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Embedding Analogical Reasoning into 5E Learning Model: A Study of the Solar System

Yasemin Devecioglu-Kaymakci
Bayburt University, TURKEY

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The purpose of this study was to investigate how the 5E learning model affects learning about the Solar System when an analogical model is utilized in teaching. The data were gathered in an urban middle school 7th grade science course while teaching relevant astronomy topics. The analogical model developed by the researchers was administered to 20 seventh grade students in a city of the Black Sea Region in Turkey. "The Solar System and Beyond: The space puzzle" unit was taught by using 5E learning model accompanied by analogical model during two class hours. In this case study, pre-experimental design with pre-test-post-test was used to collect data through questionnaire, reflective thinking scale, video recording, and informal observations. According to the findings of this study, the teaching intervention not only significantly increased the students' academic achievement but also improved their science process skills. The study suggests that analogies should be well-planned and deployed for teaching science courses. Furthermore, the number of the analogical models in textbooks should be increased to enrich meaningful learning for students' transition levels between concrete and abstract operational terms.

Keywords: science education, analogical reasoning, solar system, 5E

INTRODUCTION

In the past decades, analogies have been promoted as initial models or simple representations of science concepts (Gentner & Smith, 2012; Glynn & Takahashi, 1998; Glynn, Taasoobshirazi & Fowler, 2007; Glynn, 2008). Analogy may be simply described as a process of identifying similarities between two scientific concepts comparing the familiar concept (analog) with the unfamiliar one (target) (Dagher & Cossman, 1992; Duit, 1991; Gentner, 1983; Gentner & Markman, 1997; Gentner & Smith, 2012; Glynn, 1991, 2008; Glynn et al., 2007). When there are shared features between the analog and the target, an analogy is drawn between them.

Analogies have gained a big importance for both scientists and science teachers to explain many scientific concepts in physics, chemistry, biology, and so on. (Coll & Treagust, 2001; James & Scharman, 2007; Gentner et al., 1997; Glynn, 2008; Paris,

Correspondence: Yasemin Devecioglu-Kaymakci,
Department of Science Education, Bayburt University Faculty of Education, Bayburt University, 69000 Bayburt, Turkey.
E-mail: ydevecioglu@bayburt.edu.tr
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1999). There are some scientific perspectives from which researchers have asserted different functions of analogies (Cin, 2005; Gentner et al., 1997; Gentner & Smith, 2012; Glynn & Takahashi, 1998). Scientists have used analogies as tools to explain their discoveries and inventions throughout the history (Gentner & Smith, 2012) It is stated that these features of analogies which make the unknown resemble the known lead to new inventions (Chiu & Lin, 2005). For instance, once a hypothesis has been proposed, an analogy may be used to facilitate the theoretical and experimental basis of this hypothesis. They are called scientific analogies that may be used for four aims: discovery, development, evaluation, and exposition (Holyoak & Thagard, 1995 cited in Dilber & Duzgun, 2008). For instance, Benjamin Franklin used analogy to develop experiment for lightning-electricity (Chiu & Lin, 2005). Johannes Kepler used watch analogy for planetary motion (Gentner et al., 1997; Glynn, 2008) while Huygens used water wave analogy for the phenomenon of light (Kok-Aun & Hong-Kwen, 1999). Some well-known analogies are: analogies between electricity and gravity (Bartlett, 2004; Dilber & Duzgun, 2008; Aykutlu & Şen, 2011); Rutherford's planetary model of the atom (Taylor & Zafiratos, 1991 cited in Dilber & Duzgun, 2008); "plumb pudding" model of the atom (Harrison & Treagust, 2000); electric current and water circuits (Cosgrove, 1995; Gentner, 1983; Glynn et al., 2007; Paatz, 2004; Roland, 2006; Dilber & Duzgun, 2008; Ugur, Dilber, Senpolat & Duzgun, 2011); behaviors of particles (Chiu & Chen, 2005); chemical equilibrium and bonding (Coll & Treagust, 2001; Harrison & Jong, 2005; Şahin Pekmez, 2010); particle theory of matter (Hong-Kwen & Kok-Aun, 1997); factory analogy with animal cell (Glynn, 1991; Glynn & Takahashi, 1998); and DNA and cookbook analogy (Paris, 1999).

