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EXAMINING THE FIFTH GRADERS' UNDERSTANDING OF HEAT AND TEMPERATURE CONCEPTS VIA CONCEPT MAPPING

KAVRAM HARİTALARI YARDIMI İLE BEŞİNCİ SINIF ÖĞRENCİLERİNİN ISI VE SICAKLIK KONUSUNDAKİ KAVRAMLARI ÖĞRENİMİNİN İNCELENMESİ

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ABSTRACT: This study investigated the effect of concept mapping over traditional instruction on students' understanding and retention of heat and temperature concepts. The sample of this study consisted of 5th grade students from two classes of a elementary school (n=75). One intact class was randomly assigned to the comparison group whereas the other one was randomly assigned to the experimental group. During teaching the topic of heat and temperature concepts in earth science curriculum, the experimental group was taught with the concept mapping instruction while the comparison group was taught with the traditional instruction. The results revealed that the students in the experimental group performed better on heat and temperature concepts. However, it has been found that there was no significant difference between experimental and control group on students' retention scores of heat and temperature concept test.
Keywords: concept mapping, heat and temperature concepts, science education

ÖZET: Bu çalışmada, kavram haritalarının, geleneksel yönteme kıyasla öğrencilerin ısı ve sıcaklık kavramlarını anlaması ve kalıcılığına etkisi araştırılmıştır. Çalışmanın örneklemini bir ilköğretim okulunun iki farklı beşinci sınıfındaki 75 öğrenci oluşturmuştur. Rastgele seçilen sınıflardan biri deney grubu olarak atanırken, diğer grup karşılaştırma grubu olarak atanmıştır. Isı ve sıcaklık kavramlarının öğrenimi sırasında, deney grubu öğrencilerinde kavram haritaları kullanılmış, karşılaştırma grubu öğrencilerinde ise geleneksel öğrenim yöntemleri kullanılmıştır. Sonuçlar göstermiştir ki, deney grubu öğrencileri, ısı ve sıcaklık kavramlarını anlamada daha iyi performans göstermişlerdir. Fakat bunun yanı sıra deney ve kontrol grubu öğrencileri arasında bu kavramların kalıcılığı konusunda anlamlı bir farklılık görülmemiştir.
Anahtar Sözcükler: kavram haritaları, ısı ve sıcaklık kavramları, fen eğitimi

1. INTRODUCTION

Over the last two decades a great amout of educational research has focused on the ideas that students have in relation to scientific concepts (Butler & Cahyadi, 2004; Driver, 1981; Driver, 1983; Eryılmaz, 2002; Marohn, & Harrison, 2006; McComas, 1997; Savinainen, Scott, & Viiri, 2004; Scmidt, Kwon Anderson & Smith, 1987; Postner, Strike, Hewson, & Gertzog, 1982; Thijs & Dekkers, 1998). It is now well established that during their experiences in everyday life, children develop their own ideas, which they use to make sense of the natural phenomena they experience in the world around them. According to Piaget, students construct new knowledge on their previous cognitive structures (Piaget, 1969). Therefore, students may generate different meanings from upcoming information due to their different cognitive structures. Students' interpretations of observed phenomena and information obtained from school experiences were sometimes found to be scientifically incorrect and significantly different from the ideas which their teachers intended to convey. Alternative views were given in various terms including "children science" (Gilbert, Osborn, & Fensham, 1982; Osborn, Bell & Gilbert, 1983) "alternative frameworks", (Driver & Easly, 1978; Driver & Ericson 1983), "naive beliefs" (Caramazza, McCloskey, & Green 1981) "preconceptions", (Anderson & Smith, 1987; Arons, 1997) , "misconceptions" (Cho, Kahle, & Nordland, 1985), common sense beliefs (Champagne, Klopfer, & Anderson, 1980) and "misapplications" (Elby, 2001).

