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THE EFFECT OF MODEL BASED LEARNING ON THE ACADEMIC SUCCESS AND CONCEPTUAL UNDERSTANDING OF MIDDLE-SCHOOL STUDENTS ON THE SUBJECT OF THE PARTICULATE NATURE OF MATTER[1]

MODELE DAYALI ÖĞRENMENİN ORTAOKUL ÖĞRENCİLERİNİN MADDENİN TANECİKLİ YAPISI KONUSUNDAKİ AKADEMİK BAŞARILARINA VE KAVRAMSAL ANLAMALARINA ETKİSİ

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Abstract

The purpose of this research is to determine the effect of learning based on models on the academic success and conceptual understanding of middle-school students on the subject of the particulate nature of matter. In the research, the single group pretest-posttest semi experimental design which is one of the quantitative research methods was used. The sample of the research consists of a total of 100 students 32 of whom are 6th grade, 33 are 7th grade and 35 are 8th grade students from state middle-schools in a city in the Aegean Region of Turkey receiving education in the 2009-2010 academic year, who were selected with the simple random sampling method. The data of the research were collected through the 'Evaluation Test for the Particulate Nature of Matter' (ETPNM) and 'Conceptual Test for the Particulate Nature of Matter' (CTPNM). In the analysis of data, the t test was used for the related samples. As a result of the research, it was determined that model based learning has a positive effect on the academic success and conceptual understanding of middle-school students on the subject of the particulate nature of matter. In addition, it was found that the effect of model based learning on conceptual understanding is more positive compared to its effect on academic success. In the light of the research findings, the importance of model based learning in the teaching of abstract concepts was underlined and suggestions were made to the researchers and science teachers.

Keywords: Model based learning, Particulate nature of matter, Academic success, Conceptual understanding

Öz

Bu araştırmanın amacı modele dayalı öğrenmenin, ortaokul öğrencilerinin maddenin tanecikli yapısı konusundaki akademik başarıları ve kavramsal anlamaları üzerindeki etkisinin belirlenmesidir. Araştırmada nicel araştırma yöntemlerinden tek gruplu ön test-son test yarı deneysel desen kullanılmıştır. Araştırmanın örneklemi 2009-2010 öğretim yılında Türkiye'nin Ege Bölgesindeki bir ildeki devlet ortaokullarından basit tesadüfi örnekleme yöntemi ile belirlenen 32 altıncı sınıf, 33 yedinci sınıf ve 35 sekizinci sınıf olmak üzere toplam 100 öğrenciden oluşmaktadır. Araştırmanın verileri "Maddenin Tanecikli Yapısı Değerlendirme Testi (MTYDT)" ve "Maddenin Tanecikli Yapısı Kavram Testi (MTYKT)" ile elde edilmiştir. Veri analizinde ilişkili örneklemler için t testi kullanılmıştır. Araştırma sonucunda modele dayalı öğrenmenin, ortaokul öğrencilerinin maddenin tanecikli yapısı konusundaki akademik başarılarını ve kavramsal anlamalarını tüm sınıf düzeylerinde olumlu yönde etkilediği belirlenmiştir. Ayrıca, modele dayalı öğrenmenin kavramsal anlama üzerindeki etkisinin akademik başarı üzerindeki etkisine göre daha olumlu olduğu bulunmuştur. Araştırma bulgularının ışığında soyut kavramların öğretiminde modele dayalı öğrenmenin önemi vurgulanarak araştırmacılara ve fen eğitimcilerine önerilerde bulunulmuştur.

Anahtar Kelimeler: Modele dayalı öğrenme, Maddenin tanecikli yapısı, Akademik başarı, Kavramsal anlama

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1. INTRODUCTION

The concepts related to chemistry in physical sciences are defined in three dimensions as macroscopic, microscopic and symbolic (Johnstone, 1993). The macro dimension is related to experiments and events; the micro dimension is related to mental images and structural formulas and the symbolic dimension is related to pictoral and algebraic formulae such as graphics and chemical formulas (Ebenezer, 2001; Özmen & Ayas, 2003). The events in the macro dimension consist of the shape, color, and state changes of matter; the events in the micro dimension consist of the movements of atoms and molecules, giving and receiving electrons and the events in the symbolic dimension consist of symbols of elements, formulas of compounds and chemical formulas (Singer & Wu, 2003). In the teaching of concepts related to chemistry, it can be possible for the students to accurately structure the concepts in their minds and form relationships between the concepts by giving place to all three dimensions together (Balushi, 2013; Novick & Nussbaum, 1981).

