Manisa Celal Bayar University Journal of The Faculty of Education
ISSN: 1309-8918

2024, Vol. 12, No:2

The Effect of Using Animated Concept Cartoons in Science Education on Students' Conceptual Understandings

Fen Eğitiminde Animasyon Destekli Kavram Karikatürleri Kullanımının Öğrencilerin Kavramsal Anlamaları Üzerindeki Etkisi

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Abstract

In this study, the effects of using animated concept cartoons on students' conceptual understanding were investigated using a quasi-experimental design with a pretest-posttest control group. The study was carried out with two experimentals and one control group in a secondary school in Demirci district of Manisa province, and a total of 51 students from three classes participated in the study. The lessons in Experimental Group 1 (n=17) were covered using animated concept cartoons while the lessons in Experimental Group 2 (n=17) were covered using concept cartoons. In the Control Group (n = 17), the lessons were carried out using only the activities in the science curriculum. The data were gathered from this study with conceptual understanding test about matter and heat unit. The study results revealed that the adjusted posttest scores of Experimental Group 1 and Experimental Group 2 did not significantly differ from each other regarding the level of conceptual understanding, whereas the scores of both experimental groups were significantly higher than the scores of the control group.

Keywords

1. Conceptual understanding
2. Alternative conception
3. Concept cartoons
4. Matter and heat

Başvuru Tarihi/Received 26.09.2024
Kabul Tarihi /Accepted 19.11.2024
Araştırma Makalesi / Research Article

Önerilen APA Atıf Biçimi/Suggested APA Citation:
Evrekli, E., & Balım, A. G. (2024). The effect of using animated concept cartoons in science education on students' conceptual understandings. *Manisa Celal Bayar University Journal of the Faculty of Education, 12*(2), 414–436. https://www.doi.org/10.52826/mcbuefd.1556259

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INTRODUCTION

Conceptual understanding can be defined as the entire structure that includes the concepts related to a specific subject and the relationships and patterns between concepts, which individuals have developed in formal and informal environments until then, whether or not they include alternative conceptions. Conceptual understanding allows individuals to construct scientific explanations in their minds (Seah, 2015). Conceptual understanding is characterized by the concepts of depth and breadth. Breadth can be defined as the extent of knowledge in a specific domain, while depth can be defined as the scientific principles that describe the relationships between concepts (Alao & Guthrie, 1999). The fact that the conceptual understanding is free from alternative conceptions is also of great importance for subsequent knowledge construction. In this process, individuals are expected to a) assimilate and associate new information and b) increase conceptual understanding by increasing their ability to distinguish between related and unrelated information (Alao & Guthrie, 1999). The individual examines the reasons for the events around him and tries to understand the nature in which he is located. The basis of the information created about nature is the inferences arising from our own observations (Bekar, Yıldız and Genç, 2023). Although students encounter a scientifically proven situation in the lesson, they can still keep their own conceptions in their minds (Uzoğlu & Gürbüz, 2013). Once alternative conceptions are learned, they become persistent in the science learning process and the learner needs to identify, reorganize, and sometimes develop existing conceptions to accommodate new ideas (Yip, 2004). In order to regulate alternative conceptions, students should be aware of their own scientific and alternative conceptions along with justification and evidence (She & Liao, 2010). Regardless of the source that may cause alternative understanding, one of the main goals of science education is for students to achieve meaningful learning away from misconceptions (Karapınar and Balım, 2023). Moreover, in this process, teachers should have sufficient and comprehensive knowledge of students' interests, existing understandings, and past experiences about the current subject to provide instruction based on students' prior conceptions (Morrison & Lederman, 2003). Science teachers who use conceptual change generally have to consider the alternative conceptions and pre-instructional experiences that students bring with them to the classroom for a good teaching and learning process (Chin, 2001). These alternative conceptions are often incompatible with scientific views. Science teachers should provide a teaching process that provides students with opportunities to develop their own understanding of a particular topic by changing their alternative conceptions (Tsui & Treagust, 2010). In order to eliminate learners' alternative conceptions, it is important to reveal their prior conceptions and use teaching strategies to eliminate them (Aydın, Aydemir, Boz, Çetin-Dindar, & Bektas, 2009). Piaget's cognitive constructivism theory, which includes assimilation, adaptation, and equilibrium processes, and Ausubel's theory of meaningful learning are two important elements in revealing alternative conceptions (Driver & Easley, 1978 as cited in Treagust & Duit, 2008). In particular, Piaget's clinical interview method provides a stepping stone for the in-depth investigation of students' understanding by focusing on thoughts about a scientific subject (Duit & Treagust 2003; Treagust & Duit, 2008). At this point, the extent to which the connections used to explain the information are in line with scientific views (reasoning) is more significant than the fact that the student expresses something in a way that is not scientifically correct. Teachers should identify students' existing knowledge with appropriate assessment tools (Alwan, 2011). It is thought that it is important to observe and evaluate how students make sense of the subject by using concept cartoon activities and the change in students' learning levels (Akbaş and Kılıç, 2023). Chin (2001) states that techniques such as concept maps, prediction-observation-explanation, thought experiments, interviews, drawings, questionnaires, student questions, brainstorming, worksheets, and concept cartoons can be used to reveal students' thinking and conceptual understanding.