Since new knowledge is constructed on the base of existing cognitive structure, misconceptions have to be dispelled in order to prevent new ones developing. Students' misconceptions may be so resistant to change that traditional instruction may be inadequate to change those with scientific concepts (Anderson & Smith, 1987; Driver & Easly, 1978; Fredette & Lockhead, 1980; Osborn &

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Wittrock, 1983). Without the same conceptual framework as the teacher, students are unable to derive the intended meaning from instruction. Thus, in general, getting the students understand the concept is very difficult. Identification of misconceptions is needed to develop strategies that provide students with accurate conceptual knowledge required for scientific problem solving. The instruction should be designed in such a way that it accounts for students' initial conceptions and especially their misconceptions. The present study was concerned primarily with students' misconceptions and with instructional strategies to affect the learning of scientific conceptions, and to affect the conceptual change from alternative to scientific conception. That requires accommodation of new ideas, reorganizing or replacing existing conceptions. This is called the process of conceptual change (Smith, Blakeslee, & Anderson, 1993). Posner, Strike, Hewson, and Gertzog postulated four conditions that are necessary for conceptual change to occur: (a) there must be dissatisfaction with the existing conception (that is, prior concept must be inadequate to solve existing problem), (b) the new conception must be intelligible (that is, conception must be understandable), (c) the new conception must appear initially plausible (that is, it must be useful in solving the problems), (d) the new conception must be fruitful (that is, it must be useful in solving future problems) (Posner, Strike, Hewson and Gertzog, 1982).

One of the most successful techniques based on conceptual change approach is the use of concept mapping. Concept mapping, best displays the intricate and complex relations among the concepts of heat and temperature that are involved in an understanding of earth science. These concepts are also intertwined with other major concepts of science. Concept maps also indicate gaps in these interrelations as well as weak understandings. This technique requires students to identify important concepts and show interrelationships among them. Therefore, it allows students to give a personal meaning to subject content thinking in multiple directions. It means that students realize the link among concepts. In this way, concept mapping is helpful in promoting meaningful learning. In 1990, Okebukola found that concept mapping led to the meaning learning of genetics and ecology concepts. Moreover, results of the study performed by Heinze-Fry and Novak (1990) provided evidence that concept mapping enhances meaningful learning in an introductory biology course. Horton, McConney, Gallo, Wood, Senn, and Hamelin (1993) investigated the effectiveness of concept mapping as an instructional tool.

Science courses require students to do a lot of memorizing. It can be a challenge for instructors of such courses to encourage students to go beyond rote memorization of an understanding of processes and a view of the picture. The heat and temperature is one of the units in earth science as a school subject. Studies in the science education aimed at determining students' understanding of heat and temperature have revealed many misconceptions (Hapkiewichz, 1992; Jasien & Oberem, 2002; Kesidou & Duit, 1993). Hapkiewichz (1992) studied misconception of elementary school students on heat and temperature and defined many misconceptions. One significant misconception of students reported in this study was the belief that "All liquids boil at 100^0C and freeze at 0^0C". Another identified misconception was the notion that heat is not energy. Students participated in this study believed that the temperature of objects depends on size and boiling point is the maximun temperature a substance can reach. Another prevalent misconception was the idea that heat is a substance. Kesidou and Duit (1993) carried out a research with 34 10^{th} grade students about students' conceptions of second law of thermodynamics. The results of the study confirmed the findings of other studies that concern students' difficulties in understanding energy concept and distinction between heat and temperature. Moreover, students believed that heat only travels upward and they also thought that ice has no temperature. Jasien and Oberem (2002) studied elementary concepts in heat and temperature among college students and K-12 teachers. In their study they pointed out that participants in the research have misconceptions related to thermal equilibrium, heat capacity and specific heat. That is, they confused about a number of concepts, such as, the meaning of thermal equilibrium, the physical basis for heat transfer and temperature change, and the relationship between specific heat, heat capacity and temperature change. Understanding the heat and temperature concepts influences students' understanding of other science topics.