In the previous researches, it has been determined that students in all educational levels are successful in understanding the macro and symbolic dimensions but have difficulty in understanding the micro dimension and therefore have misconceptions about the particulate nature of matter which is the foundation of chemistry (Adadan, Irving, & Trundle, 2010; Okumuş, Öztürk, Doymuş, & Alyar, 2014; Özmen & Kenan, 2007; Paliç Şadoğlu & Sağlam Arslan, 2018; Smith & Villarreal, 2015; Yakmaci-Guzel, 2013). It was stated in these researches that the misconceptions about the particulate nature of matter also prevent the accurate understanding of subjects such as the states of matter (Ayas, Özmen, & Çalik, 2010; Nakhleh, 1992), heat (Pathare & Pradhan, 2010; Tanahoung, Chitaree & Soankwan, 2010), temperature (Sözbilir, 2003), expansion (Canpolat, Pınarbaşı, Bayrakçeken, & Geban, 2004), elements (Ayas & Demirbas, 1997), compounds (Şendur, 2012), mixtures (Costu, Ünal, & Ayas, 2007), ion (Ceyhun & Karagolge, 2005), chemical bonds (Özmen, 2004), chemical reactions (Özmen & Alipaşa, 2003), solubility (Smith & Nakhleh, 2011), solutions (Pinarbasi & Canpolat, 2003), solvation (Akgün, 2009), chemical balance (Banerjee, 1991; Kousathana & Tsaparlıs, 2002) and gases (Mayer, 2010) in the micro dimension.

It is stated that in the middle-school level, the use of models in the teaching of abstract concepts facilitates students' understanding of the subject (Güneş, & Çelikler, 2010; Harman, 2016; Wang, Chi, Hu, & Chen, 2014). In the literature, models are defined as *"the individuals' explaining and defining movements in verbal, written and other methods, taking the social structure of knowledge"* (Gobert & Buckley, 2000) and *"a simplified representation of a complex object or process"* (Harrison, 2001). It is stated that models facilitate the concretizing of seemingly complex events or abstract concepts (Gobert & Buckley, 2000) and since they do not reflect all the characteristics of the reality they represent, they cannot be regarded as an exact copy of reality and embody explanations which facilitate understanding of the reality they represent (Gobert & Buckley, 2000; Harrison, 2001). Since models address more than one sense organ, they allow students to understanding through doing and living things (Wang et al., 2014). It is stated that in the teaching of abstract subjects in the micro dimension such as the particulate nature of matter, the accurate use of models makes it easier for the students to associate the events in the macro dimensions and events and concepts in the micro dimension (Çavdar, Okumuş, Alyar, & Doymuş, 2016). Model based learning is defined as a process of creating mental models related to a system or an event. What is attempted to be done at schools is to help students change or develop the pre knowledge or mental models which they have prior to learning in accordance with the scientific models presented by scientists. In this respect, modeling can be regarded as thought process as well (Harrison & Treagust; 1998). Therefore, what makes model based learning different from the other learning environments which require the use of models is that it triggers creating mental models by thinking through structural, functional and causal mechanisms (Gobert & Pallant, 2004).

In other researches, it has been determined that model based learning used in teaching the particulate nature of matter positively affects the middle-school students' academic success and that it is efficient in reducing their misconceptions about the concepts related to the subject (Arslan & Doğru, 2014; İnal & Aydın, 2015; Merritt, Krajcik, & Shwartz, 2008; Schwarz & White, 2005; Oliva, Aragon, & Cuesta, 2015). In Schwarz and White's research (2005), it was also determined that in model based learning environments, students who participate in creating scientific models and testing these better understood the nature of models and better comprehended the concepts in these applications. In another research, it was determined that in teaching the particulate nature of matter, the students in the experiment group where model based teaching was implemented better understood the subject compared to the students in the control group (Merritt et al., 2008). Arslan and Doğru (2014) determined the effect of model based teaching of the matter and heat unit in the 6th grade students' understanding of the subject, their level of remembering the subject, their mental models and creativity. As a result of the research, it was determined that the creativity and mental models of the students in the experiment group in which model based teaching was implemented positively developed compared to the students in the control group. In a research in which the effect of model based learning on the academic success and the permanence of knowledge of 6th grade students was analyzed, it was determined that use of models increased the success of the experiment group students and positively affected the permanence of the learned knowledge (İnal & Aydın, 2015).

In certain researches which dealt with the teaching of the particulate nature of matter in model based learning environments, computer animations were used. In these researches, it was concluded that the students better comprehended the events in the microscopic dimension and that their mental models about the events in this dimension developed and their misconceptions were removed (Herga, Glazar, & Dinevski, 2015; Karaçöp & Doymuş, 2013; Kunduz, & Seçken, 2013; Liu, 2006; Özmen, 2011; Pekdağ, 2010; Smith & Villarreal, 2015). In some other researches in which model based learning was used in teaching particulate nature of matter, bead models were used to make it possible for the students to better understand granular structures in the macro dimension (Çavdar & Doymuş, 2018; Okumuş, & Doymuş, 2018; Öztürk, 2017). It was concluded that the bead models used in these researches were effective in helping the students to better understand the particulate nature of matter. In the literature, researches in which computer animations were used together with bead models in model based learning environments were not come across. In the middle-school level, it is considered that the use of different models together in the process of model based learning will allow the students to better comprehend the particulate nature of matter. In this respect, colored bead models which represent atoms or molecules in the macroscopic dimension were used together with computer animations. It is considered that conducting the research with all the grades of middle-school (between the ages of 12-14) and the use of both computer animations and bead models in the model based learning environment are important. The results to be obtained from the research are expected to contribute to the science education literature.