Concept cartoons

Keogh and Naylor (1999) argue that concept cartoons are developed in relation to an event that is thought to take place in students' previous experiences in order to lead them to reflect scientific phenomena in their daily experiences. Moreover, these tools show scientifically acceptable perspectives in addition to the general misconceptions held by students from daily life (Chin & Teou, 2009). Concept cartoons, on the other hand, are visual tools that express a scientific event from daily life in the form of a discussion with the help of cartoon characters and offer different perspectives on the event (Akbaş and Toros, 2016). Concept cartoons are two-dimensional graphical drawings that have proven to be one of today's important learning and teaching strategies in many studies (Yıldız, 2023). The focus of concept cartoons is on situations from daily life that students are used to seeing in relation to their own experiences (Naylor & Keogh, 1999). Since the cartoon characters are in an equivalent position with respect to their perspectives, students are encouraged to discuss, reveal their thoughts, and confront their existing conceptions (Allen, 2006). Thus, concept cartoons can be interesting to students, especially as they involve cartoon characters, and they can play an active role in students' participation in the lesson. The students may be more willing to explain their own thoughts, especially when they see that their own thoughts are presented by the cartoon characters. Therefore, concept cartoons are educational tools that can be used to create conceptual change in an understanding based on the constructivist approach in science education (De Lange, 2009; Naylor & Keogh, 1999). In classroom environments where concept cartoons are used, students try to explain the situations they encounter in parallel with cognitive and social constructivism, often think about their explanations of their friends' opinions and actively participate in the cognitive conflict process. When students realize that they need to solve the discussion in the concept cartoon, they are invited to participate in further questioning following their discussions in order to integrate the discussion into the process as an aspect of scientific inquiry (Keogh, Naylor, & Downing, 2003; Naylor, Keogh, & Downing, 2007). While concept cartoons ensure students' participation in the lesson, they also provide permanent and meaningful learning through the imbalance-balance process it creates in their mental schemas (Uslu and Çakmak, 2021). After the cognitive conflict process, students can be directed to first-hand sources of information or experimentation to find the truth and find a solution to the problem. It is believed that this process may lead to more permanent learning in students' minds. In this regard, especially concept cartoons can be used to get an idea about what students know, what they learn, and their cognitive structures. According to Atasoy, Tekbıyık, and Gülay (2013), these tools can help students identify their prior knowledge and realize their misconceptions. Learning the concepts in some courses can be challenging for students, and students may confuse the concepts they learn (Karaduman and Ceviz, 2018). Korkmaz (2004) states that concept cartoons can be used to facilitate conceptual learning in small classes, to reveal students' preconceptions, and to determine what they have learned, as well as to discuss. It is well known that individuals constantly develop thoughts and explanations about their world (Keeley, 2013). It is thought that it is important to observe and evaluate how students make sense of the subject by using concept cartoon activities and the change in students' learning levels (Akbaş and Kılıç, 2023). With concept cartoons, students can easily express their thoughts in the classroom environment and have the opportunity to restructure their thoughts by comparing them with pluralistic perspectives (Şengül & Aydın, 2013). It can be argued that these tools are very useful in assessing students' prior learning, identifying alternative conceptions that emerge from the learning process through prior experiences and learning, attracting students' attention to the lesson, and providing social learning environments by creating a discussion and questioning environment in the classroom. Therefore, it is considered that concept cartoons can effectively contribute to the learning process, especially in environments based on a constructivist approach and inquiry learning strategy. Moreover, one of the most prominent advantages of concept cartoons for students is that concept cartoons eliminate the students' concerns about the possibility of making a mistake by defending an incorrect point of view. (Duban, 2013).

Literature review

Research on concept cartoons

In the relevant literature review, studies have been encountered regarding the general features, benefits, and limitations of concept cartoons (De Lange, 2009; Keogh and Naylor, 1996; Keogh, Naylor, and Wilson, 1998; Keogh and Naylor, 1999; Keogh et al., 2001); their effects on affective and cognitive characteristics such as academic achievement, inquiry-based learning, attitude, motivation, logical thinking, self-efficacy, and anxiety (Azman ve

Alpat, 2022; Balım, İnel, and Evrekli, 2008; Baysarı, 2007; Çetin, Pehlivan, and Hacıeminoğlu, 2013; Çiçek and Öztürk, 2011; Çinici et al., 2014; Demir, 2021; Demirel and Aslan, 2014; Evrekli and Balım, 2010; Evrekli, İnel, and Balım, 2011; Gölgeli, 2012; Gölgeli and Saraçaloğlu, 2011; Gül, Köse, and Konu, 2014; İnel and Balım, 2011; Kaptan and İzgi, 2014; Özmen et al., 2012; Özyılmaz Akamca and Hamurcu, 2009; Özyılmaz Akamca, Ellez, and Hamurcu, 2009; Polat, 2014; Şengül, 2011; Şengül and Üner, 2010; Şengül and Aydın, 2013; Tokcan and Alkan, 2013; Yılmaz, 2013; Yolcu, 2013; Taşkın, 2014; Topçubaşı and Yılmaz ve Usta, 2023); their use as an assessment tool (Canan ve Aslan, 2023; Chin and Teou, 2009; İngeç, 2008; Ormancı and Şaşmaz Ören, 2011; Sexton, Gervasoni, Brandenburg, 2009; Şaşmaz Ören et al., 2012); perspectives of individuals at different stages and levels regarding concept cartoons (Balım et al., 2014; Birişçi, Metin, and Karakaş, 2010; Cengizhan, 2011; Ceylan Soylu, 2011; Duban, 2013; İnel and Balım, 2013; İnel, Balım, and Evrekli, 2009; Şengül and Aydın, 2013; Şaşmaz Ören and Meriç, 2014); their effect on creating a classroom discussion environment (Webb, Williams, and Meiring, 2008); the development of an evaluation form for concept cartoons (Şaşmaz Ören, 2009); their effect on discussion skills (Chen, Ku, & Ho, 2009); more effective usage of cartoons (Kabapınar, 2009); and their effect on views related to the nature of science (Çil, 2014). Moreover, the relevant literature includes studies addressing the identification of misconceptions, the revelation of alternative conceptions, the elimination of misconceptions, and the effects of concept cartoons on conceptual understanding (Atasoy and Akdeniz, 2009; Atasoy, Tekbıyık, and Gülay, 2013; Chin and Teou, 2010; Demir, Uzoğlu, and Büyükkasap, 2012; Demirel and Aslan, 2014; Duran, Ballıel, and Bilgili, 2011; Ekici, Ekici, and Aydın, 2007; Erdoğan and Özsevgeç, 2012; Gül, Köse, and Konu, 2014; Kabapınar, 2005; Meriç, 2014; Özmen et al., 2012; Özyılmaz Akamca, Ellez, and Hamurcu, 2009; Sancar ve Koparan, 2019; Saka et al., 2006; Say, 2011; Stephenson and Warwick, 2002; Şaşmaz Ören et al., 2010; Taşlıdere, 2013; Türkoğuz and Cin, 2013; Uzoğlu et al., 2013; Yavuz and Büyükekşi, 2011).