1.1. Misconception Studies in Turkey

There have been many studies concerning misconceptions in Turkey. Bilgin et al. (2001 had conducted a study that aimed to determine misconceptions of third grade Lycee students about chemical equilibrium. Researchers found some misconceptions about chemical equilibrium, balance in chemical equilibrium, changing the conditions of equilibrium and addition of catalizor. Sungur et al.(2000) did a study concerning the contribution of conceptual change texts accompanied with concept mapping to students' understanding of human circulatory system. Results revealed that there was a significant contribution of conceptual change texts accompanied with concept mapping on students'understanding of human circulatory system. The students' in experimental group performed better on human circulatory system concepts. Yurd (2007) carried out a study to remove the fifth grade students' misconceptions in the topic of "light and voice" at Science and Technology course by using the Know- want-sample-learn strategy. The findings of the study proved that the most of the misconceptions of the experimental group students were removed. That is, understanding of experimental group students were better than the control group students.

Recent studies in science education have showed that teaching strategies based on conceptual change approach have been effective at dispelling students' misconceptions (Champagne, Gunstone, & Klopfer, 1985; Nussbaum & Novick, 1982). Some studies showed that concept mapping, one of the conceptual change approaches, caused a significantly better acquisition of scientific conceptions and elimination of alternative conceptions (Sungur, Tekkaya, & Geban, 2001). However, it must be pointed out that students utilizing conceptual change approach did not have excellent understanding of scientific conceptions after instruction (Hynd, Mcwhorter, Phares, & Suttles, 1994). Therefore, there is a great deal of room for improvement in effecting conceptual change from existing alternative conceptions. It is clear that still further experimentation needs to be carried out to explore ways in which the potential of conceptual change approach in the educational field may be more effectively realized.

2. METHOD

2.1. Purpose

The main theme of this study was the explanation of the effectiveness of the concept mapping over traditional instruction on the 5^{th} grade students' understanding and retention of the heat and temperature concepts.

2.2. Subjects

The participants of this study were 75 5^{th} grade students from the two intact classes of the same teacher in a elementary school in Hatay. Participants were belonged to middle-class families. The school where the study was conducted was a public school. Students began to study science at 4^{th} grade with one life and one earth science unit. Before 4^{th} grade, they took a course where science and social science topics were taught together. Students' ages ranged from 11 to 12 years old. Each of two modes of instruction was randomly assigned to two intact classes. True experimental research design was used in the study. The experimental group received the concept mapping instruction while the comparison group was exposed to the traditional instruction. The data were analyzed for 38 students in the experimental group and 37 students in the comparison group.

2.3. Instruments

Heat and Temperature Concepts Test (HTCT). In order to assess students' understanding of heat and temperature concepts, a 20 items multiple-choice test was developed by researchers. During the developmental stage of the test, first, the instructional objectives of the unit heat and temperature were stated. This step was carried out to define the content of the test. Then, students' conceptual difficulties, and misconceptions were identified from previous studies in literature, and interviews with science teachers. The most common misconceptions of heat and temperature used in the test were stated (see Table 1). Items of the test were constructed with respect to misconceptions obtained from literature and interviews carried out with the science teachers about heat and temperature concepts. Each item of the test included one correct answer and three distracters that reflected students' misconceptions related to topic of heat and temperature.

Table 1: List of Students' Misconceptions about the Topic of Heat and Temperature

1. Objects of different temperature that are in contact with each other, or in contact with air at different temperature, do not necessarily move toward the same temperature.
2. Ice has no temperature.
3. All liquids boil at 1000C and freeze at 00C.
4. Heat is not energy.
5. The temperature of objects depends on size.
6. Boiling point is the maximum temperature a substance can reach.
7. Heat is a substance.
8. Heat only travels upward.
9. 'Joule' and 'calorie' is types of temperature unit.
10. Heat and temperature are same.
11. Heat is measured by thermometer.
12. Calorimeter measures the temperature.
13. Heat is the average kinetic energy that the particulars of matter have.
14. Centigrade degree (0C) is the unit of heat.
15. Heat rises.