In this research, it was aimed at determining the effect of model based learning on the academic success and understanding of concepts of middle-school students about subject of the particulate nature of matter. In line with this aim, the answers to the following questions were sought:

1. Does model based learning have any effects on the academic success and understanding of the concepts of 6th grade students about subject of the particulate nature of matter?
2. Does model based learning have any effects on the academic success and understanding of the concepts of 7th grade students about subject of the particulate nature of matter?
3. Does model based learning have any effects on the academic success and understanding of the concepts of 8th grade students about subject of the particulate nature of matter?
4. How does model based learning effect the academic success of middle-school students about subject of the particulate nature of matter in terms of their grade levels?
5. How does model based learning effect the conceptual understanding of middle-school students about subject of the particulate nature of matter in terms of their grade levels?

2. MATERIALS and METHODS

2.1. Research Model

This research was carried out using the single grouped pretest-posttest semi experimental design which is one of the quantitative research methods. In this experimental design, the measurements of the subjects consisting of a single group in terms of the dependent variable are obtained using the same measurement tolls as pretest prior to the process and as posttest after the experimental process (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz, & Demirel, 2016). The single group pretest-posttest semi experimental design is one of the weakest experimental designs. However, in researches in which a new educational or learning approach for the students is applied, preferring the single group experimental design is stated to result from the nature of the research (Creswell, 2012).

2.2. Population and Sampling

The population which was reached in this research consists of 5th, 6th, 7th and 8th grade students receiving education at state middle-schools located in a city in the Aegean Region of Turkey in the 2009-2010 academic year. The sample of the research was determined through the simple random sampling method which is one of the sampling methods based on probability. In this sampling method, the probability of each unit forming the population to be included in the sampling is the same. In other words, the units have a chance of being selected equally as independent from each other (Karasar, 2016; Ural & Kılıç; 2006). In this respect, the sampling of the research consists of randomly chosen 32 6th grade students, 33 7th grade students and 35 8th grade students from the population.

2.3. Data Collection Tools of the Research

In the research, the 'Evaluation Test for the Particulate Nature of Matter' (ETPNM) was used to determine the effect of model based learning on the academic success of middle-school students about the particulate nature of matter and the and 'Conceptual Test for the Particulate Nature of Matter' (CTPNM) was used to determine its effect on the students' conceptual understanding on the same subject. The content validity and construct validity of both tests were provided by consultation with two faculty members expert in the field of science education. According to expert opinions, it was agreed that the tests included the outcomes in the science program, and that the 6th, 7th and 8th grade students were sufficient to determine the academic success and conceptual understanding of the particulate nature of the matter.

2.3.1. Evaluation test for the particulate nature of matter (ETPNM)

The test which consists of 20 multiple choice questions aims at determining the success levels of the students' related to the dimensions of the particles which make-up matter, their weight, compound and energy in different states of matter and state change events. In each false choice in the questions, there are misconceptions frequently seen in the literature about the particulate nature of matter. The original of the test was applied to 72 students and the Cronbach's alpha coefficient value was determined as .78 (Yezierski & Birk, 2006). In this research, the English form of the test was translated into Turkish by the researchers. The Turkish translation was analyzed by two academicians competent in both languages and an English teacher and the necessary corrections were made through the comparison with the original test text. The test was applied to 135 9th grade students and the Kuder-Richardson 20 (KR-20) reliability coefficient was determined as .79. Since the KR-20 value being .70 and over is acceptable for the reliability of the measurement tool (Tan, 2014), it can be stated that ETPNM is reliable. While the students who marked the correct choice in the evaluation of the test data, the students who marked the false choice and left the question unanswered did not receive any points. The highest score which can be received from the test was determined as 20 and the lowest as 0.

2.3.2. Conceptual test for the particulate nature of matter (CTPNM)

The conceptual test consisting of 5 multiple choice questions was prepared by Sarıkaya (1996) by taking into consideration the misconceptions in the literature about the subject. Each question in the test consists of visuals related to the appearance of the state change in matter such as pins, coal, mothballs and mercury which the students can frequently see in their daily lives or the appearance of particulate structure after physical events such as hitting and crashing. The test aims at determining the students' level of comprehension about physical events about the matter they see in their daily lives in the atomic and molecular level. The test was applied to 135 9th grade students and the Kuder-Richardson 20 (KR-20) reliability coefficient was determined as .80. Since the KR-20 value being .70 and over is acceptable for the reliability of the measurement tool (Tan, 2014), it can be stated that CTPNM is reliable. While the students who marked the correct choice in the evaluation of the test data, the students who marked the false choice and left the question unanswered did not receive any points. The highest score which can be received from the test was determined as 5 and the lowest as 0.

2.4. Analysis of Data

In the research, it was determined whether the students' pretest and posttest scores displayed normal distribution prior to the analysis of data. In case the sample size is lower than 35, it is suggested to use the Shapiro-Wilk normalcy test (Shapiro & Wilk, 1965).