Among these studies, Kabapınar (2005) expressed concept cartoons as a teaching technique based on the constructivist approach and included sample concept cartoons in the study. In addition, the researcher determined the effect of the concept cartoon-based teaching method on the misconceptions of fourth and fifth-grade students on some chemistry topics with pretest-posttest. The study results revealed that teaching based on concept cartoons was successful in eliminating misconceptions. Saka et al. (2006) investigated the effectiveness of concept cartoons prepared for misconceptions in the unit of energy transformation in living things in eliminating these misconceptions of third-grade high school students. 60 senior high school students participated in the study. The study involved control and experimental groups, and data were collected through interviews and worksheets containing concept cartoons. The study results showed that the rate of elimination of misconceptions was higher in the group in which the lesson was conducted using cartoons. Ekici, Ekici, and Aydın (2007) examined the effects of concept cartoons on the identification and elimination of students' misconceptions on the topic of photosynthesis. The interviews with the students on the topic revealed that concept cartoons are an effective tool not only in identifying misconceptions but also in eliminating these misconceptions. Atasoy and Akdeniz (2009) tried to determine the effect of concept cartoons on the elimination of misconceptions about action-reaction forces. The researchers concluded that concept cartoons were effective in eliminating misconceptions in their study conducted with 38 first-year pre-service science teachers. Baysarı (2007) investigated the effects of using concept cartoons in the living and life unit of the fifth-grade science and technology lesson on students' success, attitudes, and elimination of misconceptions. The results showed that concept cartoons did not make a significant difference in students' academic success and attitudes. In a study conducted by Kabapınar (2009), some of the features that were considered to increase the effectiveness of concept cartoons in classroom use were included and research was conducted on the possible contributions of these features. In the study conducted on 4th and 5th graders, questions in the form of concept cartoons, researcher notes, and video recordings of the applications were used as data collection tools. Concluding the study, the researcher determined that concept cartoons designed in the form of worksheets were as effective as poster-style concept cartoons in eliminating misconceptions. In addition, it was stated that the naming of the characters in the cartoon facilitated classroom management and the organization of the classroom discussion during the in-class discussion and that the character names did not affect the students' responses. Chin and Teou (2010) investigated students' conceptual understanding of biological inheritance using concept cartoons, drawings, and group discussions in their study on 10-11-year-old students. The results of the study included and discussed students' alternative conceptions. Şaşmaz Ören et al. (2010) sought to determine the misconceptions of sixth, seventh and eighth-grade elementary school students (n=191) on the topic of photosynthesis-respiration with concept cartoons. According to the study results, it was determined that students had different misconceptions about the concepts in question. Say (2011) investigated the effect of concept cartoons on seventh-grade students' (n=49) conceptions of "structure and properties of matter". As a result of the study in which a quasi-experimental design with a pretest-posttest control group was used, it was stated that concept cartoons reduced students' misconceptions, did not reveal new misconceptions, and enabled students to better comprehend the subject. Yavuz and Büyükekşi (2011) sought to determine the misconceptions of pre-service science teachers about heat and temperature by using concept cartoons in their study on first-year pre-service science teachers (n=35). Erdoğan and Özsevgeç (2012) investigated the effect of using concept cartoons on students' (n=17) misconceptions about the greenhouse effect and global warming within the scope of the seventh-grade science and technology lesson with a single group pretest-posttest model. The results of the study indicated that concept cartoons contributed to the elimination of most of the misconceptions. Furthermore, in the interviews with the students, the students stated that concept cartoons made the learning process fun and facilitated remembering. Özmen et al. (2012) investigated the effects of laboratory applications enriched with concept cartoons on the achievement of eighth-grade students (n=36) on the acid-base topic using a pretest-posttest control group design. In the study, it was found that the experimental group had a better level of learning about acid-base concepts when compared to the control group. In addition, it was found that the alternative conceptions of the students in the experimental group decreased more than the control group. Atasoy, Tekbıyık, and Gülay (2013) examined the effect of concept cartoons on fifth-grade students' (n=67) understanding of the concept of sound with a quasi-experimental design with a pretest-posttest control group. According to the results obtained from the study, it was determined that the students in the experimental group, in which the lessons were taught with concept cartoons, constructed the concepts better. In a study conducted by Taşlıdere (2013), the effect of worksheets used with concept cartoons on the conceptual understandings of second-year pre-service science teachers (n=121) on geometric optics was investigated with a quasi-experimental design with a pretest-posttest control group. In the study, it was determined that worksheets used with concept cartoons were significantly effective on pre-service teachers' conceptual understanding. In their study, Türkoğuz and Cin (2013) investigated the effect of argumentation-supported concept cartoon activities on the conceptual understanding of seventh-grade students (n=54) in the electricity in our lives unit of science and technology course. In the study, it was concluded that argumentation-supported concept cartoon applications were significantly effective on students' conceptual understanding. Uzoğlu et al. (2013) compared the effectiveness of concept cartoons and open-ended questions in identifying the misconceptions of 1st, 2nd, and 3rd-year pre-service science teachers (n=212) regarding the topic of light. The study results indicated that concept cartoons are as effective tools in determining misconceptions as open-ended questions. In addition, alternative conceptions encountered in pre-service teachers were included in the study. Demirel and Aslan (2014) conducted a study on the seventh-grade solar system and beyond unit in the science and technology curriculum, aiming to determine the effects of the use of concept cartoons on students' academic achievement and conceptual understanding. The results of the study showed that the post-test scores of the students in the experimental and control groups did not differ significantly in academic achievement, whereas a significant difference was found in favor of the experimental group regarding the level of conceptual understanding. In their research, Artun, Gülseven and Temur (2019) investigated the effects of concept cartoons on fifth grade students' understanding of the concept of biodiversity. In their study conducted on fifth grade students (n=50), it was determined that the scores of the group in which concept cartoons were used differed significantly compared to the control group. Gül, Köse, and Konu (2014) investigated the effect of the use of concept cartoons in genetics unit on pre-service biology teachers' (n=48) conceptual understanding, their perceptions of inquiry learning skills, and their motivation towards biology learning. It was determined that the use of concept cartoons in the genetics unit resulted in a significant difference in pre-service teachers' conceptual understanding and motivation towards biology learning, but did not result in a significant difference in their perceptions of inquiry learning skills. In their study, Karakırık and Kabapınar (2019) investigated the effects of concept cartoons on ninth grade students' (n=64) learning the concept of atomic radius and determined that concept cartoons contributed to this issue. Meriç (2014) investigated the effect of using concept cartoons in the seventh-grade force and motion topic on students' conceptual understanding, motivation, and attitudes. The findings demonstrated that the use of concept cartoons caused a significant difference in students' conceptual understanding and attitudes. Moreover, the study determined that concept cartoons significantly increased students' motivation levels for performance, and the post-test research motivation scores of the students in the experimental group were significantly higher than the pre-test. Evrekli and Balım (2015) investigated the effect of using animated concept cartoons in science lessons on sixth-grade students' perceptions of inquiry learning skills. In the study conducted on sixth-grade students, it was determined that the applications had no effect on students' perceptions of inquiry learning skills, but the post-test scores of the experimental group using animated concept cartoons were significantly higher than the pre-test scores. Pınarkaya (2017) investigated the effects of animated concept cartoons on students' academic achievement, misconceptions, and attitudes in the unit of reflection and absorption of light in mirrors. The results of the study showed that animated practices were significantly more effective on the achievement and attitudes of 7th grade students. In their study, İspir and Aydın (2020) investigated the effect of concept cartoons used in the simple machines' unit on the achievement and conceptual understanding levels of eighth-grade students (n = 81), and concluded that concept cartoons had a significant effect on the development of conceptual understanding. In their research, Ergün and Külekçi (2020) investigated the conceptual understanding levels of fifth grade students (n = 17) in PBL applications supported by concept cartoons and determined that concept cartoons did not contribute in this sense.