State of the literature

- Being a conceptual technique, analogy plays a very important role in explaining many scientific concepts in physics, chemistry, biology, astronomy, and so on. It is used to reinforce meaningful conceptual understanding and learning in science education. As a matter of fact, analogies are rather instructive to link daily life experiences to abstract and complex scientific concepts.
- One of the most popular versions of constructivism is 5E model. Since constructivism is identified with conceptual change, analogies play an important part in ensuring conceptual change and making students construct new knowledge by using their pre-existing knowledge.
- Astronomy is used for endearing science, providing students with conceptual knowledge, and making changes in the conceptual understanding of students. Learning about the Solar System helps students understand certain events that shape and form a significant part of their everyday lives.

Contribution of this paper to the literature

- In this study, we created a novel analogy about the Solar System, which can potentially contribute to the literature by setting a positive example.
- It is believed that in an interactive lecturing of the Solar System through an analogy which is based on situations from daily life, students can see the traces of their own lives, which makes lessons more enjoyable and the learning of concepts more lasting.
- The analogy is used to eliminate the alternative conceptions of students about the Solar System by using the instructional strategy based on 5E learning model. It has proved the effects of analogies on students' conceptual understanding and learning and their attitudes towards scientific subjects

Being a conceptual technique, analogies play an important role in reinforcing meaningful conceptual understanding and learning in science education (Aykutlu & Şen, 2011; Atav et al., 2006; Bilaloğlu, 2006; Bilgin & Geban, 2001; Chiu & Chen, 2005; Chiu & Lin, 2005; Dagher, 1994; Demirci Güler, 2007; Dilber & Duzgun, 2008; Duit, 1991; Garde, 1986; Gentner, 1983; Gentner & Smith, 2012; Glynn, 2007; Glynn et al., 2007; Harrison & Treagust, 1993; Kok-Aun & Hong-Kwen, 1999; Sağırlı, 2002; Thiele & Treagust, 1994; Treagust, Harrison & Venville, 1998). Analogy is frequently used to make abstract scientific concepts more comprehensible (Chiu & Lin, 2005; Gentner, 1983; Glynn, 1989; Harrison & Treagust, 1993; Wong, 1993). As analogy is a way of matching recently learned knowledge with the ones that are already held in the long-term memory (Bilaloğlu, 2006; Karadoğu, 2007; Lawson, 1993), the use of analogies promotes students' conceptual understanding (Dagher & Cossman, 1992;

Dilber & Duzgun, 2008; Dinçer, 2005; Garde, 1986; Rigas & Valanides, 2003). For example, it is reported that when analogy is used in teaching scientific concepts such as electrics (Dilber & Duzgun, 2008), pressure (Demirci Güler, 2007; Wong, 1993), and conduction of heat and wave properties of light (Harrison & Treagust, 1993), positive changes occur in students' levels of achievement as well as their levels of conceptual understanding and attitudes towards such scientific concepts.

Some researchers have revealed that use of analogies is more instructive to link daily life experiences to abstract and complex scientific concepts (Duit, 1991; Glynn, 1991; Harrison & Treagust, 1993; Karadoğu, 2007). Analogy is used by providing visualization of abstract concepts and comparing similarities of the real world events or concepts with the new concepts during the learning process (Atav et al., 2004; Chiu & Lin, 2005; Duit, 1991; Glynn & Duit, 1995; Kok-Aun & Hong-Kwen, 1999; Newton, 2003). By pointing the similarities between objects or events and the real world, the concrete analog facilitates understanding of many abstract concepts for students (Bilaloğlu, 2002; Bilgin & Geban, 2001; Garde, 1986; Karadoğu, 2007; Şahin et al., 2001). Sophisticated and complex scientific concepts can make sense for students when they are taught by using analogies. As to using real analogies, it can be said that analogies can also be motivational. For example, when elaborate analogies are used (relative to use of no analogy or use of simple analogies), not only students' levels of success in understanding scientific concepts increase but also their attitudes are improved (May et al., 2006; Paris & Glynn, 2004). For example, more positive results can be gained when analogy is used to teach "Particle Theory of Matter" or "behaviors of particles" (Chiu & Chen, 2005; Dinçer, 2005) by using analogy with text, analogy and dynamic analogy with text, or dynamic computer analogies (Hong-Kwen & Kok-Aun, 1997).

