7[c]				

Table 5. Volume of concept pre-post Wilcoxon signed ranks test in experimental group.

Volume of concept		N:25	Mean rank	Sum of ranks	Z	p
Pre-post	Negative ranks	8[a]	7.63	61.00	-2.73	0.006
	Positive ranks	17[b]	15.53	264.00		
	Ties	0[c]				

According to the results of the Wilcoxon Signed Ranks Test, the p value was 0.006. In addition to these data, the level of significance between the scores obtained from the puzzle test that measures the concept knowledge of the experimental and control groups is given in Table 6.

According to Table 6, puzzle pre-test results show that p value is 0.000. It is also stated that the grade point average of the experimental group is higher than the grade point average of the control group. However, in the post test results, p value is 0.798. This indicator shows that there is no meaningful relationship between the puzzle post test scores of the groups. In addition to these data, the level of significance between the tools used to determine the relationship between the concepts in the experimental and control groups is given in Table 7.

Table 7 shows that the pre-test results have a p value of 0.000, and the average of the control group is higher than the grade point average of the experimental group. The post test results also show a similar situation. In fact, the final test has a p-value of 0.006, and the control group grade point average is higher than that of the experimental group.

Qualitative findings obtained, in addition to the above quantitative findings, are given in Table 8. The descriptive data obtained from the analysis of fully structured interview form data are presented in Table 8.

Table 8 shows the results of the descriptive analysis of fully structured interview form data. By means of this form, the level of understanding the relationship between the concepts was determined. Generally, it is seen that the basic particles of the atom (Question 1) have been understood by experimental and control groups equally (98.67%). It was observed that the control group was 82% and the experimental group was 72% for the association of pure substances (Question 2). In addition, it was seen that the control group was 80% and the experimental group was 66% in the determination of the recycled materials (Question 6). Moreover, the experimental group was 64%, and the control group had 44% in Mixture types (Question 3). In the classification of the substance types in the solution (Question 4), the experimental group was 96%, and the control group was 72%. Finally, it is seen that the experimental group was 68%, and the control group was 62% for separation methods (Question 5). According to this, the general frequency average of the control group students was 18.21 (72.84%) while the average frequency of the experimental group students was 18.84 (75.37%). Furthermore, the level of significance between the grades given by the groups is given in Table 9.

Table 9 shows the independent sample T-test results of the fully structured interview form descriptive data of the experimental and control groups. Accordingly, p is understood to be 0.662. These data indicate that there is no significant relationship. All of the data in the findings section are detailed in the discussion section.

Table 6. Pre-post test results of the puzzle test independent groups t-test.

Tests	Groups	N	Mean	Standard deviation	t	p
Pre test	Control group	27	7.85	3.08	-4.477	0.000
	Experiment group	27	11.29	2.67		
Post test	Control group	25	11.40	2.18	0.257	0.798
	Experiment group	25	11.24	2.23		

Table 7. Volume of concept and concept map pre-post test results independent groups t-test.

Tests	Groups	N	Mean	Standard deviation	t	p
Pre test	Control group (C. Map)	27	13.96	2.63	6.277	0.000
	Experiment group (C. Volume)	27	7.18	4.99		
Post test	Control group (C. Map)	25	14.00	1.82	2.892	0.006
	Experiment group (C. Volume)	25	11.08	4.70		

Table 8. Fully structured interview form descriptive analysis statistics.

Questions	Concepts	Control group			Experimental group		
		Frequency (f)	Percent (%)	General (%)	Frequency (f)	Percent (%)	General (%)
1. Question	Proton	25	100	98.67	25	100	98.67
	Neutron	25	100		25	100	
	Electron	24	96		24	96	
2. Question	Element	22	88	82	20	80	72
	Compound	19	76		16	64	
3. Question	Homogeneous	11	44	44	16	64	64
	Heterogeneous	11	44		16	64	
4. Question	Solvent	18	72	72	24	96	96
	Soluble	18	72		24	96	
5. Question	Elimination	17	68	62	20	80	68
	Distillation	17	68		21	84	
	Density difference	12	48		19	76	
	Filtration	18	72		16	64	
	Magnets	13	52		10	40	
	Evaporation	16	64		16	64	
6. Question	Paper waste	24	96	80	21	84	66
	Glass bottles	21	84		21	84	
	Plastic bottles	20	80		14	56	
	Metal	15	60		10	40	
Mean		18.21	72.84		18.84	75.37	

Table 9. Fully structured interview form scores independent groups t-test.

