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On the Teaching Polygons to Primary School 7th Grade Students Using Vee Diagrams and Mind Maps

Çokgen Konusunun Öğretiminde Kullanılan Vee Diyagramı ve Kavram Haritalarının İlköğretim 7.Sınıf Öğrencilerinin Başarısı Üzerindeki Etkisi

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Abstract
This study investigates the influence of teaching “polygons”, which is a subject covered in seventh grade mathematics course in primary education, focusing on the impacts of using vee diagrams and mind maps on student achievement and the permanence of knowledge. Pretest-posttest control group design was used in the study, which was carried out with 39 seventh grade students in the 2010-2011 academic year. Two groups were formed out of these students through random sampling. Polygons were taught to the experimental group using vee diagrams and mind maps while they were taught to the control group through the traditional method (in accordance with the 7th grade curriculum). The research data were collected via an achievement test consisting of 35 questions, which was developed by the researcher. At the end of teaching, a posttest was administered to both groups. Then the views of the experimental group students about mind maps and vee diagrams were received. 40 days after the end of teaching, a permanence test made up of the questions asked in pretest and posttest was administered to the experimental group and the control group students. A significant difference was found between the scores achieved by the groups in the permanence test ($F(1.37)=4.398$; $p<.05$). The results of this study show that mind mapping and vee diagramming are more effective than traditional teaching and have an influence on permanence.

Keywords: Mind map, vee diagram, polygons, permanence.

Öz
Bu çalışmada, ilköğretim 7. Sınıfta okutulan çokgen konusunun öğretiminde kullanılan vee diyagramı ve kavram haritalarının öğrenci başarı üzerindeki etkisi araştırılmaktadır. Çalışma, ön ve son test uygulamasının yapıldığı deneysel bir çalışma olup 2010-2011 akademik yılında 7. sınıfta okuyan 39 öğrencinin katılımıyla yapılmıştır. Seçkisiz örnekleme yöntemi ile kontrol ve deney grubu olmak üzere iki grup oluşturulmuştur. Çokgenler, deney grubuna vee diyagramı ve kavram haritaları ile öğretilirken, kontrol grubuna ise müfredatta belirtilen geleneksel yöntemle öğretilmiştir. Çalışmanın verileri, araştırmacı tarafından hazırlanan 35 soruluk bir başarı testi ile toplanmıştır. Öğretimin sonucunda, iki gruba da son test uygulanmıştır. Ayrıca, deney grubuna vee diyagramı ve kavram haritaları ile ilgili görüşleri de sorulmuştur. Öğretimden 40 gün sonra, her iki gruba da ön test ve son testte kullanılan sorulardan oluşan bir devamlılık testi uygulanmıştır. Grupların devamlılık testinden elde ettikleri sonuçlar arasında anlamlı farklılık bulunmuştur ($F(1.37)=4.398$;$p<.05$). Sonuçlar, vee diyagramı ve kavram haritalarının devamlılık üzerinde, geleneksel öğretim yönetimine göre daha etkili olduğunu göstermiştir.

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Anahtar Kelimeler: Kavram haritası, vee diyagramı, çokgenler, devamlılık.

1. Introduction

The Five process standards announced by National Council of Teacher of Mathematics (NCTM) are problem-solving, reasoning and proof, communication, connections, and representation. Representation highlights the use of diagrams, manipulatives, graphs, tables, and symbols as strong methods for expressing mathematical ideas and relations. Symbolization in mathematics should be perceived by students as ways of conveying mathematical ideas to other people through means like graphs and tables that help with visualization. Transition from one representation to another is an important way of understanding a newly formed idea in depth (Van de Walle, Karp and Bay-Williams, 2013). Mind maps and vee diagrams are two representation types.