According to the results of the Shapiro-Wilk normalcy test analysis, it was determined that the *p* value of the students' pretest and posttest scores was over α=.05 in all grade levels and thus the scores were obtained as a result of normal distribution (Mertler & Vannatta, 2005). Therefore, the t test which is a parametrical test used in the analysis of the students' pretest and posttest for the related samples. The scores which the students received from the tests were evaluated over 100 and their success levels were interpreted as low for the 0-44 score interval; as medium for the 45-69 score interval and as high for the 70-100 score interval.

2.5. The Application Duration of the Research

In the research, 1 lesson duration (40 minutes) was given to the students to answer the ETPNM and CTPNM pretests consisting of a total of 25 questions. The students were given information about how to answer the questions. The model based learning application process of the research was carried out in three weeks and in 4 lessons each week. In the teaching of the concepts of atoms, molecules, elements and compounds which are a part of the particulate nature of matter and the particulate structure in physical and chemical change events, computer animation models were used. In model based teaching related to the questions in the CTPNM, black, white, blue and yellow colored beads representing coal, pins, mothballs, mercury and their particles were used together with computer animation models. In the application related to the questions in CTPNM, the students were asked what structure makes up coal and the students were given time to think and answer the question. Then, the students were asked, "When a piece of coal is hit by a hammer, what would be the final state of the single carbon atom inside it?", a piece of coal was hit with a hammer and the students were asked about their observations. The students were asked to visualize what would happen if a piece of coal was broken down numerous times. The black beads representing the carbon atoms in coal were put in a cup and the students were asked what they observed when the beads were hit with a hammer. A majority of the students stated that the beads changed places. When they were asked, "Did anything happen to the single carbon atom in the coal?" a majority of them replied that nothing happened to the bead representing the carbon atom and that it simply changed its place. Similarly, in the case of hitting a pin with a hammer, putting a solid mothball inside a tube and liquefied by melting it with candle flame, the students were asked what would happen to the atoms or molecules making up these matter. Then, the students were allowed to interact with the beads models representing the particles of these matter and it was made possible for the students to understand that the changes which take place in the outer appearance of the matter resulting from physical changes do not create a change in the microscopic dimension. In addition to these applications in the lesson, computer animation models representing the appearance of matter which go through physical change in the atomic dimension. After the model based teaching process, the ETPNM and CTPNM were applied as posttest.

3. Results

3.1. Results Related to the Effect of Model Based Learning on 6th Grade Students' Academic Success and Conceptual Understanding on the Subject of the Particulate Nature of Matter

Prior to and after the model based learning process, the changes in the scores of 6th grade students from the ETPNM and CTPNM were analyzed using the t test for the related samples. The results of the analysis are presented in Table 1.

Table 1. The t Test Results of the Related Samples in Terms of the ETPNM and CTPNM Pretest and Posttest Scores of 6th Grade Students

Test		**N**	**M**	**SD**	**df**	**t**	***p***	**Change (%)**
ETPNM	Pretest	32	8.88	4.34	31	9.28	.00	53.83
	Posttest	32	13.66	2.68				
CTPNM	Pretest	32	0.75	1.24	31	13.17	.00	412.00
	Posttest	32	3.84	0.92				

According to the analysis in Table 1, there is a significant difference between the pre and post ETPNM success of the 6th grade students [$t_{(31)}$ = 9.28, p < .05]. While the score average of the students from the ETPNM in the pretest was (M = 8.88) 44.40 (low) over 100, after the model based learning process (M =13.66) it reached 68.30 (medium) points over 100. The rate of increase in the students' academic success was determined as 53.83%.

According to Table 1, there is a significant difference between the pre and post CTPNM success of the 6th grade students [$t_{(31)}$ = 13.17, p < .05]. While the score average of the students from the CTPNM in the pretest was (M = 0.75) 15.00 (low) over 100, after the model based learning process (M = 3.84) it reached 76.80 (high) points over 100. The rate of increase in the students' academic success was determined as 412.00%. The changes in the scores the 6ht grade students received from pre and post ETPNM and CTPNM are shown in Figure1.