Groups	N	Mean	Standard deviation	t	p
Control group (C. Map)	25	13.84	4.21	-0.44	0.662
Experiment group (C. Volume)	25	14.32	3.46		

DISCUSSION

A significant increase is observed in the control group's puzzle pre-post test averages. However, there is no significant increase in the concept map test results of the control group. It can be said that the control group students are familiar with the subject concepts. In addition, the concept map used in the control group is commonly used in schools, and its effect on concept training is known. Therefore, it can be suggested that there is no significant increase at the beginning and end of the implementation. It is understood that the experimental group has almost the same pre-post test average in the puzzle test. Consequently, it can be said that experimental group students' knowledge about the subject is sufficient before application. However, it is understood that there is a significant increase in the volume of concept of the experimental group between the pre-post test results. Here, it can be said that experimental group students understand the relations between concepts better. As a matter of fact, the relationship between the pre-post test scores of the experimental group students' grades obtained by both measurement instruments was examined. According to the results of the Wilcoxon Signed Ranks test, the p value of the experimental group was higher than 0.05. It was found that there was no significant relationship between the pre-study and post-study status of the experimental group students' puzzle test. In addition, there is a significant correlation between the level of volume of concept applied in the experimental group and the pre-post test data as the p value is less than 0.05 according to the Wilcoxon Signed Ranks Test results. In other words, it can be said that the volume of concept has a positive effect on determining the relations between concepts. In his study, Gülen (2018) found that the volume of concept provided significant changes over the single group. Apart from this, there are studies which have increased the success of the experimental groups (Çelik and Gündoğdu, 2016). However, studies on the volume of concept could not be identified. Still, it can be said that the volume of concept has an effect on determining the relationships between concepts.

According to the pre-test p value of the puzzle test and the average grade of the groups, it can be said that the concept knowledge of the experimental group is higher than the control group. However, this significant difference was closed according to the final test p value of the puzzle test. In other words, it was determined that the concept knowledge of the experimental group was higher than the control group before the application of puzzle pre-post test p values. No significant relationship was found between the concept knowledge of both groups after the application. As a matter of fact, while the experimental group maintains the existing concept knowledge, it can be said that the control group brings their concept knowledge to the experimental group's level. In the study of Yılmaz (2015), it was determined that the teachers used the puzzle activities in order to assess the concept knowledge of the students and to have fun. In addition, Kaymakçı (2012) found that the concept learning became easier with the puzzle. According to the puzzle test used in the measurement of concept information, there is no significant difference between experimental and control groups in terms of concept knowledge.

When the scores of the tools used to determine the levels of understanding the relationship between the concepts are examined, it can be said that the control group students are more successful in terms of both pre-post test scores. However, the increase in the grade point averages of the experimental group is also noteworthy. In fact, it can be said that there is a significant change in this increase in the Wilcoxon Signed Ranks test. In general, concept maps are used to determine the relationships between concepts (Atapattu et al., 2017). In their study, Koponen and Nousiainen (2018) used the concept maps to analyze the students' knowledge better than traditional methods. Lachner et al. (2018) determined that feedback provided by computer-aided concept maps makes gaining true information easier. Moreover, in the study of Stokhof et al. (2018), it is stated that learning is facilitated by visualization of concepts and evaluations are made with this method. As seen in these studies, the concept map is used to determine the relationships between the concepts or to evaluate them (Llinás et al., 2018). In addition, there is no study on the volume of concept. Therefore, there are no studies on comparing the concept map and the volume of concept. Only Gülen (2018) conducted a single group study with students at different levels. As a result of the interpretation of quantitative data, it can be said that the concept map is better than the volume of concept in determining the relations between the concepts. However, when the single group data were examined, it was found that the volume of concept had a significant increase in determining the relationships between the concepts. As a result, it has been determined that the volume of concept can be used at least as well as the concept map.

According to the fully structured interview form data used to determine the relationship between concepts, it can be said that both groups have similar results in determining the relationship between atom and its particles. It may be suggested that the control group students are more successful than experimental group in terms of associating pure substances and specifying recycling substances. In addition to these data, it was determined that the experimental group was more successful in separation of mixtures, classification of substances in solution, separation methods of mixtures subjects than the control group. In general, when all the data are taken into consideration, it can be said that the experimental and control group average scores are quite close to each other. By using a fully structured interview form, the relationships between concepts and concepts

are determined. As a matter of fact, there are studies to determine the situation with interview forms in the literature (Koray et al., 2006; Uğraş and Zengin, 2019; Vural and Yıkmış, 2008). When the significance level between the fully structured interview form data and descriptive data was examined, it was determined that the value of p was greater than 0.05. For this reason, it can be said that there is no meaningful relationship between groups' achievements in determining the relationship between concepts. In contrast, Akuysal et al. (2011) found positive results in favor of the experimental group with a similar scale. Lin and Hu (2003), in their study with 7th grade students, found that most of the students were inadequate to establish the relationships between the concepts related to substance cycle issues. Apart from these, in terms of similarity to the method of research, Yetim (2019) first used the concept map and then made interviews according to the mistakes which were made. Although the author only used the concept map and interviewed, it is similar to the research. As a result of the interpretation of the qualitative data, it was determined that the participants were slightly more successful in the volume of concept. However, there was no significant difference between concept volume and concept map in determining the relationship between concepts.