The related literature indicates the advantages of using mind maps in teaching. Steyn and Boer (1998) emphasize the increase in the academic performance levels of the students who use mind mapping. Budd (2004) conducted an online survey on the use of mind mapping and found out that students with "accommodating" learning style (Kolb, 1984) have positive attitude towards learning through mind maps. Paykoç et al. (2004) used mind mapping as a brainstorming practice in their study and revealed the contributions of the use of mind maps to students' discovering relationships between subjects, associating their experiences with their observations, and learning. On the other hand, Farrand et al. (2002) who investigated the effectiveness of mind maps determined that mind maps have a negative influence on students' studying motivation.

In mathematics teaching, mind maps were used by Entrekin for the first time. Entrekin described mind maps as enjoyable and effective tools that could be used in algebra and trigonometry classes in the university (Steyn and Boer, 1998). Longhurst (2002) carried out a case study with a group of 5 people in order to determine students' personal development levels and confidence levels in mathematics using alternative teaching methods such as relaxation, visualization, and mind mapping, and concluded that mind mapping are more effective than other alternative teaching methods (i.e. relaxation and visualization). Longhurst (2002) observed that mind mapping is a technique that enables students to use their imagination and creativity. All the students participating in that study stated that they became more self-confident thanks to mind maps. However, it was observed in this study that the students spent too much time drawing mind maps. Bütüner (2006) investigated the influence of teaching "Angles and Triangles" through vee diagrams and mind maps on student achievement. In that study, although there was no significant difference between the pretest results of experimental group and control group ($p>0.05$), a significant difference in favor of experimental group was found between the posttest results ($p<0.05$). These results demonstrated that mind mapping and vee diagramming were more effective than traditional teaching.

Novak and Gowin (1977) firstly introduced vee diagram to undergraduate students and faculty members and found out that vee diagram was associated with every discipline in the university. In 1978, they introduced vee diagram to help learning in science lessons. Since then, vee diagram has been used as a tool helping learning in many stages of studies conducted at high school and university levels.

Lebowitz (1998) showed that vee diagram drives students to think and learn more in comparison to traditional laboratory approach. Nakipoğlu and Meriç (2000) report that vee diagrams allow eliminating the misconceptions of students, encourage them to make preliminary preparations before subjects are taught, ensure permanent learning because they provide learning by thinking, allow students to learn subjects better by improving their ability to ask questions, and provide students with an opportunity to engage in group work. In another study, Nakipoğlu et al. (2002) revealed that vee diagrams may help instructors determine the misconceptions of students easily and help students learn the subjects. Likewise, Atılboz and Yakışan (2003) determined the contributions of the use of vee diagrams to students' academic performance.

2. Theoretical framework

2.1. Mind maps

Ausubel suggested the use of such visual stimuli as examples, schemes, maps, and tables and named them advance organizers. One of the reasons for the use of two-dimensional visual tools is advance organizers seen in Ausebel's expository (meaningful) teaching approach (Bütüner 2006).

Mind mapping technique was developed by Tony Buzan, who is an English psychologist, mathematician, and brain researcher, in the late 1960s. Mind mapping is a recall technique in which the unstructured functions of the brain are used for recording information in mind more effectively (Buzan 2003).

To Nast (2006), mind mapping is a way of organizing ideas through key words and pictures and the technique of summarizing knowledge sets on a sheet, and it is also used as a tool of recalling. This technique, in which logic combines with creative thinking, was developed based on the following foundations:

1) “Research on note-taking skills
2) Memory psychology
3) The comprehension of networks and natural systems
4) Understanding of the brain’s structure and functioning
5) What mind wants to do in reality” (Gelb, 2002).

To Novak (1998), mind mapping is a kind of graphical representation that is recommended as a way of establishing the framework of meaningful learning for students. In preparing mind maps, students see whether or not they have enough knowledge of concepts about which they are preparing the maps, think on the properties of relationships between concepts, observe how they learn concepts, and make plans to learn them (Ünver, 2005). On the other hand, according to Buzan (1996), mind mapping is a creative visual note-taking technique that both improves the organization of knowledge and the efficiency of individuals and enables them to learn, and this technique can be used in any activity requiring planning, thinking, recalling, and creativity.