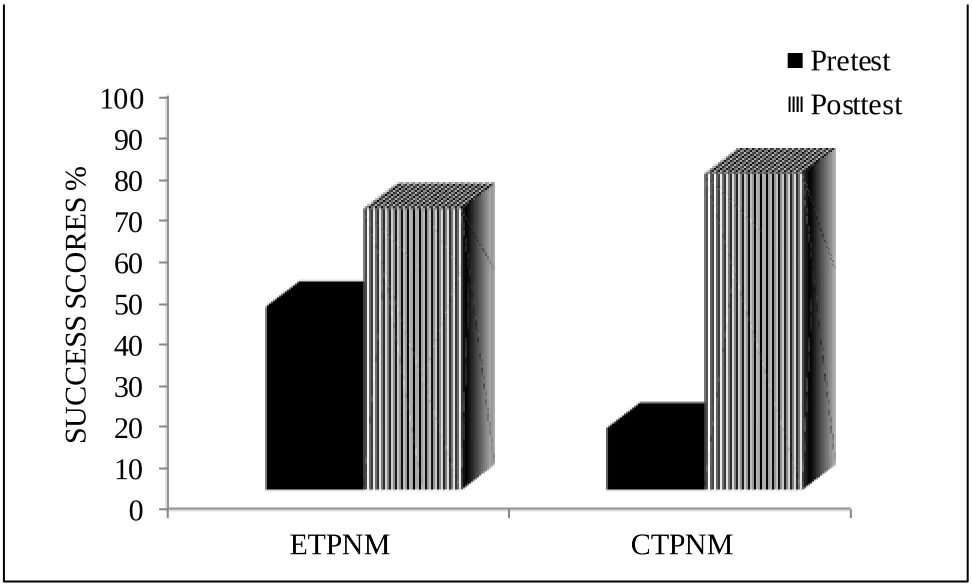

Figure 1. The Effect of Model Based Learning on the Academic Success and Conceptual Understanding of the 6th Grade Students

According to the graphics in Figure 1, it can be seen that model based learning positively affects both the academic success and the conceptual understanding of the students. In addition, it can be stated that the effect of model based learning on the conceptual understanding of the students is greater compared to its effect on their academic success.

3.2. Results Related to the Effect of Model Based Learning on 7th Grade Students' Academic Success and Conceptual Understanding on the Subject of the Particulate Nature of Matter

Prior to and after the model based learning process, the changes in the scores of 7th grade students from the ETPNM and CTPNM were analyzed using the t test for the related samples. The results of the analysis are presented in Table 2.

Table 2. The t Test Results of the Related Samples in Terms of the ETPNM and CTPNM Pretest and Posttest Scores of the 7th Grade Students

Test		N	M	SD	df	t	*p*	Change (%)
ETPNM	Pretest	33	10.73	3.95				
	Posttest	33	13.79	3.55	32	9.95	.00	28.52
CTPNM	Pretest	33	1.58	1.95				
	Posttest	33	3.79	1.24	32	8.75	.00	139.87
		33	17.58	4.48				

According to the analysis results in Table 2, there is a significant difference between the pre ETPNM and post ETPNM success of the 7th grade students [$t_{(32)} = 9.95$, $p < .05$]. While the score average of the students from the ETPNM in the pretest (M = 10.73) was 53.65 (medium) over 100, after the model based learning (M = 13.79), it reached 68.95 (medium) points over 100. The rate of increase in the students' academic success was determined as 28.52%.

According to the analysis results in Table 2, there is a significant difference between the pre CTPNM and post CTPNM success of the 7th grade students [$t_{(32)} = 8.75$, $p < .05$]. While the score average of the students from the CTPNM in the pretest was (M = 1.58) 31.60 (low) over 100, after the model based learning process (M = 3.79), it reached 75.80 (high) points over 100. The rate of increase in the students'' conceptual understanding was calculated as 139.87%. The changes in the scores the 7ht grade students received from pre and post ETPNM and CTPNM are shown in Figure 2.

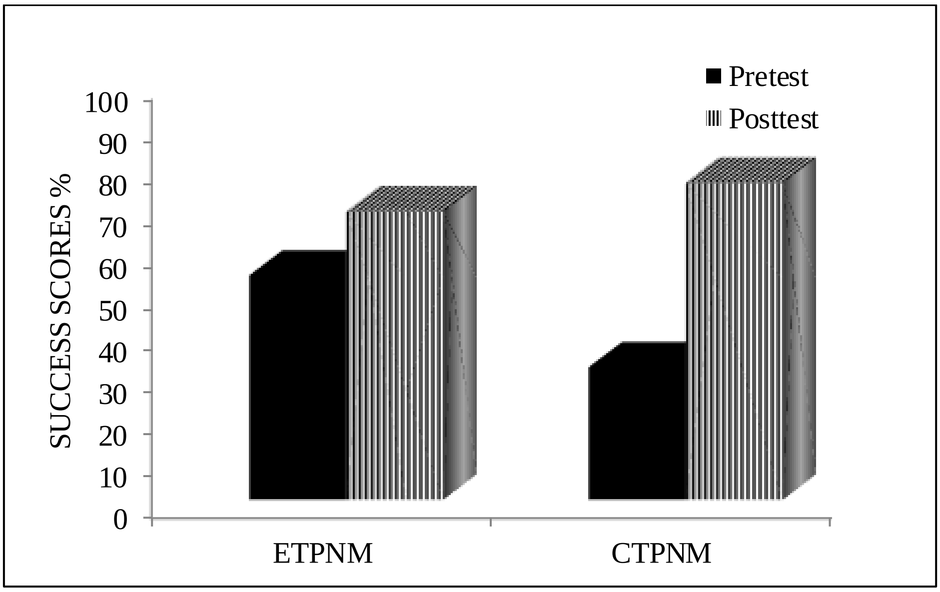

Figure 2. The Effect of Model Based Learning on the Academic Success and Conceptual Understanding of the 7th Grade Students

According to the graphics in Figure 2, it can be seen that model based learning positively affects both the academic success and the conceptual understanding of the students. In addition, it can be stated that it can be stated that the effect of model based learning on the conceptual understanding of the students is more positive compared to its effect on their academic success

3.3. Results Related to the Effect of Model Based Learning on 8th Grade Students' Academic Success and Conceptual Understanding on the Subject of the Particulate Nature of Matter

Prior to and after the model based learning process, the changes in the scores of 8th grade students from the ETPNM and CTPNM were analyzed using the t test for the related samples. The results of the analysis are presented in Table 3.