When the literature is examined, it can be seen that although studies on the effects of concept cartoons on concepts have increased in recent years, they are still limited. In addition, it has been determined that studies on animation-supported concept cartoons or animated concept cartoons are quite limited. Again, when studies on concept cartoons and their effects on conceptual understanding were examined, very few studies were encountered, especially on chemistry and the granular structure of matter.

Research problem

Upon reviewing the literature, it is evident that studies on animated concept cartoons are limited. Additionally, a few studies have been encountered in the literature that aims to determine the effect of concept cartoons on the level of conceptual understanding of the subject of matter and heat and that reveals students' in-depth conceptual understandings and alternative conceptions of matter and heat. Therefore, this research was deemed necessary. The research question was determined as "Is there a significant difference between the post-test conceptual understanding levels of the experimental group 1 using animated concept cartoons in science lessons, the experimental group 2 using only concept cartoons, and the control group using only the science curriculum?"

METHOD

This study utilized a non-equivalent pre-test/post-test control group quasi-experimental design to determine the effectiveness of animated concept cartoons on sixth-grade students' conceptual understanding within the "matter and heat" unit of the science and technology course (Christensen, 2004; Marczyk, DeMatteo, & Festinger, 2005; Cohen, Manion, & Morrison, 2005).

Table 1. Symbolic representation of the research

	Pretest	Learning-teaching process	Posttest
Experimental Group 1	T1	Teaching with animated concept cartoons	T1
Experimental Group 2	T1	Teaching with concept cartoons	T1
Control Group	T1	Science and Technology Curriculum	T1

*T1= Conceptual understanding test

Study Group

The study group of the research consisted of a total of fifty-one sixth-grade students (n_{exp1}=17; n_{exp2}=17; $n_{control}$=17) studying in three different classrooms (A-B-C) in a secondary school in the Demirci district of Manisa province. All the students in the groups are aged between 11 and 13. In Experiment Group 1, 47.1% of the students (n=9) are female and 52.9% (n=8) are male. In both Experiment Group 2 and the Control Group, 52.9% of the students (n=8) are female and 47.1% (n=9) are male.

Data Collection Tools

Conceptual understanding test

To assess students' conceptual understanding of the "Matter and Heat" unit, the "Conceptual Understanding Test on Matter and Heat" developed by Balım et al. (2013) was used. Some questions from the original test were revised and modified with permission from the researchers to form a preliminary version of the test. This draft was reviewed by four subject-matter experts, and adjustments were made based on structural issues and any misalignments with the test blueprint. Following these revisions, the preliminary form was administered to a group of sixth-grade students (n=25) with similar characteristics to the study group. During the implementation, students were asked to mark unclear sections and inform their teacher if they encountered any issues. Based on student feedback, the final version of the Conceptual Understanding Test was developed. The final version contains sixteen items in total, including drawing, open-ended, semi-open-ended, and closed-ended questions. Semi-open-ended questions were designed in two stages with the first part being closed-ended and the second part being open-ended. The first part required students to choose what they believed was the correct answer, and the second part asked them to explain why they chose that option in detail. The five-point scoring system proposed by Abraham, Williamson, and Westbrook (1994) was used to score the test responses, as follows:

4- Full understanding: Answers that contain all scientifically accepted concepts.

3- Partial understanding: Answers that include some scientifically accepted concepts.

2- Partial understanding and a specific misconception (alternative conception): Answers that contain both correct concepts and a misconception (alternative conception).

1- Specific misconception (alternative conception): Scientifically incorrect answers.

0- No understanding: Blank answers, repeated questions, irrelevant, unclear responses, or only a selected answer with no explanation provided.

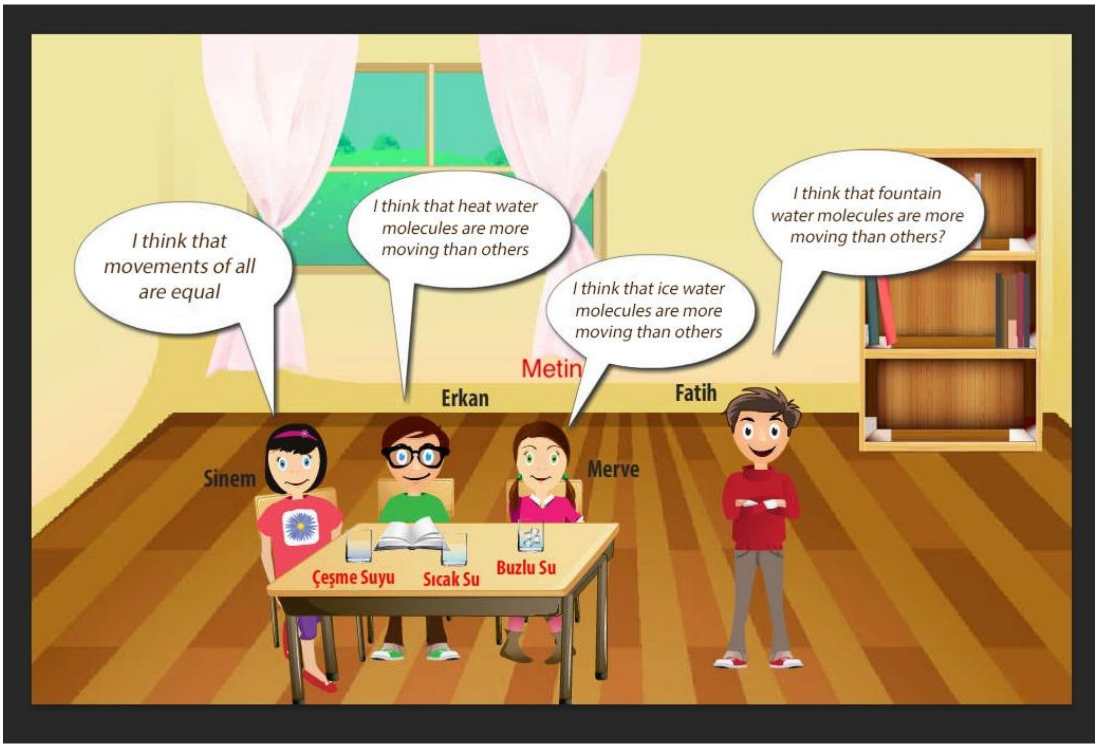
Two experts were consulted in the process of analyzing the conceptual understanding tests. After the analysis, the total score each student received from each rater was calculated, and the inter-rater agreement was determined using an intra-class correlation analysis. The inter-rater reliability value was found to be .91, indicating a high level of agreement between the raters when evaluating the Conceptual Understanding Test.