2.2. Vee diagrams

David Ausubel is one of the first researchers who focused on the relationship between meaning and learning, and he argues that the most important factor influential on an individual’s learning is his prior knowledge (Novak, 1993, as cited in Gür et al. 2006). People have reasoned on how to determine the readiness levels of learners and considered classic test method ineffective for it. Piaget style clinical interview method was effective, but it required experienced individuals to conduct it, and it was time-consuming.

Novak has obtained hundreds of tape records through the studies he has carried out. He has revised them one by one and reached the following results:

1) Meaningful learning involves the correspondence of new concepts and propositions in the given cognitive structure.
2) Knowledge is hierarchically organized in the cognitive structure, and a lot of new learning involves the scope of the concepts and the propositions within the existing hierarchies.
3) Knowledge is acquired differently from rote learning (Novak, 1993).

In the light of these data, Novak (1993) proposed vee diagram as a metacognitive tool that helps students and teachers understand knowledge and knowledge generation process. Vee diagram was firstly developed by Gowin in the 1970’s as a tool helping educators and students to understand the aim of laboratory work and helping students to comprehend the method of constructing their own knowledge structures during laboratory experiments (Roehring et al. 2001). Gowin developed vee diagram within the framework of five questions created for organizing knowledge not packaged in any scientific field.

Vee diagram consists of 3 main parts. There is a focus question in the middle of the diagram that starts with the drawing of a big V letter. A good focus question is associated with conceptual part on the left side of the diagram and methodological part on the right side of the diagram and provides transition. The left side of the vee diagram contains the dimension of thinking. It is also the left side of the diagram where conceptual or structural knowledge used in formulating hypotheses is presented. Theories, principles, and concepts are written on this side. The right side of the diagram contains the dimension of doing and presents methodological and operational activities undertaken by students (Nakiboğlu et al., 2001). The left side and the center of the vee diagram are filled in before the lesson while its right side is filled in after the lesson (Nakiboğlu& Meriç, 2000). *Figure 1* provides a general representation of the vee diagram.

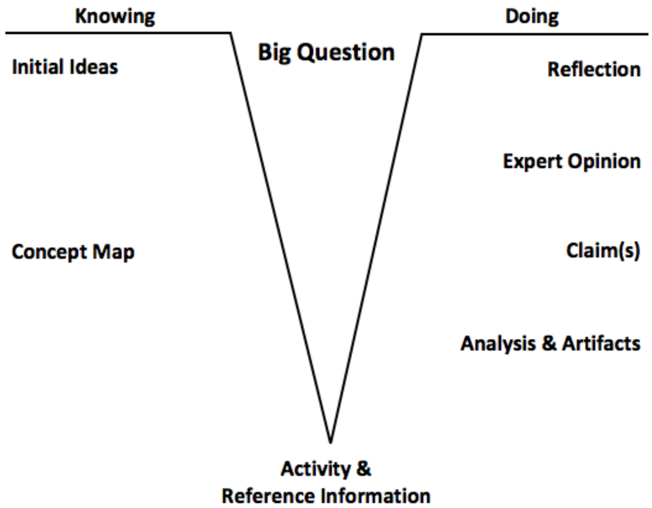

Figure 1 *Vee diagram (Novak & Gowin, 1984)*

2.3. The significance of the study

Geometry results of TIMSS (Third International Mathematics and Science Study) and PISA (Program for International Student Assessment) show that Turkey is far below the international average. In TIMSS 2011 that was designed to measure the mathematics and science achievement levels of the primary school students at international level on the basis of programs, teaching methods, schools, and countries, Turkey ranked 35th among 50 countries in the 4th grade and ranked 24th among 42 countries in the 8th grade. It came 34th among 8 countries. In the human development index, Turkey is mostly at the same low level as its neighboring Middle East countries and some African countries.