Table 3. The t Test Results of the Related Samples in Terms of the ETPNM and CTPNM Pretest and Posttest Scores of the 8th Grade Students

Test		**N**	**M**	**SD**	**df**	**t**	***p***	**Change (%)**
ETPNM	Pretest	35	10.89	2.68				
	Posttest	35	14.77	1.97	34	16.07	.00	35.63
CTPNM	Pretest	35	0.86	1.17				
	Posttest	35	3.74	1.07	34	14.44	.00	334.88
		35	18.51	2.16				

According to the analysis results in Table 3, there is a significant difference between the pre ETPNM and post ETPNM success of the 8th grade students [$t_{(34)} = 16.07$, $p < .05$]. While the score average of the students from the ETPNM in the pretest (M = 10.89) was 54.45 (medium) over 100, after the model based learning (M = 14.77), it reached 73.85 (high) points over 100. The rate of increase in the students' academic success was determined as 35.63 %.

According to the findings in Table 3, there is a significant difference between the pre CTPNM and post CTPNM success of the 8th grade students [$t_{(34)} = 14.44$, $p < .05$]. While the score average of the students from the CTPNM in the pretest was (M = 0.86) 17.20 (low) over 100, after the model based learning process (M = 3.74), it reached 74.80 (high) points over 100. When the rate of increase in the students'' conceptual understanding was calculated, it was seen that it increased in the rate of 334.88%. The changes in the scores the 8th grade students received from pre and post ETPNM and CTPNM are shown in Figure 3.

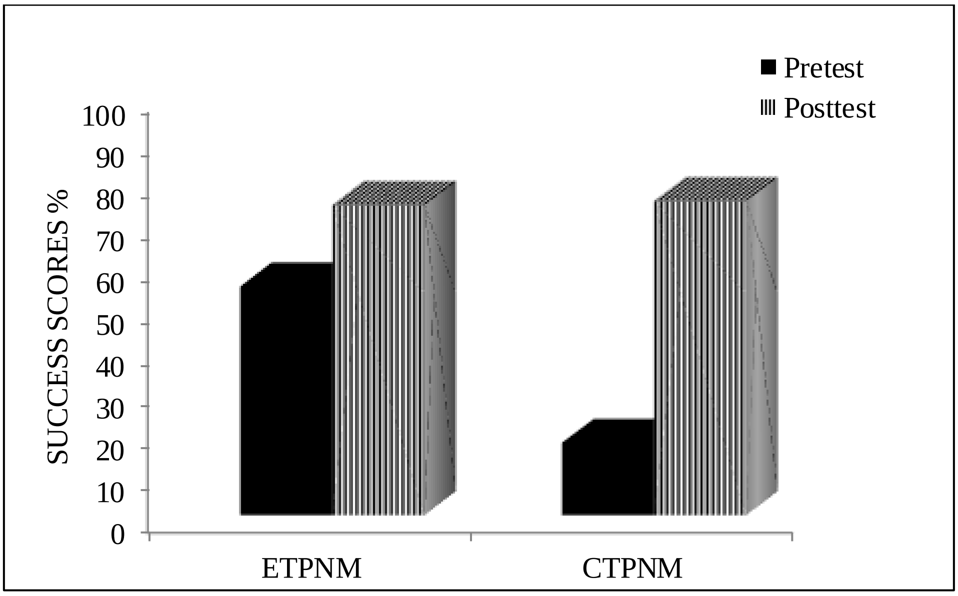

Figure 3. The Effect of Model Based Learning on the Academic Success and Conceptual Understanding of the 8th Grade Students

According to the graphics in Figure 3, it can be seen that model based learning positively affects both the academic success and the conceptual understanding of the students. In addition, it can be stated that it can be stated that the effect of model based learning on the conceptual understanding of the students is more positive compared to its effect on their academic success.

3.4. Results Related to the Effect of Model Based Learning on the Academic Success of Middle-School Students in Different Grades on the Subject of the Particulate Nature of Matter

In order to determine how model based learning affects the students' academic success on the subject of the particulate nature of matter in terms of grade levels, the success scores the 6th, 7th and 8th grade students received from the ETPNM were evaluated over 100 points and the success change rate related to pre and post tests are presented in Figure 4.