CONCLUSIONS AND RECOMMENDATIONS

Considering both the control group data and the used puzzle test tool data, a significant change was determined in the experimental group. It was determined that the volume of concept used in the experimental group had a positive effect on determining the relationship between the concepts. It can be said that the volume of concept can be used as other concept association tools. It is recommended that the relations between the concepts of a course can be used to visualize and determine the relationships between them.

As a result of the analysis of the puzzle test data, there is no significant relationship between the concept knowledge of the experimental group and control group. Although the knowledge of the experimental group was found to be higher than the control group before the application, it was determined that this difference was closed after the application. It is suggested that the puzzle test can be used to determine the concept knowledge.

A significant relationship was found between the groups' quantitative data in favor of the concept map. It was determined that the concept map gives more successful results in determining the relations between the concepts. However, it was determined that the volume of concept showed a significant increase in the single group experimental study. Here, the success of the volume of concept, according to another concept of the association tool, can be examined. Moreover, these results are considered to be normal since they are used in determining the relationships between concepts. Therefore, it will be possible to change the result of this research with the new studies about the use of the volume of concept.

In the descriptive analysis of the qualitative data of the groups, it was determined that the concept volume was slightly more successful than the concept map in determining the relations between the concepts. However, no significant relationship was found between the scores obtained as a result of the scores. As a result, it was found that the volume of concept and concept map showed similar success in determining the relationship between the concepts. It is suggested that both tools can be used to determine the relationship between concepts of a group.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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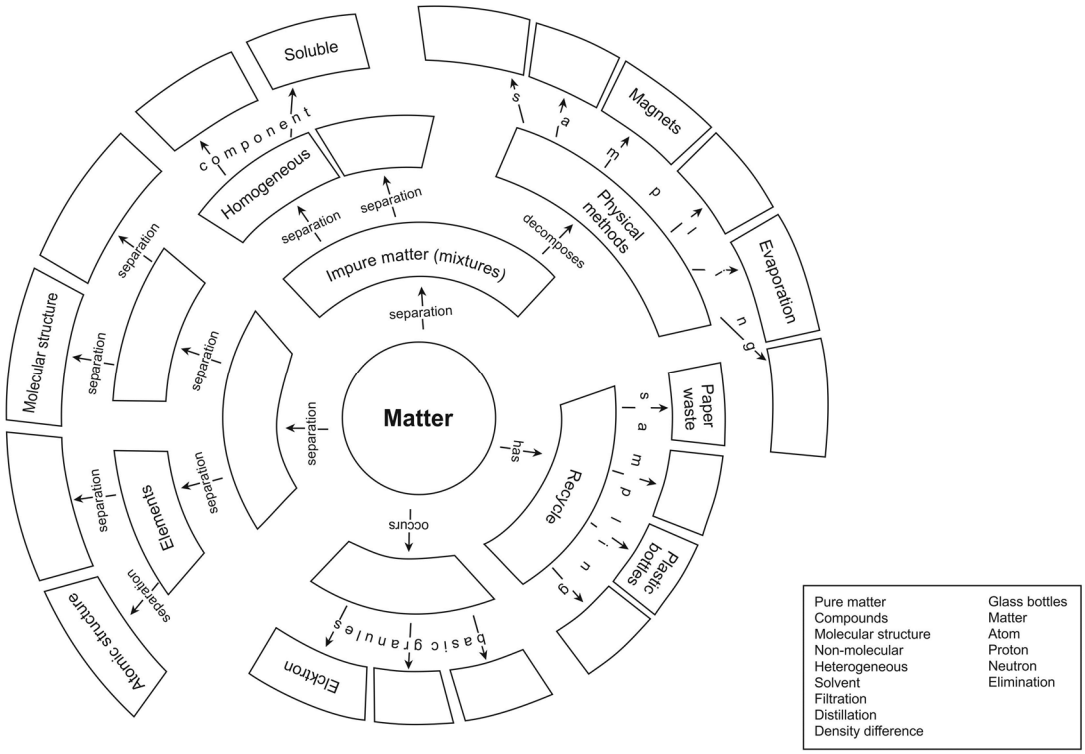
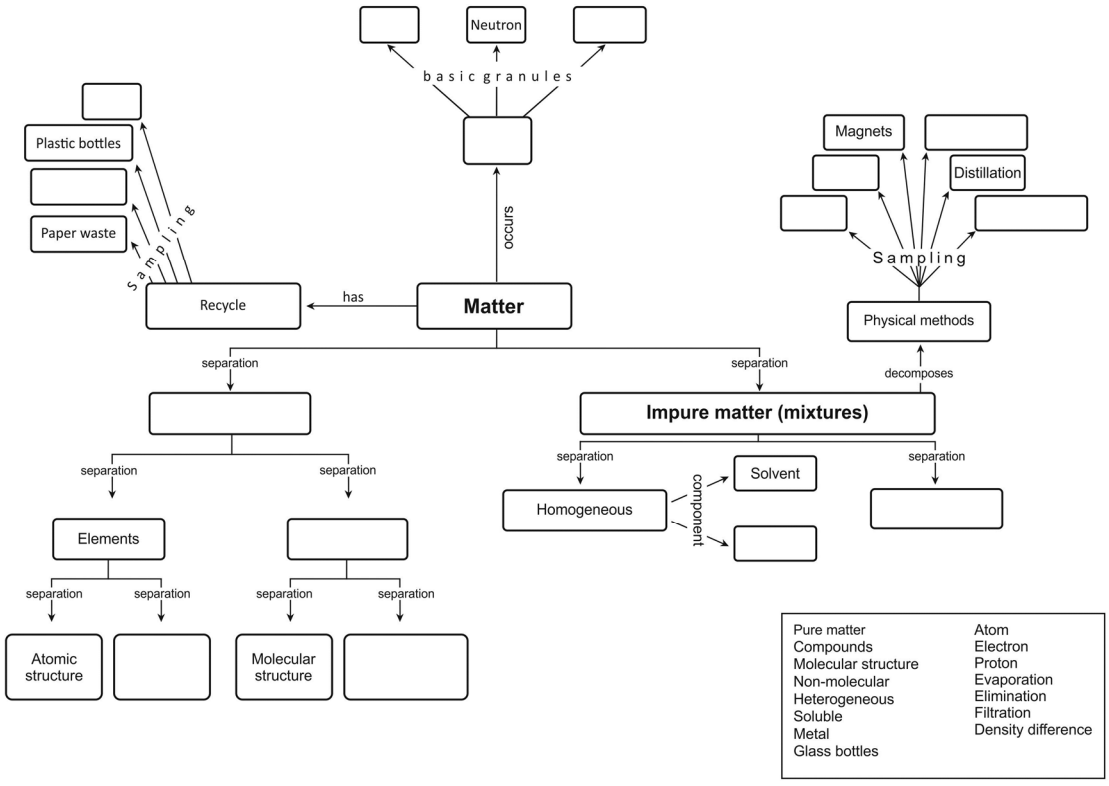
Citation: Gülen, S. (2020). The effect of 'volume of concept' on the level of identifying concepts and understanding of relationships between concepts for 7th grade students. African Educational Research Journal, 8(1): 57-69.

Appendix 1. Volume of concept used in research.

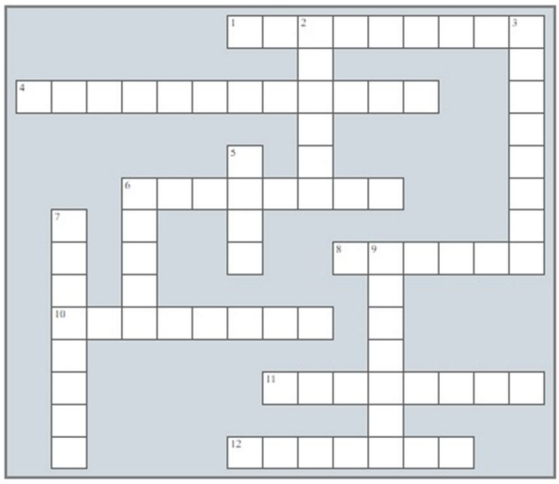


Appendix 2. Concept map used in research.



Appendix 3. Puzzle used in research.

Science Education / Matter



Across

1. They are the pure substances shown by the formulas.
4. One of the physical methods used in the separation of mixtures
6. They are impure substances
8. A positive charge in the nucleus of the atom
10. It is the name of the groups where both elements and compounds can be found
11. The moving particle in the layer of the atom
12. The amount in solution is a lot.

Down

2. It is called with mass, volume and particles
3. Homogeneous mixtures
5. The smallest particles of matter
6. A recyclable substance
7. Pure substances shown by symbols
9. Re-use of substances