A group of expert in assessment, and science education and also science teacher examined the test for the appropriateness of the items as the extent to which the test measures a representative sample of the domain of tasks with respect to the heat and temperature unit of science course. The internal consistency reliability of the test was found to be .77. The final form of test was administered as pre test before treatment, post test after treatment and retention test one month later after administering post test.

2.4.Treatment

This study was conducted over a 4-week period during which the topics related to the heat and temperature concepts were covered as a part of the regular curriculum in the science course. A total of 75 5th grade students were enrolled in two science classes in a elementary school. In this study, 2 groups, pretest-posttest design was utilized in order to determine the effectiveness of the two different instructional methods: concept mapping and conventional large group. The comparison group classroom was exposed to the traditional large group science instruction, whereas the experimental group was instructed using the concept mapping instruction. The lessons for both groups were regularly scheduled as four 40-minute periods per week.

The teacher-directed strategy represented the customary instruction used in the traditional group. In this group, the teacher provided instruction through lecture and note-taking to teach the concepts. The students were asked to read their textbook before coming to class. The teacher lectured to the students and asked questions. After the teacher's explanation, students took notes.

Students in the experimental group were exposed to concept mapping instruction in order to help students change their preconceptions or misconceptions with the scientific ones. Before treatment, teacher was trained, because she took on a facilitator role instead of being expert on topic in concept mapping instruction and she was offered a set of guidelines to help students gain experience in grasping the concepts. Prior to the beginning of concept mapping application, the concept mapping strategy was introduced to students. They were asked to do some exercises, such as filling a map, constructing a concept map, or drawing a concept map from given short passage. After that, the teacher lectured students about the topic of heat and temperature by focusing on relationships amount the concepts. The teacher was also encouraging students from creating links among the concepts through discussion and questioning. After teaching all concepts of heat and temperature topic, students were directed to construct their own maps to show interrelationships among the concepts, with the aim of further promoting meaningful learning. The concept maps were prepared by students were concerning the fundamental concepts of heat and temperature. While students were constructing their own maps, the teacher roamed the room, activated as a facilitator and answered some questions, made suggestions when needed.

3. RESULTS

In order to control students' previous learning in heat and temperature before the treatment, all of the students were asked to respond to pre-test (HTCT). The result indicated that no significant difference was found between the experimental and the comparison group in terms of learning heat and temperature concepts (t =0.42, $p > 0.05$) at the beginning of the treatment. The means and standard deviations of the pre and post-test results of variables were presented in Table 2.

Table 2: Means (M) and Standard Deviations (SD) of the Pre- and Post Test Results of the Heat and Temperature Concept Test (HTCT), Retention of Heat and Temperature Concepts Test (RHTCT).

	N	Pre-HTCT		Post-HTCT		RHTCT	
Group		**M**	**SD**	**M**	**SD**	**M**	**SD**
Experimental Group	38	8.4	3.22	15.05	2.67	14.21	3.97
Comparison Group	37	8.68	2.96	12.78	2.48	13.26	4.29

Statistics (t-test) was used to compare the effectiveness of two different instructional methods on the achievement obtained from the post-test scores after the treatment. The results indicated that there was a significant difference between the performance of students in the experimental group and of the students in the comparison group ($t = 4.76$, $p < 0.05$). Higher mean scores demonstrated by the experimental group indicated that the students taught by concept mapping instruction scored significantly better than students taught by the traditional instruction (Table 2).