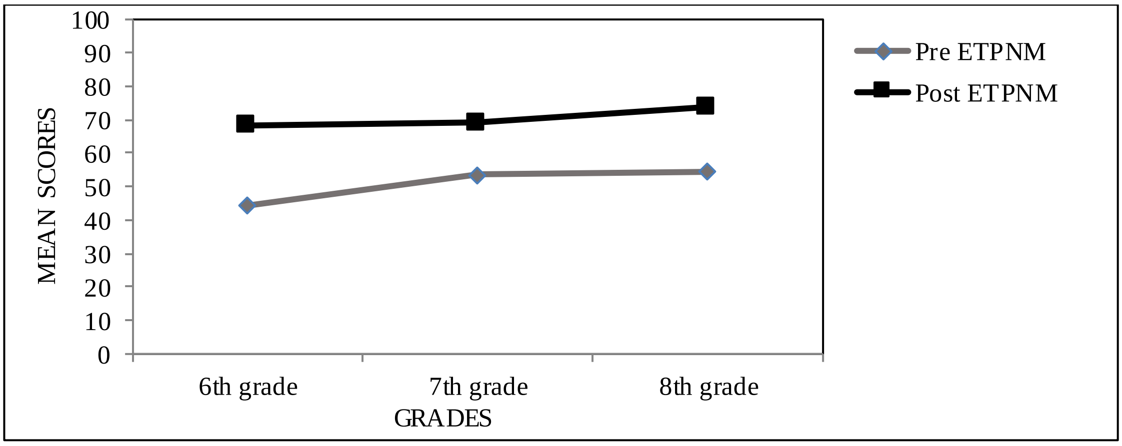

Figure 4. The Effect of Model Based Learning on Academic Success in Terms of Grade Level

According to the graphics in Figure 4, as the grade level of the students' increases, the effect of model based learning on academic success increases as well. In other words, as the age of the students increases, their understanding of the subject particulate nature of matter becomes easier. The effect of model based learning on the academic success of the students on the subject of the particulate nature of matter in terms of grade levels was determined as 54% in 6th grade students, 29% in 7th grade students and 36% in 8th grade students. The reason for the increase rate in the academic success levels remaining below 40% in 7th and 8th grade students is considered to be the students' being familiar with this teaching method or having learned their physical sciences lessons from different teachers through different methods.

3.5. Results Related to the Effect of Model Based Learning on the Conceptual Understanding of Middle-School Students in Different Grades on the Subject of the Particulate Nature of Matter

In order to determine how model based learning affects the students' conceptual understanding on the subject of the particulate nature of matter in terms of grade levels, the success scores the 6th, 7th and 8th grade students received from the CTPNM were evaluated over 100 points and the success change rate related to pre and post tests are presented in Figure 5.

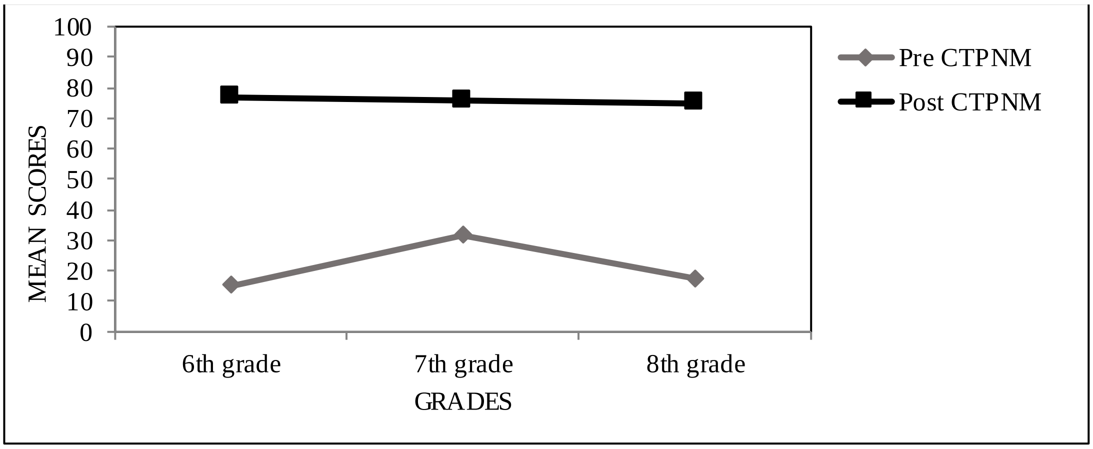

Figure 5. The Effect of Model Based Learning on Conceptual Understanding in Terms of Grade Level

According to the graphics in Figure 5, the effect of model based learning on the student's conceptual understanding on the subject of the particulate nature of matter in terms of grade level was determined as 412% in the 6th grade students, 140% in the 7th grade students and 335% in the eighth grade students. The average increase rate in the students' conceptual understanding was determined as 296%. According to this, it was determined that the increase rate in the conceptual understanding of the 7th grades remained the average rate of increase. While the 8th graders' pre CTPNM success was (M = 0.86), the 7th graders' pre CTPNM success was (M = 1.58). Despite this striking change in the pretest, it was seen that the increase in the success level of the 8th grade students is twice the success level of 7th grade students. Therefore, it can be concluded that abstract thinking increases as age increases and that abstract concepts are better understood.