Another noteworthy result of TIMSS 2011 is the negative relationship between mathematics homework and mathematics achievement. The students doing more mathematics homework had poorer mathematics performance. This finding indicates that teachers must review the content of mathematics homework and the time allocated to do such homework (Yayan & Berberoğlu, 2004). With mind maps, homework which students enjoy doing and improves their creativity may be given. In this way, the limitedness of mathematics teaching to school is stopped.

Constructive approach is based on students' constructing new knowledge upon their prior knowledge under the guidance of their teachers. However, those students who cannot achieve a complete understanding of the basic concepts of mathematics commit errors that are difficult to correct on their way to acquiring new knowledge. For example, a teacher who tries to teach the relationship between the central angle and the inscribed angle of a circle through discovery learning fails to achieve perfect teaching when a student whom s/he tells to draw a circle and a central angle or an inscribed angle on the board cannot draw them even if s/he makes the student find out the relationship eventually. Therefore, before new knowledge is constructed, students should be enabled to acquire these concepts perfectly.

In this study, an attempt was made to make students give up their traditional note-taking habits. The concepts associated with the subjects were introduced a the beginning through mind maps instead of having students write long sentences on their notebooks during teaching. In addition, the students drew mind maps on related subjects. Colorful and illustrated mind maps were presented so that students could recall the subjects better, learn them permanently, and notice the relationships between the concepts associated with the subjects.

It is frequently observed that although students say that they have understood a subject taught in a lesson lasting 40 to 45 minutes, they fail to use what they know while solving problems. At this point, vee diagrams can be helpful. In the present study, an attempt was made to teach the students how to make principles, theories, and concepts usable by means of vee diagrams.

2.4. The aim of the study

This study aims to determine whether or not teaching polygons to middle school 7th grade students using mind maps and vee diagrams is influential on the students' achievement and the permanence of knowledge.

2.5. Problem statement

Does the use of vee diagrams and mind maps in teaching polygons have any influence on students' academic achievement and the permanence of their knowledge?

To find an answer to this research question, an attempt was made to answer the below-mentioned sub-questions:

1) Does the use of vee diagrams and mind maps in teaching polygons have any influence on students' academic achievement?
2) Does the use of vee diagrams and mind maps in teaching polygons have any influence on the permanence of students' knowledge?
3) What are the views of experimental group students about vee diagrams and mind maps?

The present study is limited to activities conducted based on constructivist learning, vee diagrams, and mind maps.

3. Method

Pretest-posttest control group model, which is a semi-experimental model, was used. A pretest-posttest control group model has two groups (i.e. an experimental group and a control group) formed through random sampling. Pre-experimental and post-experimental measurements are carried out (Karasar 2003).

3.1. Study group

Study group consisted of 39 seventh grade students attending Merkez Cumhuriyet Primary School located in Atkaracalar district of Çankırı province and Çardaklı Regional Primary Boarding School located in Çardaklı town of Çankırı province in the 2010-2011 academic year**.** The experimental group consisted of 19 students, 11 of whom were females. The control group consisted of 20 students, 10 of whom were females.

3.2. Developing the data collection tools

The researcher prepared an achievement test to obtain quantitative data. The below-mentioned steps were followed in preparing this test:

1. Objectives associated with polygons included in the Ministry of National Education (2010) middle school 7th grade teacher's guide were reviewed.
2. Textbooks, supplementary books, and test books involving these objectives about polygons were reviewed.
3. The views of five primary school mathematics teachers were received by interviewing.
4. Master's thesis on polygons and data collection tools used in them were reviewed.
5. Based on the views of experts, a 35-question achievement test was prepared in accordance with Bloom's taxonomy.
6. A pilot study was conducted with 100 eight grade students attending 2 schools in the province where the present study was carried out.
7. The results of the pilot study were analyzed via Statistical Package for the Social Sciences 14.0 (SPSS), and the reliability and the difficulty of the test were determined.
8. Based on the data obtained from the pilot study and the views of experts, a 25-question achievement test was prepared finally to be used as pretest, posttest, and permanence test in accordance with Bloom's taxonomy.