The misconceptions reflected by the distracters of the items in Heat and Temperature Concepts Test were the common misconceptions. The average percent of correct responses of the experimental group was 74.85%, and that of the control group was 64.06%. When the proportion of correct responses and misconceptions determined by item analysis for both groups was examined, striking differences between the two groups in favor of the experimental group on several items were indicated. For example, one such items was related to the determine the unit of "joule and calorie". In this item students were asked to identify which one of the concept listed in question have unit of "joule and calori". 89.5% of the students in experimental group selected "heat", only 54.5% of the students in control group selected this correct response. The most prevalent misconceptions among students in the control group (35.1%) were that "heat is the average kinetic energy that the particulars of matter have" (see Misconception 13 in Table 1), and they believed that heat and temperature are the same meaning (see Misconception 10 in Table 1). The misconception reflected from this item indicated that most of the students in the control group failed to realize the differences between heat and temperature concepts. They did not recognize the definitions of heat and temperature. Also, there was an item assessing students' understanding the ways of measuring the amount of heat. In each alternative of this item, students were provided with one statement related to calorimeter and required to select the correct one. The desired response was that "Calorimeter measures the substance' amount of heat". A majority of the students (73.70%) in the experimental group answered this item correctly. However, the percentage of students in the control group selecting the correct response was 41.8%. another most prevalent misconception held by 38% of the students in the control group was that **"**Centigrade degree is the unit of heat" (see Misconception 14 in Table 1). The misconception reflected from this item indicated that most of the students in the control group, failed to realize the differences between measurement unit of heat and measurement unit of temperature. Another item reflecting the striking difference among students in the experimental group and the control group was related to definition of temperature. 68.4% of the students in the experimental group selected the correct response that "temperature is the average kinetic energy that the particulars' of matter have". Only 45.9% of the students in the control group selected this desired response. Crucial percentage of the control group (27%) even, believed that "heat is the average kinetic energy that the particulars' of matter have" (see Misconception 13 in Table 1). On the other hand, no significant difference existed in retention mean scores of heat and temperature concepts between the students taught with the conceptual mapping instruction and those taught with the traditional instruction ($t = 1.1$, $p > 0.05$).

4. DISCUSSION AND IMPLIMENTATIONS

The concept mapping instruction caused a significantly better acquisition of scientific conceptions and elimination of alternative conceptions than the traditional instruction. This result supports the notion that it is not easy to eliminate misconceptions just by employing traditional instructional methods. In the traditional instruction, the underlying principle was that knowledge resides with the teacher, and it is the teacher's responsibility to transfer that knowledge as fact to students. Among its many uses such as teaching and research, concept maps allow for evaluation of prior knowledge and diagnosis of alternative conceptions. The concept mapping definitely dealt with students' misconceptions while the traditional instruction did not. The concept mapping instruction required students to construct an alternative schema to replace the misconception schema. The method of dealing with these misconceptions was to use strategies of conceptual change designed to promote the acquisition of new conceptions as a consequences of the exchange and differentiation of the existing concepts and the integration of new conceptions with existing conceptions.

The greater success of students in experimental group can be explained as follows. Students in the experimental group were involved in activities that helped them revise their prior knowledge and struggle with their misconceptions for example making their own maps to think in multiple direction (Okebukola, 1990), to externalize all the relationships formed in their cognitive structure, and learn the heat and transfer topic meaningfully. Students' discussion of the concepts with the teacher during implementation could help the changing misconception with scientific ones. The instruction encouraged intensive teacher-student, student-student interaction. Discussion of the concepts could facilitate students' understanding as well as encourage their conceptual restructuring. However, students in the comparison group were not exposed to instructional methods that would help them realize the presence of certain misconceptions present in their minds and overcome these misconceptions. The traditional instruction in this study stressed lectures given by the teacher, use of textbooks. The teacher undertook the task of transferring knowledge to students. Also it would appear that a possible reason for the poor progress of the students in traditional instruction in acquiring scientific conceptions lies with the continued presence of the alternative conceptions in their conceptual framework.

On the other hand, both the experimental and the comparison groups did not show statistically different retention scores about "heat and temperature" concepts. Students in experimental group retention scores decreased one point below when it is compared to post test scores. However retention scores of control group increased one point above. Researcher discussed with teacher the posibble reasons for improvement in retention scores of comparison group students. After taking poor scores from post test, control group students studied a lot and improved their scores. This could be the social threat to internal validity which is the social pressures in the research context that can lead to retention test differences that are not directly caused by the treatment itself. Most of these threats occur because the various groups (e.g., program and comparison), or key people involved in carrying out the research (e.g., teachers and principals) are aware of each other's existence and of the role they play in the research project or are in contact with one another. Many of these threats can be minimized by isolating the two groups from each other. In this study isolating two classes from each other was not possible. This reason may have caused no significant difference between the groups in terms of the concept retention.