4. DISCUSSION and CONCLUSION

As a result of the research, it was determined that model based learning positively affects the academic success and conceptual understanding of middle-school students on the subject of the particulate nature of matter in all grade levels. It is considered that during the process of teaching the subject of the particulate nature of matter, using materials such as coal, pins and mercury and colored bead models representing the atoms of these materials along with computer animated models play a significant role in the result obtained in the research. In the other researches in the literature, it has been concluded that model based learning increases the academic success of the students on the particulate nature of matter and reduces their misconceptions related to the subject (Adadan, 2006; Arslan & Doğru, 2014; Barnea & Dori, 2000; İnal & Aydın, 2015; Merritt, Krajcik, & Shwartz, 2008; Schwarz & White, 2005; Oliva, Aragon, & Cuesta, 2015

In the research, in the teaching process related to the content of the questions in ETPNM used to measure academic success, computer animation models were used. As a result of the research, it was determined that an average of a 40% increase took place in the ETPNM success of the students. Similar to this finding, in other researches in which computer animation models were used in the teaching of the particulate nature of matter, it was concluded that the mental models of the students about the events in the microscopic dimension developed, their misconceptions were removed and their rate of academic success increased (Ardaç & Akaygün, 2004; Herga, Glazar, & Dinevski, 2015; Karaçöp & Doymuş, 2013; Kunduz, & Seçken, 2013; Liu, 2006; Özmen, 2011; Pekdağ, 2010; Smith & Villarreal, 2015; Wu, Krajcik, & Soloway, 2001). It can be stated that the computer animation models used in the research are effective in the students' understanding of subjects such as how the change in the states of matter, break-up and fracture take place in the macroscopic and microscopic dimensions. It is stated that when three dimensional animations are used, students are able to fully understand concepts related to chemistry in the microscopic dimension such as molecular structures and reaction mechanisms (Ebenezer, 2001).

In the research, in the teaching process related to the content of the questions in CTPNM used to measure academic success, computer animation models were used together with colored bead models representing the particles of matter mentioned in the questions. As a result of the research, the average increase rate in the students' conceptual understanding was calculated as 353%. As a result, it was determined that the effect of model based learning on the conceptual understanding of the students is more positive compared to their academic success. In this respect, it can be stated that the use of computer animation models together with models such as colored beads models which the students can interact by touching is more efficient in increasing conceptual understanding on the particulate nature of matter. It is considered that as a result of the students' interaction through seeing and touching the bead models used in the environment of model based learning, they were able to concretize abstract concepts in an easier manner and that their level of conceptual understanding increased. In parallel to the results of this research, it is reported in the results of other researches in which models and modeling were used that the models give students the opportunity to experience events or situations through seeing and interacting and that this makes it easier for them to concretize abstract concepts (Adadan, 2014; Develaki, 2017; Kimberlin & Yezierski, 2016). Although there are no researches in the literature in which computer animation models are used together with colored bead models, it was concluded that hand-made models and bead models which are used to make students understand granular structures in the macro dimension positively affects the conceptual understanding of students (Çavdar & Doymuş, 2018; Kim, 2008; Sarıkaya, 2007; Okumuş, & Doymuş, 2018; Öztürk, 2017).

In the research, the effect of model based learning on academic success and conceptual learning was evaluated in the terms of the grade levels of the students. As a result of the research, it was determined in general that as the grade level increases, the effect of model based learning on academic success also increases. In this respect, it can be stated that as age increases, it becomes easier for the students to learn the subject of the particulate nature of matter. In Krnel's research (2013), it was determined similar to this finding that students aged 11 and over who are learning about abstract concepts better comprehend abstract science concepts such as granular structures compared to students who are younger. In the research, it was determined that the increase in the academic success rates of 7th and 8th graders remained below the average success increase rate. It is considered that this finding is related to the students' being familiar with this teaching method or having learned their physical sciences lessons from different teachers through different methods.

As a result of the research, it was determined that the conceptual understanding of the students displayed differences in terms of grade level and that as a result of model based learning, the highest increase in conceptual understanding was seen in the 6th graders and that they were followed by the 8th and 7th graders. It was determined that the conceptual understanding of the 8th graders in the pretest was significantly lower, their success increase rate in the post test is twice the success increase rate of 7th graders. It is considered that the low level of success in conceptual understanding of 8th graders in the pretest might be a result of getting prepared to high-school entrance exams or having taken the physical sciences lessons from different teachers through different teaching methods.

The findings of the research have shown that model based learning and the models used in the research are effective in the students' understanding of the macroscopic and microscopic dimensions of the particulate nature of matter and the relationships between these dimensions. In this respect, it can be concluded that the use of models which students can actively interact with in learning environments are important in terms of making it possible for students to understand the particulate nature of matter in a clear and accurate manner.

5. RECOMMENDATIONS

This research is limited with 100 middle-school students receiving education at state middle-schools in a city located in the Aegean Region in Turkey and the model based learning approach in which computer animation models were used together with colored bead models in teaching the subject of the particulate nature of matter. The researchers can determine the effect of model based learning on learning types by using different models and different measurement tools in different countries, different grade levels and teaching different subjects. In the light of the findings obtained in the research, it is suggested to physical sciences teachers to (1) identify the pre knowledge of their students prior to teaching them about the concepts of atoms and molecules which make up matter and the basic foundation of matter; (2) to use model based learning applications more frequently and in a more efficient manner in teaching the concepts related to microscopic chemistry and (3) to use computer animation models together with models such as hand-made or bead models and create a chance for the students to do applications with the models.

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