The validity of the achievement test that was prepared to be used as pretest, posttest, and permanence test was determined based on the views of experts. 10 questions were removed from the test administered to the participants of the pilot study. The distribution of the questions in the finalized test in terms of objectives is given in the chart below.

Table 1

The distribution of the questions in the test in terms of which objectives

Objective 1	1, 2, 3, 4, 5, 8, 10, 11, 15, 22, 25
Objective 2	6, 7, 12, 13, 16, 17, 18, 19, 21, 24
Objective 3	3, 5, 9, 10, 14, 19, 20, 23, 25
Objective 4	3, 5, 8, 9, 10, 14, 20, 23, 25

Objective 1. Determining the diagonals as well as the internal and external angles of polygons.

Objective 2. Determining the edge, angle, and diagonal features of quadrilaterals.

Objective 3. Calculating the sum of the interior angle measures of polygons.

Objective 4. Defining the regular polygon and calculating angle measures.

The questions whose removal from the test would increase its reliability were removed from the test based on the data obtained from the pilot study and the expert views. The Cronbach's alpha reliability coefficient of the achievement test which was reduced to 25 questions was found to be 0.883, which was considered adequate to indicate its reliability.

Vee diagrams were developed to provide the experimental group students with intended objectives. In preparing these materials, diagrams covering the objectives included in the 7^{th} grade mathematics teacher's guide were formed in the first place. The control group students, on the other hand, were taught using the activities included in the MONE(2010) Ministry of National Education Primary school 7^{th} grade mathematics textbooks.

The interview questions about mind mapping and vee diagramming are as in the following:

What aspects of the concept mapping technique did you like?

What aspects of the concept mapping technique did not you like?

Did the use of concept maps help you on the subject of polygons? Explain your answer.

Did you like creating concept maps in groups? Explain your answer.

What aspects of the vee diagramming technique did you like?

What aspects of the vee diagramming technique did not you like?

Did the use of vee diagrams help you on the subject of polygons? Explain your answer

Did you like creating vee diagrams in groups? Explain your answer.

3.3. Pre-experimental Equivalence of the Groups

Findings concerning whether or not there was a significant difference between the average number of correct answers of the experimental group students and that of the control group students are given below in order to statistically show that the two groups were equivalent.

To choose the appropriate statistical technique, the number of the correct answers given by the experimental group students and that of the control group students were separately subjected to normality tests. *Table 2* shows the results of the normality tests on the data obtained from the experimental group students and the control group students. *Table 3* demonstrates whether or not there is a significant difference between the average number of the correct answers of the experimental group students and that of the control group students in the pretest.

Table 2

Pretest normality results

Pretest	Shapiro-Wilk		
	Statistic	Df	Sig.
Experimental group	.781	17	.001
Control group	.904	20	.048

Shapiro- Wilk test was carried out in order to understand whether or not the number of the correct answers of the experimental group students in the pretest and that of the control group students in the pretest had a normal distribution. Since the levels of significance of the tests performed on the data of both groups were lower than 0.05 (level of significance in the control group = 0.01; level of significance in the experimental group = 0.048) ($p<.05$), distribution was seen to be non-normal. Thus, Mann Whitney U test, which is a non-parametric test and the equivalent of the unrelated t-test, was used for determining whether or not there was a significant difference between the average number of the correct answers of the experimental group students in the pretest and that of the control group students in the pretest.

Table 3
Findings concerning the corrects answers of students in the pretest for measuring mathematics achievement

Group	N	Mean Rank	Rank Sum	U	P
Control	20	35.36	434.50	155.50	0.336
Experimental	19	35.80	345.50		

As is clear from the table 3, there was a little difference (0.56) in favor of the control group between the arithmetic averages of the pre-test scores of the experimental group students and the control group students. Mann Whitney U test was carried out via SPSS 14.0 in order to determine whether or not such difference was a significant one. The test indicated no significant difference between the number of the correct answers of the experimental group students in the pretest and that of the control group students in the pretest ($U=155.5$, $p>.05$).