Preparation of Activities and Materials Used in the Research

During the preparation of the activities and materials used within the scope of the study, first of all, the achievements of the sixth-grade matter and heat unit were examined, and the lesson plans were prepared according to the 5E learning model. The sample activities in the curriculum and the activities in the Turkish MoNE textbook (Tunç et al., 2006a; 2006b; 2006c) were used jointly in the control and experimental groups and transformed into lesson plans within the scope of the 5E learning model. For the "Particulate nature of matter and heat", "Distribution of heat" and "Heat insulation" topics, the lesson was planned in parallel with the curriculum as 4 hours, 8 hours, and 4 hours, respectively, for a total of 16 lesson hours. Then, concept cartoons were developed and incorporated in the teaching plan in the form of worksheets for the experimental group in which animated concept cartoons would be used (experiment 2) and for the experimental group where only concept cartoons would be used (experiment 1). Concept cartoons were mainly used to reveal students' views before the experiments, to enable them to share their thoughts, and to arouse curiosity. In total, twelve concept cartoons were developed for three topics and included in the lesson plan as worksheets. The worksheets included the students' preliminary opinions-estimates and the conclusion sections intended to compare their preliminary opinions or predictions with their observations. The concept cartoons designed for the applications in the Experimental Group 2 were animated and included a voiceover.

Experimental Procedure

In the study, three sixth-grade classes (6A-6B-6C) from the determined primary school were randomly assigned to Experiment 1, Experiment 2, and Control groups. Interviews were conducted with randomly selected students (n=8) from each group to assess their conceptual understanding. Before the quasi-experimental application, the conceptual understanding test was administered to all groups as a pre-test. The applications were carried out by the researcher over sixteen class hours. The lessons were taught with animated concept cartoons as well as the activities in the science and technology curriculum in the experimental group 2, only with concept cartoons in addition to the science and technology teaching program, in the experimental group 1, and only on the basis of the science and technology curriculum in the control group. In the applications related to the concept cartoons in the experimental group 2, first of all, worksheets were distributed and the students were asked to read the scenarios, and then to listen to the opinions and watch the animation by drawing their attention to the projected concept cartoons.



Picture 1. The concept cartoons about the topic of "Which molecules are more moving than others?"

Then, they were asked to write down which view they agreed with and their predictions on the worksheet. In the class, firstly, everyone expressed their opinions individually, and then different opinions were taken and an atmosphere of discussion was tried to be created. After the application, students conducted experiments or discussed the outcomes, comparing their predictions and observations to reach conclusions. In Experimental Group 1, only worksheets were distributed without using any projection tools. Similarly, students wrote down their predictions, discussed them in class, and compared them with their observations. At the end of the study, the conceptual understanding test was administered again as a post-test.

Data Analysis Techniques

In the analysis of the quantitative data obtained from the research, it was considered to use non-parametric tests primarily because the number of students in the groups was not suitable. However, parametric statistical methods were ultimately used due to the normal distribution of data (Shapiro-Wilk test, Experimental group 1; $p=.958>.05$; experimental 2 group; $p=.741>.05$; control group; $p=.720>.05$) and the necessity of controlling pre-tests, and since ANCOVA, which is one of the parametric tests, does not have a nonparametric equivalent. In this context, ANOVA was used for pre-test data analysis, and ANCOVA for post-test data analysis. A paired t-test was employed to compare dependent variables within groups.

Ethics Statement

The ethical permission for the research was approved by Dokuz Eylül University's letter dated 25.11.2013 and numbered 02141 and by Manisa Governorship Provincial Directorate of National Education's letter dated 05.12.2013 and numbered 3705932.

RESULTS

Descriptive statistics of the pretest and posttest scores of the conceptual understanding (CU) test for the research groups are presented in Table 1. Experiment Group 1 was defined as the group that utilized animated concept cartoons, while Experiment Group 2 only used concept cartoons.

Table 1. Comparison of pretest and posttest scores of experimental and control groups on conceptual understanding test

Dependent Variable	Experimental Group 1 (n = 17)				Experimental Group 2 (n = 17)				Control Group (n=17)			
	Pretest		Posttest		Pretest		Posttest		Pretest		Posttest	
	X_{mean}	SD	X_{mean}	SD	X_{mean}	SD	X_{mean}	SD	X_{mean}	SD	X_{mean}	SD
CU	27.76	15.32	58.82	20.97	27.24	11.16	58.94	21.13	33.12	12.34	53.41	19.66

When pre-test scores were analyzed via ANOVA, no significant differences were found between groups ($F_{(2,50)}=1.05$, $p=.356$).

The research question was defined as "Is there a significant difference between the post-test conceptual understanding levels of the experimental group 1 using animated concept cartoons in science lessons, the experimental group 2 using only concept cartoons, and the control group using only the science curriculum?" In line with the solution of this problem, the post-test scores of the participant students from the conceptual understanding test were analyzed with ANCOVA by controlling the pre-test. The results of the analysis revealed a significant difference between the post-test conceptual understanding scores of the groups ($F_{(2,47)}= 4.53$, $p=.016$, $\eta_p^2 = .162$). To determine the source of the observed difference among the groups, the results of the ANCOVA analysis were examined. No significant difference was found between the scores of Experimental Group 1 and Experimental Group 2 ($p = .870$). However, the scores of the Experimental Group 1 significantly differed from those of the Control Group ($p = .014$), and the scores of the Experimental Group 2 also showed a significant difference compared to the control group (p = .010). Additionally, a paired samples t-test was conducted to compare the pre-test and post-test scores within each group. The results indicated significant differences favoring the post-test for the Control Group ($t_{(16)}$=6,41, p=.000), the Experimental Group 1 ($t_{(16)}$=9,20, p=.000) , and the Experimental Group 2 ($t_{(16)}$=9,57, p=.000).