One of the advantages of analogies is that they promote teachers to take students' prior knowledge into consideration and may reveal their misconceptions regarding previously taught topics (Kok-Aun & Hong-Kwen, 1999; Taylor & Coll, 1997). However, in addition to its advantages, the use of analogy may also bring some disadvantages. For instance, uncritical use of analogies may lead to misconceptions (Cin, 2005; Hong-Kwen & Kok-Aun, 1997; May et al., 2006). This situation occurs especially when unshared features are compared between an analogy and a target concept. Moreover, sometimes learners may not be familiar with analogy and analogy features. Students may have difficulties in recognizing relations and explanations of an analogy (Gentner & Smith, 2012). They may not easily grasp the real point of analogy. In this respect, it is very important to indicate the true description of the analog for the target concept through analogy (Glynn, 1989; Duit, 1991; Harrison & Treagust, 1993; Hong-Kwen & Kok-Aun, 1997). Consequently, analogy, which makes students mentally active by having them use their prior knowledge, is one of the important tools used within constructivist approach (Glynn & Duit, 1995; Newton, 2003). 5E learning model of the constructivist approach is used in this study, and we will explain 5E learning model in the following part.

5E model as a teaching strategy

The fact that analogies allow students to construct their own knowledge shows that analogies are part of the constructivist approach (Gentner, 1983; Glynn & Takahashi, 1998). Thus, this study, in which analogies were used, required conducting teaching by using one of the learning models. Considering the characteristics of the curriculum (MEB, 2013) and the grade of the students, the researcher thought 5E model would be more suitable.

In the light of many studies, we certainly know that one of the most popular versions of constructivism is 5E model. Apart from that, different models such as 3E (Explore-Explain-Elaborate), 4E (Engage-Explore-Explain-Evaluate), and 7E (Excite-

Explore-Explain-Expand-Extend-Exchange-Examine) are also suggested (Çalık & Ayas, 2005; Çalık, Ayas & Coll, 2010). For 5E learning model, each step with "E" refers to help students' learning by the experience of linking prior knowledge to new concepts. It is seen that 5E learning model is especially effective in the elimination of alternative conceptions (misconceptions) (Bybee et al., 2006; Çalık, 2006; Özsevgeç, 2007; Ültay & Çalık, 2016). This is because; constructivist learning theory claims that learning is an interaction between new knowledge and pre-existing knowledge (e.g. Bybee et al., 2006; Driver et al., 1994; Freedman, 1998; Hewson, 1992; Yager, 1995), and people construct their own knowledge by using their existing knowledge. Since constructivism is identified with conceptual change (Driver et al., 1994; Duit, 1991; Hewson, 1992), analogies play an important part in ensuring conceptual change and making students construct new knowledge by using their pre-existing knowledge (Gentner, 1983; Glynn & Takahashi, 1998).

We decided to use the analogy for teaching astronomy topics within 5E learning model. It has five stages, which are Enter (Engagement), Exploration, Elaboration, and Evaluation. The strategy would make a positive contribution to students' levels of conceptual understanding and their conceptual change. We planned the instruction activity by using 5E model (see Appendix 1) in accordance with the steps of the model.