This study led to the identification of students' misconceptions and the elimination of misconceptions by using the concept mapping instruction. Well-designed concept mapping approach to science instruction represents an alternative approach to traditional method to remediate misconceptions. The instructional strategy has to be designed in such a way that the individual is convinced that the scientific conception is more useful than the existing alternative conception. Science educators must become more involved in developing and designing the optimum conceptual change strategies and the teachers should be informed about the application of conceptual change strategies in their classroom.

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GENİŞLETİLMİŞ ÖZET

Fen ve teknoloji dersleri öğrencileri ezbere itmektedir. Oysaki öğrencilere bilimsel süreçlerin öğretilmesini hedef alan ana derslerden biri olan fen ve teknoloji dersinin ezberden uzak işlenmesi gereklidir. Öğrencilerin bilimsel süreçleri anlaması ve günlük hayata uygulaması fen ve teknoloji dersinin ana hedeflerinden biridir. Isı ve sıcaklık konusu fen ve teknoloji dersinin bir konusudur. Fen bilimleri alanında yapılan birçok çalışma öğrencilerin ısı ve sıcaklık konusunda birçok kavram yanılgısına sahip olduğunu göstermiştir. Yapılandırmacı-oluşturmacı yaklaşımının da savunduğu gibi yeni bilgiler varolan bilgilerin üzerine yapılandırıldığı için yeni bilgilerin öğrenilmesi eski bilgilere Bğlidir. Öğrencilerin kavramlaı doğru öğrenebilmesi varolan kavram yanılgılarının yok edilmesine bağlıdır. Kavram yanılgılarının yok edilmesi çok zor olduğu için geleneksel öğretim yöntemleri kavram yanılgılarının giderilmesinde yetersiz kalmaktadır. Varolan kavram yanılgılarının giderilmesi için öncelikle yanılgıların ortaya çıkarılması gereklidir. Daha sonra etkin bir öğretim yöntemi ile bu kavramların değiştirilmesi gereklidir.

Bu çalışma öğrencilerin kavram yanılgılarını giderecek öğretim yöntemleri ve varolan kavram yanılgılarını bilimsel kavramlarla değiştirilmesini içermektedir. Kavram değişimi yeni fikirlerin akamadasyonu, var olan kavramların yeniden organizasyonu ve bilimsel kavramlarla değiştirilmesi anlamına gelmektedir. Bu sürece kavram değiştirme süreci denmektedir. Posner, Strike, Hewson ve Gertzog kavram değişiminin oluşabilmesi için dört şart belirlemiştir. 1. Varolan kavramla ilgili bir başarısızlık yaşanması (Varolan kavram problemi çözmeye yetmez ise). 2. Yeni kavramın anlaşılır olması. 3. Yeni kavramın mantıklı olması (Gelecekteki problemim çözümü için gerekli olmalı). 4. Yeni kavram verimli olmalı (Problem çözümünde kullanılmalı). Kavram değişimi yaklaşımında geleneksel yöntemlere alternative birçok yöntemle kavram yanılgılarının giderilmesi sağlanır. Kavram değişimi için kullanılan öğretim yöntemlerinden biri de kavram haritalarıdır. Bu çalışmada kavram haritaları ısı ve sıcaklık kavramları arasındaki bağları göstererek fen ve teknoloji dersinin anlaşılmasını kolaylaştırması hedeflenmiştir. Kavram haritaları ayrıca ilişkiler arasındaki boşlukları ve zayıf yanlarını gösterir. Bu teknik öğrencilerin önemli kavramları anlamaları ve kavramlar arasındaki ilişkileri tanımalarını sağlar. Böylece öğrencilerin kavramlar arasındaki bağları görerek konunun bir bütün halinde öğrenmesini sağlar. Bu nedenle çalışmanın ana amacı kavram haritalarının beşinci sınıf öğrencilerinin ısı ve sıcaklık konusundaki kavram yanılgılarının giderilmesindeki etkisi olarak beirlenmiştir. Çalışma müfredatta ısı ve sıcaklık konusu işlenirken dört hafta sürecinde yapılmıştır. Öğrencilerde genel olarak görülen kavram yanılgılarından bazıları şunlardır: Bütün sıvılar 100 derecede kaynak 0 derecede donar; Isı enerji değildir; Sıcaklık maddenin büyüklüğüne bağlıdır;