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

The results regarding the solution of the "Is there a significant difference between the post-test conceptual understanding levels of the experimental group 1 using animated concept cartoons in science lessons, the experimental group 2 using only concept cartoons, and the control group using only the science curriculum?" sub-problem of the research was analyzed. The results showed that the adjusted post-test conceptual understanding scores of Experimental Group 1 using animated concept cartoons and Experimental Group 2 using only concept cartoons differed significantly compared to the Control Group. It was observed that the adjusted post-test conceptual understanding scores of Experimental Group 1 and Experimental Group 2 did not significantly differ compared to each other. A literature review revealed studies that supported the results of the present study (Artun, Gülseven ve Temur, 2019; Atasoy, Tekbıyık, and Gülay, 2013; Demirel and Aslan, 2014; Duran, Ballıel, and Bilgili, 2011; Ekici, Ekici, and Aydın, 2007; Erdoğan and Özsevgeç, 2012; İspir ve Aydın, 2020; Kabapınar, 2005; Karakırık ve Kabapınar, 2019; Meriç, 2014; Saka et al., 2006; Say, 2011; Türkoğuz and Cin, 2013). However, the findings obtained from the research also differ from the research findings of Ergün and Külekçi (2020). Atasoy, Tekbıyık, and Gülay (2013) examined the effect of concept cartoons on fifth-grade students' understanding of sound concepts; Türkoğuz and Cin (2013) investigated the impact of argumentation-supported concept cartoons on seventh-grade students' conceptual understanding of the topic of electricity in daily life; Demirel and Aslan (2014) explored the effect of concept cartoons on seventh-grade students' conceptual understanding of the solar system and beyond; Meriç (2014) studied the effect of concept cartoons on seventh-grade students' understanding of force and motion; Saka et al. (2006) focused on the effect of concept cartoons on eliminating high school third-year students' misconceptions regarding energy transformations in living organisms; Ekici, Ekici, and Aydın (2007) researched the impact of concept cartoons on eighth-grade students' misconceptions about photosynthesis; Kabapınar (2005) examined the influence of concept cartoons on eliminating fourth- and fifth-grade students' misconceptions in certain chemistry topics; Baysarı (2007) investigated the effect of concept cartoons on eliminating fifth-grade students' misconceptions in the life and living unit of the science and technology course; Duran, Ballıel, and Bilgili (2011) studied the effect of concept cartoons on eliminating sixth-grade students' misconceptions in the particle structure of matter unit in science and technology classes; Say (2011) investigated the effect of concept cartoons on seventh-grade students' conceptual understanding of the structure and properties of matter; Erdoğan and Özsevgeç (2012) researched the effect of concept cartoons on eliminating seventh-grade students' misconceptions regarding the greenhouse effect and global warming. These studies found that concept cartoons contribute to enhancing conceptual understanding and eliminating misconceptions. From the primary education level to university, students encounter increasingly complex information regarding the particulate nature of matter and the pathways of heat transfer. As Karaer (2007) noted, if students do not learn the concepts related to matter meaningfully at the primary level, they may face significant understanding and comprehension issues in other chemistry topics in the following years. Therefore, identifying alternative conceptions and planning a learning process targeting these concepts is of great importance.

Considering the characteristics of concept cartoons, topics are initially selected from daily life that individuals may be open to alternative conceptions. As Keogh and Naylor (1999) point out, concept cartoons are developed concerning events believed to be part of students' previous experiences to reflect scientific phenomena relevant to their daily lives. Subsequently, these prepared concept cartoons are used to elicit students' existing thoughts. During this process, students are encouraged to compare their ideas and prior knowledge with different thoughts and opinions, creating cognitive conflict in their minds. The establishment of cognitive conflict is crucial as it provides students with the opportunity to construct knowledge using the scientific method. Concept cartoons facilitate the need for resolving cognitive conflict and assist students in thinking more openly (Naylor, Keogh, and Downing, 2003). Given all these stages, it can be said that concept cartoons significantly support individuals' conceptual understanding processes by uncovering students' prior knowledge, creating cognitive conflict in their minds, and allowing them to test their thoughts using the scientific method. Naylor and Keogh (1999) argue that concept cartoons are a unique and encouraging strategy that can enhance conceptual construction, considering a constructivist approach. Korkmaz (2004) also notes that concept cartoons can be used to facilitate conceptual learning in small groups, reveal students' prior concepts, and assess what they have learned, as well as for discussions. Concept cartoons can uncover students' misconceptions and help address existing misconceptions (Özyılmaz-Akamca, Ellez, and Hamurcu, 2009; Saka et al., 2006). In addition, the study shows that the animated concept cartoons do not have a positive effect on students' conceptual understanding. In this sense, it can be said that concept cartoons, whether two-dimensional or with animation support, can be used in lessons. It is thought that studies at lower grade levels may yield better results regarding the effectiveness of concept cartoons with this feature. It is estimated that such animation and voice-over on concept cartoons can contribute to the development of the concept, especially for students who have limitations in reading and writing.

In light of the discussion of the results obtained from the research, it is suggested that concept cartoons can be frequently used within the science teaching curriculum for aims such as revealing students' views, ensuring participation in the class, and eliminating alternative conceptions. Increasing the number of studies related to concept cartoons and examining their effectiveness across different units and topics are anticipated to contribute to the literature. It can be stated that in-depth research is necessary to uncover students' understandings regarding the particulate nature of matter and pathways of heat transfer and to identify the sources of alternative conceptions. It is also estimated that conducting studies on the effectiveness of visual tools, which can contribute in different ways to the visualization of information, in the learning process, will contribute to the literature.

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APPENDİX Conceptual Understanding test about "Matter and Heat" Unit

Sevgili öğrenciler;

Ekte "Madde ve Isı" ünitesine ilişkin sizlerin kavramsal anlamalarınızın belirlenmesi amacıyla bir test yer almaktadır. Soruların cevaplandırılması aşamasında soruya uygun gördüğünüzü görüşünüzü işaretledikten sonra görüşünüzün nedenini açık bir şekilde alt kısmına yazınız. Verdiğiniz içten cevaplar için çok teşekkür ederiz…

Ad-Soyad: **Okul Adı: ....** **Şube Adı: ....**

Sınıfı : …………… **No : ……………**

1) Su tanecikleri ile ilgili olarak;

Isıtılmadan önceki su taneciklerini çiziniz **Isıtıldıktan sonraki su taneciklerini çiziniz**

Isıtıldıktan sonra taneciklerin hareket hızları;

( ) Artar ( )Azalır ( ) Değişmez ( )Bilmiyorum

Nedeni:……

……………………..

Isıtıldıktan sonra tanecikler arasındaki mesafe;

( ) Artar ( )Azalır ( ) Değişmez ( )Bilmiyorum

Nedeni:……

……………………..……….

Isıtıldıktan sonra taneciklerin büyüklükleri/genişlikleri/hacimleri;

( ) Artar ( )Azalır ( ) Değişmez ( )Bilmiyorum

Nedeni:……

……………………..……….

2) Isı iletkeni ile ilgili olarak;

( ) Isı iletkeni kavramını hiç duymadım,

( ) Isı iletkeni kavramını duydum ancak ne olduğunu tam olarak bilmiyorum,

( ) Isı iletkeni kavramını duydum ve hakkında bir şeyler söyleyebilirim.

Isı iletkeni ne demektir?

……

…………………...…………

3) <u>Isı yalıtkanı ile ilgili olarak;</u>

( ) Isı yalıtkanı kavramını hiç duymadım,

( ) Isı yalıtkanı kavramını duydum ancak ne olduğunu tam olarak bilmiyorum,

( ) Isı yalıtkanı kavramını duydum ve hakkında bir şeyler söyleyebilirim.