3.4. Data collection procedures

Two groups were formed in this study. One of the groups was taught in a teaching environment based on mind mapping and vee diagramming while the other group was taught in a teaching environment arranged based on the principles of the approach adopted in the curriculum of the ministry of national education (i.e. activity-based constructivist approach). The data were collected by administering the measurement tool prepared by the researcher to these groups before and after teaching. Control group t-test model was used. *Table 4* presents the experimental design employed in the study.

Table 4
Data gathering processes

Stages	Duration
Giving information about mind maps and vee diagrams	2 course hours
Teaching the subject (the experimental group and the control group)	12 course hours

Before teaching, the experimental group students were informed about mind maps for 2 course hours, and they were requested to draw mind maps. In this way, the students who had not heard of this method before had information about it. Then introduction was made by drawing a mind map about polygons on the board. After that, the mind map drawn on the board was erased, and the students who were provided with empty papers and colored pencils were asked to draw their own mind maps on the subject taught. The subject was divided into 3 subtitles, and the students were asked to do the same thing (i.e. drawing a mind map) 3 times (i.e. once for each sub-title). In other words, the students were made to draw mind maps under 3 subtitles: elements of polygons, quadrilaterals, and regular polygons. Vee diagrams were used at the problem-solving stage. A vee diagram was drawn on the board, and the problem was solved by putting a focus question in the middle. Separate vee diagrams were prepared for examples (questions) involving the essence of the subject. They were distributed to the students for them to achieve a better comprehension of the subject.

The experimental group students worked individually throughout the research. This is because each mind map was meaningful for the individual preparing it. The objectives focused on in the control group were handled based on the activities included in the ministry of national education primary school 7th grade mathematics textbooks. At the end of lessons, assignments in the workbooks were given to the students for them to comprehend the subject better.

After teaching was completed, the achievement test was simultaneously administered to the control group students and the experimental group students as posttest. Ten weeks after the completion of teaching, the same test was administered to the control group students and the experimental group students as permanence test. The obtained data were analyzed and interpreted via SPSS 14.0.

4. Findings

This section of the paper includes the statistical analyses of the data collected from the tests carried out before and after teaching in order to answer the research question and the sub-questions as well as the results obtained through the interpretation of such analyses.

4.1. Findings concerning the first sub-question

To find an answer to this sub-question, two-way ANOVA for repeated measures was used to compare the posttest scores of the experimental group students and those of the control group students. *Table 5* presents the arithmetic averages of the pretest scores and the posttest scores of the experimental group students and those of the pretest scores and the posttest scores of the control group students as well as their standard deviations. *Table 6* gives the results of two-way ANOVA for repeated measures.

Table 5
Arithmetic averages and standard deviations of the pretest and the posttest scores of the experimental group students and the control group students

Group	Pretest			Posttest		
	N	$\overline{X}$	S	N	$\overline{X}$	S
Control	20	35.36	18.3	20	53.40	22.1
Experimental	19	35.80	18.6	19	69.89	18.3

As can be seen in the table above, the arithmetic average of the scores achieved by the control group students in the pretest was 35.36. Their arithmetic average increased up to 53.40 in the posttest. The arithmetic average of the scores achieved by the experimental group students in the pretest was 35.80. However, their arithmetic average increased 69.89 in the posttest. It is clear that the average scores of both groups increased through teaching, which indicates the effectiveness of both traditional approach and the use of mind mapping and vee diagramming. However, the difference between the pretest and the posttest averages of the experimental group students who were taught using mind maps and vee diagrams (34.09) was higher than the difference between the pretest and the posttest averages of the control group students who were taught through traditional method (18.04). The difference occurring in the experimental group was 16.05 higher than that occurring in the control group in the posttest.

Table 6 below shows that the factors demonstrating measurements carried out in the experimental group and the control group at different times (pretest and posttest) were found to have a significant joint effect on the academic achievement levels of the participants ($F_{(1,37)} = 20,61; p<,05$).The change in the academic achievement levels of the experimental group students to whom polygons were taught through vee diagrams and mind maps was significantly different from that in the academic achievement levels of the control group students to whom polygons were taught through traditional approach. This difference in the academic achievement levels of the students may have resulted from vee diagrams and mind maps.