Kaynama noktası bir maddenin ulaşacağı maksimum sıcaklıktır; Isı bir maddedir; Isı sadece yukarı doğru hareket eder; Isı termometre ile ölçülür; Sıcaklık kalorimetre ile ölçülür.

Çalışma iki ilköğretim beşinci sınıfında okuyan 75 öğrenciye uygulanmıştır. Çalışmadaki katılımcılar orta sınıf gelir düzeyine sahip ailelerinin çocuklarından oluşmuştur. Öğrencilerde ısı ve sıcaklık konusundaki varolan kavram yanılgılarının giderilmesi için 20 çoktan seçmeli maddeden oluşan kavram yanılgısı testi geliştirilmiştir. Kavram yanılgısı testi geliştirilken gerekli olan kavram yanılgıları literature taraması ve fen ve teknoloji dersi öğretmeleri ile konuşularak elde edilmiştir. Test maddelerindeki çeldiriciler konu ile ilgili kavram yanılgılarından oluşturulmuştur. Veriler 38 deney ve 37 kontrol grubu öğrencisinden alınmıştır. Çalışmada iki grub öntest son test araştırma deseni iki öğretim yönteminin öğrencilerin ısı ve sıcaklık konusundaki kavram yanılgılarına etkisini anlamak için kullanılmıştır. Kontrol grubunda geleneksel düz anlatım yöntemi kullanılırken, deney grubunda kavram haritaları yöntemi kullanılmıştır. Yöntemler, grublara kırk dakikalık ders saatlerinde uygulanmıştır. Yöntemlerin, öğrencilerin ısı ve sıcaklık konusundaki kavramları anlamalarına etkisi t-test istatistik analizi ile test edilmiştir.

Sonuç olarak deney ve kontrol grubu öğrencilerinin arasında deney grubu lehine anlamlı farklılıkların olduğunu bulunmuştur. Yani kavram haritaları uygulanan deney grubu öğrencileri, geleneksel yöntemler uygulanan kontrol grubu öğrencilerine göre ısı ve sıcaklık kavram yanılgısı testinden daha yüksek notlar almışlardır. Bunun yanısıra, öğrencilerin kalıcılık test sonuçlarında anlamlı farklılık olmadığı görülmüştür. Bunun nedeni ise iç geçerlilik te yatmaktadır. Deney grubuna farklı bir öğretim yöntemi uygulandığını bilen kontrol grubu öğrencilerinin deney grubu öğrencilerinden daha başarılı olma isteği olarak değerlendirilebilir. Kavram haritaları deney grubu öğrencilerini ısı ve sıcaklık konusundaki kavram yanılgılarının gidelmesinde önemli rol oynamıştır. Bu da göstermektedir ki varolan kavram yanılgıları bilimsel kavramlarla değiştirilebilir. Kavram değiştirme yaklaşımı yöntemlerinden biri olan kavram haritaları kavram yanılgılarının yok edilmesi için geleneksel yöntemlere göre daha etkilidir. Sonuç olarak, iyi desenlenmiş kavram haritaları yaklaşımı fen ve teknoloji dersinde ısı ve sıcaklık konusu işlenirken varolan kavram yanılgılarının giderilmesi için geleneksel yöntemlere alternative olarak kullanılabilir.