Isı yalıtkanı ne demektir?

………………………………………………………………………………………………........................…………

………………..

....

4) Aşağıda verilen katı, sıvı ve gaz maddelerini oluşturan taneciklerin hareketleri ile ilgili olarak uygun seçeneği/seçenekleri işaretleyiniz.

Katı bir maddeyi oluşturan tanecikler:

( ) Titreşim hareketi yapar ( ) Öteleme hareketi yapar ( ) Hareket etmez ( ) Bilmiyorum

Sıvı bir maddeyi oluşturan tanecikler:

( ) Titreşim hareketi yapar ( ) Öteleme hareketi yapar ( ) Hareket etmez ( ) Bilmiyorum

Gaz bir maddeyi oluşturan tanecikler:

( ) Titreşim hareketi yapar ( ) Öteleme hareketi yapar ( ) Hareket etmez ( ) Bilmiyorum

Cevaplarınızın nedenlerini açıklayınız:

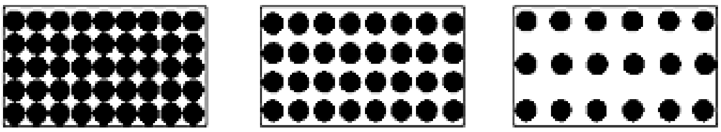
………………………………...

....………………………….......................................

....

....

5) Aşağıda farklı maddelere ilişkin örneklerden hangisi ısıyı en yavaş iletir, hangisi en hızlı iletir?



A B C

En yavaş .... iletir:

Nedeni:

………………………………………………..

....

....

En hızlı .... iletir:

Nedeni:

……

……

……

6) Aşağıda verilen maddeleri ısı iletkeni ve/veya ısı yalıtkanı olarak sınıflandırınız.

	Isı iletkeni	Isı yalıtkanı	Bilmiyorum
Plastik			
Bakır			
Cam			
Tahta			
Seramik			
Alüminyum			
Yün			
Demir			

7) **<u>İletim yoluyla ısının yayılması ile ilgili olarak;</u>**

( ) İletim yoluyla ısının yayılmasının ne olduğunu hiç duymadım,

( ) İletim yoluyla ısının yayılmasını duydum ancak ne olduğunu tam olarak bilmiyorum,

( )İletim yoluyla ısının yayılmasını duydum ve hakkında bir şeyler söyleyebilirim.

<u>İletim yoluyla ısının yayılması ne demektir?;</u>

……

………………………………………………...

....

8) **<u>Işıma yoluyla ısının yayılması ile ilgili olarak;</u>**

( ) Işıma yoluyla ısının yayılmasının ne olduğunu hiç duymadım,

( ) Işıma yoluyla ısının yayılmasını duydum ancak ne olduğunu tam olarak bilmiyorum,

( ) Işıma yoluyla ısının yayılmasını duydum ve hakkında bir şeyler söyleyebilirim.

<u>Işıma yoluyla ısının yayılması ne demektir?;</u>

……

……………………...

....

9) **<u>Konveksiyon yoluyla ısının yayılması ile ilgili olarak;</u>**

( ) Konveksiyon yoluyla ısının yayılmasının ne olduğunu hiç duymadım,

( ) Konveksiyon yoluyla ısının yayılmasını duydum ancak ne olduğunu tam olarak bilmiyorum,

( )Konveksiyon yoluyla ısının yayılmasını duydum ve hakkında bir şeyler söyleyebilirim.

<u>**Konveksiyon yoluyla ısının yayılması ne demektir?;**</u>

………

………………………………………………………………………...

....

10) <u>**Isı yalıtımı ile ilgili olarak;**</u>

( ) Isı yalıtımının ne olduğunu hiç duymadım,

( ) Isı yalıtımını duydum ancak ne olduğunu tam olarak bilmiyorum,

( )Isı yalıtımını duydum ve hakkında bir şeyler söyleyebilirim.

Isı yalıtımı ne demektir?

………

………………………...

....

Isı yalıtımı günlük yaşamda hangi amaçlarla kullanılmaktadır?

………

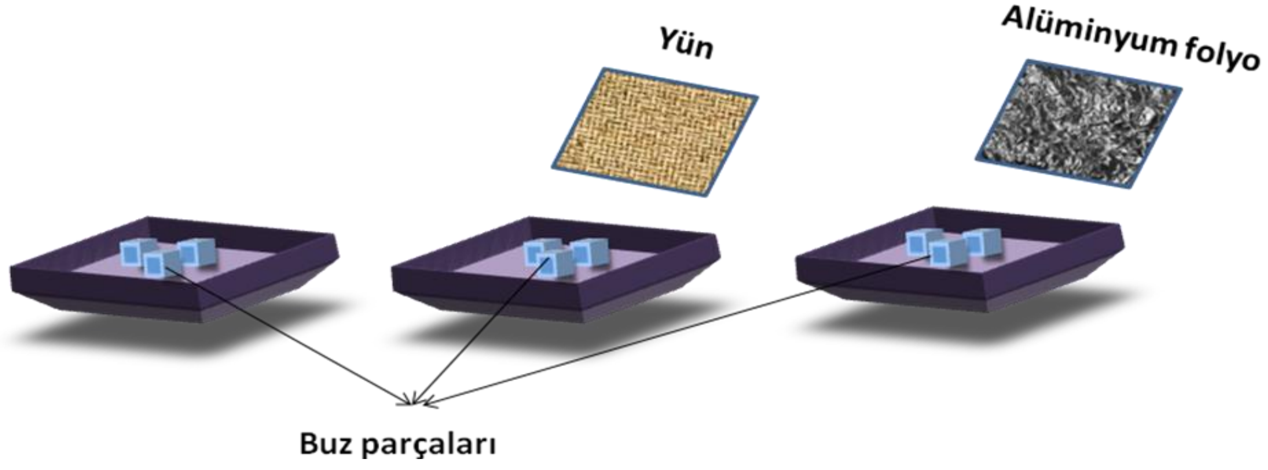
………………………...

......

11) Aşağıda verilen durumlarda hangi <u>yolla/yollarla</u> ısının yayılabileceğini işaretleyiniz.

Olaylar	İletim	Işıma	Konveksiyon	Bilmiyorum
Sıcak çorba içine konulan kaşığın ısınması				
Kaloriferin odayı ısıtması				
Güneş alan evlerin ısınması				
Mikrodalga fırında yiyeceklerin ısınması				
Su ısıtıcısına konan suyun ısınması				
Giyeceklerin ütülenmesi				
Mangalda yiyeceklerin pişirilmesi				

12) Ali ile Ahmet oda sıcaklığında gerçekleştirdikleri deneylerinde birinci tabakta yer alan buz parçalarını açıkta bırakıyor, ikinci tabaktaki buz parçalarını yün ile sarıyor, son tabaktaki buz parçalarını ise alüminyum folyo ile kaplıyor. Sizce hangi buz kalıpları daha önce eriyecektir?