Table 6
The results of two-factor ANOVA for repeated measures concerning the pretest and the posttest scores of the experimental group students and the control group students

The Source of Variance	Tests	KT	SD	KO	F	P (Sig.)
Test	Pretest-posttest	26052.923	1	26052.923	192.348	.000
test * group	Pretest-posttest	2791.540	1	2791.540	20.610	.000

Error (test)	Pretest-posttest	5011.537	37	135.447		

4.2. Findings concerning the second sub-question

To find an answer to this sub-question, the results of the posttest and the results of the permanence test administered to the experimental group students and the control group were subjected to normality test in the first place (the permanence test normality of the control group: p=0.662; the permanence test normality of the experimental group: p=0.737; the posttest normality of the control group: p=0.432; and the posttest normality of the experimental group: p=0.986). After the normality of the test results of both groups was found to be over 0.05, two-factor ANOVA for repeated measures was conducted in order to determine whether or not the differences significantly varied between the groups. Tables 7 and 8 indicate the results of two-factor ANOVA for repeated measures.

Table 7

Arithmetic averages and standard deviations concerning the posttest and the permanence test scores of the experimental group students and the control group students

Group	Posttest			Permanence test		
	N	$\overline{X}$	S	N	$\overline{X}$	S
Control	20	69.89	18.34	20	65.89	20.84
Experimental	19	53.40	22.14	19	43.20	14.36

Table 8

The results of two-factor ANOVA for repeated measures concerning the posttest and the permanence test scores of the experimental group students and the control group students

The Source of Variance	Tests	KT	SD	KO	F	P (Sig.)
Test	Posttest-permanence test	2010.256	1	2010.256	23.604	.000
test * group	Posttest-permanence test	374.544	1	374.544	4.398	.043
Error (test)	Posttest-permanence test	3151.200	37	85.168		

The data in the first row of the table show a significant difference between posttest and permanence test scores regardless of groups (p=.000). *Table 8* (test*group) indicates that the factors demonstrating measurements carried out in the experimental group and the control group at different times (posttest and permanence test) were found to have a significantly different joint effect on the permanence scores of the participants ($F_{(1,37)} = 4,398; p<,05$). This result implies that the difference between the posttest and the permanence test scores of the control group students was significantly different from that between the posttest and the permanence test scores of the experimental group students. Thus, it can be said that vee diagrams and mind maps used in the teaching of polygons to the experimental group students were influential on permanence.

4.3. Findings concerning the third sub-question

The third sub-question was as follows: “What are the views of experimental group students about vee diagrams and mind maps?”. *Table 9* presents the analysis of the answers given by 7 students, who were randomly chosen from among 19 students in the experimental group, to the interview questions about mind mapping and vee diagramming.

The featured themes about the positive sides of mind maps are permanence (f=5) and facilitating learning (f=4). Within the scope of these two themes, one student, called as Student 5, (S5) stated, “We have learned subjects more easily. In this way, more things have remained in our minds.” Some other benefits of the use of mind maps expressed by the students are multiple representations (f=3), pleasure (f=3), constructing (f=3), meaningful learning (f=2), and summarizing (f=1). S4 highlighted the visual representation of mind maps and emphasized multiple representations by saying, “They have enabled me to comprehend the subject because we learn based on pictures rather than doing rote learning.” S6 stressed the pleasure given by mind maps as follows: “…It is better than writing. Lessons are more enjoyable.” Focusing on the theme of constructing, S7 told, “The use of mind maps has helped. This is because we have achieved a better understanding by drawing mind maps.” S2 stated, “It has helped me understand the subject. I used to be afraid of failing to solve a problem when I saw it. Such fear of mine has gone away thanks to mind maps.” With this statement, S2 indicated that mind maps both promoted meaningful learning and helped him overcome his fear of mathematics. The benefits expressed by the students are consistent with the objectives of mathematics education set forth in the ministry of national education middle school mathematics curriculum (2013). The students did not mention any negative side of mind mapping.