( )Açıkta bırakılan buz kalıpları **( )Yüne sarılı buz kalıpları**

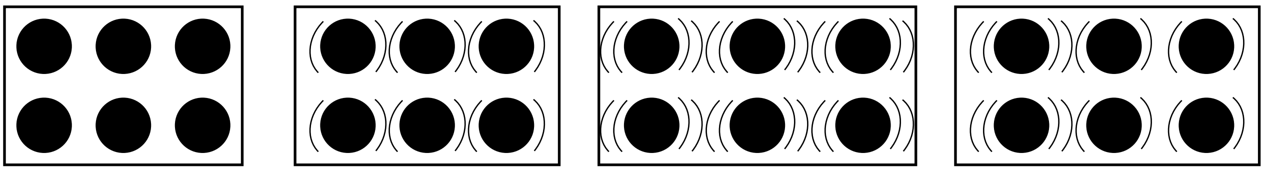
( )Alüminyuma sarılı buz kalıpları **( )Bilmiyorum**

<u>Lütfen nedeni yazınız</u>

………
………
………
………
………
……………………………

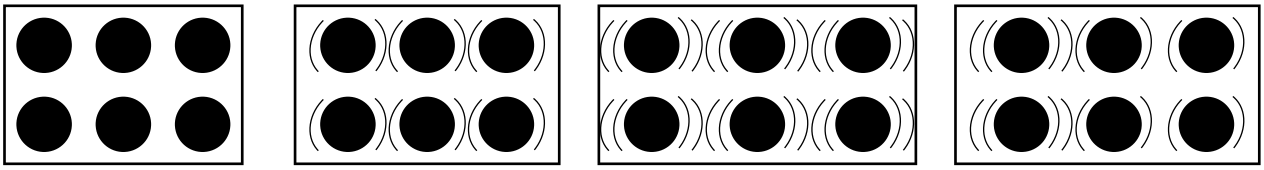
13) Bir **metal çubuk** bir mum yardımıyla ısıtılıyor. Isıtılmaya başlandıktan bir süre sonra metal çubuğu oluşturan taneciklerin hareketleri nasıl olacaktır? (Çubuğun küçük bir kısmının kesiti aşağıdaki seçeneklerde sunulmuştur.)

<u>Metal çubuğun ısıtılmadan önceki hali;</u>



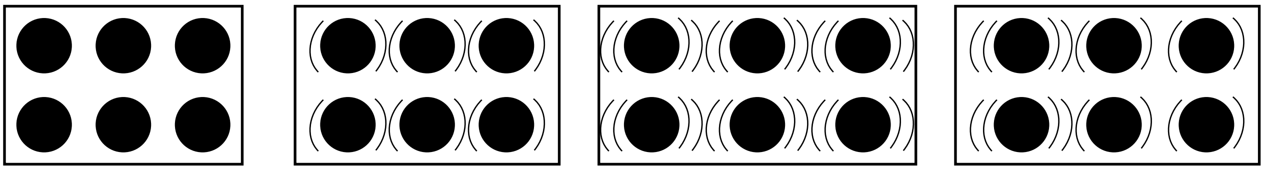
A ( ) B ( ) C ( ) D ( )

Metal çubuk ısıtılırken;



A ( )   B ( )   C ( )   D ( )

Isıtma işlemi bittikten bir süre sonra;



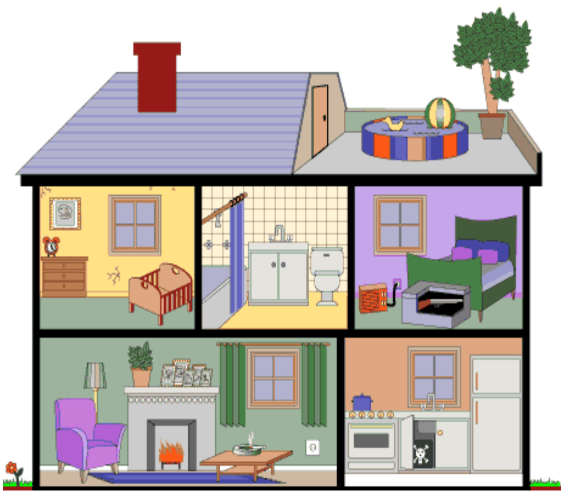
A ( )   B ( )   C ( )   D ( )

Nedeni:

....

....

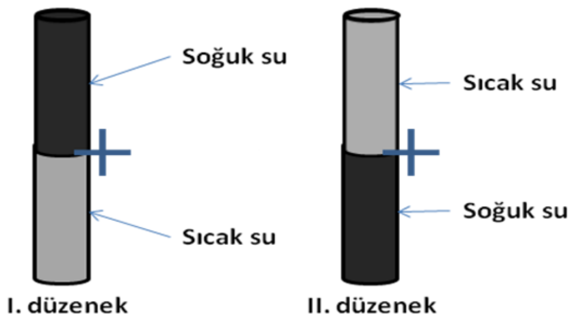
14) Evlerinin farklı bölümlerinde yalıtım teknolojilerini kullanmak isteyen bir aile için aşağıdaki yalıtım malzemelerinden **hangisini/hangilerini** önerirdiniz?



1.

	İç ve Dış Duvarlar	Pencere, Kapılar	Çatı	Zemin, Tavan
Cam Yünü				
Strafor Köpük				
Çift cam				
Ahşap				
Parlak Yüzeyler				

15) Ali aşağıdaki deney düzeneklerini hazırlayarak sıcak suyun soğuk su içerisinde yayılmasını sağlamaya çalışmaktadır.



Sizce hangi düzenekteki sıvılar birbirine daha hızlı karışır?

( ) I. Düzenek **( ) II. Düzenek** **( ) Bilmiyorum**

Nedeni:

……

……………………………………………………………………………...……………………………………

16) Ahmet, içmek istediği sıcak çayın **uzun süre aynı sıcaklıkta** kalmasını istemektedir. Buna göre; sizce aşağıdaki **dış yüzeyleri aynı, iç yüzeyleri farklı renklerdeki** porselen bardaklardan hangisini tercih etmelidir?

Nedeni………

……..

Ahmet bu seferde soğuk bir bardak suyun **uzun süre soğuk kalmasını** istemektedir. Sizce aşağıdaki **iç yüzeyleri aynı, dış yüzeyleri farklı** renklerdeki porselen bardaklardan hangisini tercih etmelidir?

Nedeni………

……