Table 9
The students' views about the use of mind maps and vee diagrams

	Mind maps	Vee diagrams
Positive Sides	• Permanence (f=5) • Facilitating learning (f=4) • Multiple representations (f=3) • Taking pleasure (f=3) • Constructing (f=3) • Meaningful learning (f=2) • Overcoming fear of mathematics (f=1)	• Active learning (f=3) • Permanence (f=3) • Promoting learning (f=4) • Allowing discussion (f=1) • Getting rid of rote learning (f=1)
Negative Sides	• Nothing (f=6) • Unanswered (f=1)	• Time-consuming (f=1)

The featured themes about the positive sides of vee diagrams are promoting learning (f=4), active learning (f=3), permanence (f=3), allowing discussion (f=1), and getting rid of rote learning (f=1). S4 said, “They have enabled me to reach the information and to learn more by discussing with my friend on experimental claims and data transformations.” Thus, he pointed out that vee diagrams provided an active learning environment based on discussion. With regard to the themes of promoting learning and permanence, S3 said, “We write formulas in questions. These formulas are put into our minds. As a result, we do not forget them.” S7 told that they did not have to memorize formulas thanks to vee diagrams. He spoke as follows: “We write information on the side and so we can look at it to see what to do.” The only theme about the negative sides of vee diagrams is “time-consuming”.

5. Conclusion and Discussion

The below-mentioned results were obtained based on the findings of the present study, which was carried out in order to determine whether or not teaching polygons to primary school 7th grade students through vee diagrams and mind maps is influential on students' achievement and the permanence of knowledge:

1. There was a significant difference between the achievement levels of the experimental group students taught by use of vee diagrams and mind maps and those of the control group students.
2. Teaching of polygons to primary school 7th grade students through vee diagrams and mind maps has higher influence on students' achievement in comparison to the traditional method.
3. The results of the permanence test carried out 4 weeks after the end of teaching indicated a significant difference between the achievement levels of the experimental group students and those of the control group students.
4. All the experimental group students responding to the written interview delivered positive views about vee diagramming and mind mapping. The students who stated that lessons in which these techniques were used were more enjoyable, so they would like to have these techniques in other courses, too.

The findings of the present study about vee diagramming and mind mapping are consistent with those of Steyn and

Boer (1998), Longhurst (2002), Ferrand et al. (2002), and Shameen, Rafik and Jasvir (2004) focusing on mind maps, those of Tiskus (1992), Lebowitz (1998), Nakiboglu et al. (2002), and Atılboz and Yakışan (2003) concentrating on vee diagrams, and those of Bütüner (2006) dealing with mind maps and vee diagrams.

In the light of the research findings listed above, the following recommendations are made:

Meaningful learning tools should be used in mathematics lessons for giving preliminary information as a whole. Traditional note-taking can be replaced by mind mapping in note-taking in primary schools. Mind mapping can reveal that those students who do not give any piece of answer in their exam papers actually learn most of the subjects taught. Though the right learning approach has been adopted, assessment tools which still include classic questions or placement test-oriented multiple choice questions are not adequate. Therefore, perfect learning is not achieved. This method which allows students to put most of their ideas about a subject in paper may be used as an assessment instrument besides its usage as a learning tool. To ensure the permanence of knowledge, mind maps can be created for each mathematics subject through elaborative reasoning on subjects. This is because the more interesting are mind maps, the more permanent gets the learnt knowledge. Mind map assignments through which students can improve their creativity and revise subjects can be given instead of traditional and boring homework. Vee diagramming technique may be used at the problem-solving stage so that students can use their theoretical knowledge. It was seen that the use of different techniques in class makes teachers and students closer and positively influences the attitudes of students towards courses. Thus, teachers and pre-service teachers should be informed about these methods.

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