The definitions of 5E learning model's stages are presented below as the related literature describes (Çalık, 2006; Eisenkraft, 2003; Krantz, 2004; Özsevgeç, 2006; Orgill & Thomas, 2007; Wilder & Shuttleworth, 2005):

1. Engagement: It refers to drawing students' interest to concept(s), revealing their prior knowledge, and making them aware of their own knowledge about the concept(s). This stage is a kind of warming action phase to make students ready to learn. For this reason, students are not expected to give the correct explanations.

2. Exploration: Students are very active in this stage. They apply their own knowledge by making observations and gaining experiences about the concepts. They try to explore scientific knowledge by working in groups. At this stage, teacher guides students to study in videos, computers, and so on to solve problems.

3. Explanation: At this stage, teacher is the most active. Students share and discuss their own experiences with each other. Students are encouraged to compare their prior knowledge with the new knowledge and explain the relationship between the two concepts (i.e. the new and the old one). Teacher(s) could benefit from different methods such as animations, simulations, analogies, discussions, and videos.

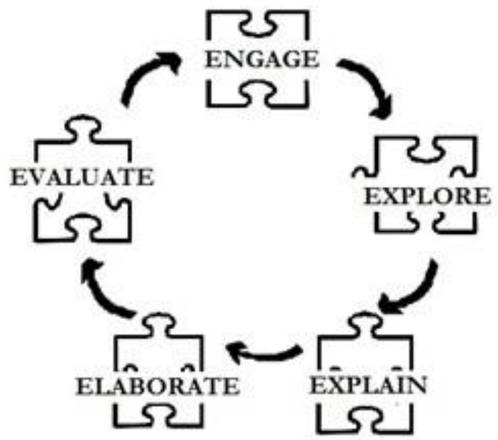

Figure 1. 5E Learning Model Stages (Adapted from Wilder & Shuttleworth, 2005)

4. Elaboration: Students are encouraged to adapt and associate the new knowledge with their daily life. Work sheets, model preparation and activities, drawing, and problem situations can be used to improve students' thinking skills. Questions are used to reinforce the relationship between the concept and the daily life.

5. Evaluation: Students examine and make an inference about new knowledge of concept(s) learned during the previous four stages. Eventually, they check out their own improvement.

The solar system as an analogy case in 5E model

Astronomy is one of the essential phenomena of life. It is the field that teaches people how to think correctly and logically. It enables individuals to understand the world better and strengthens their senses of curiosity, imagination, and discovery. From this aspect, astronomy can be accepted as an alternative approach to form the bases of scientific method (Percy, 1998; Trumper, 2006a). Therefore, it is reported that astronomy teaching is necessary for not only teaching various concepts to students but also developing the system of thought of a society as a whole and having an astronomically literate and conscious society (Trumper, 2006b). Astronomy is used for endearing science, providing students with conceptual knowledge, and making changes in the conceptual understanding of students (Percy, 1998). Astronomy is a field that requires high-level skills such as three-dimensional thinking and imagination. In this sense, astronomy education is important for enhancing both two dimensional and three dimensional thinking skills of individuals (Tunca, 2002). In addition, learning about the Solar System helps students understand certain events that shape and form a significant part of their everyday lives. It makes an important contribution to the development of scientific literacy and the public understanding of science (Millar & Driver, 1987; Percy, 1998). Despite this, however, children's ideas about the Solar System are not particularly well-documented or understood.

Astronomical concepts seem to be concrete concepts that students have some difficulties to understand. Astronomical concepts are abstract and very complex for students (Sharp & Kuerbis, 2006). In parallel with the rise of the constructivist approach or "alternative frameworks movement" (Driver et al., 1994), students' ideas about, for example, the figure of the Earth and the day and night cycle have received more attention in recent years (Cin, 2007; Jones, Lynch, & Reesink, 1987; Samarapungavan, Vosniadou, & Brewer, 1996; Sneider & Ohady, 1998; Vosniadou & Brewer, 1992, 1994). Therefore, astronomy education is recommended to start in elementary education as early as possible (Calderón-Canales et al., 2013; Sharp & Kuerbis, 2006). This is because; students acquire a lot of non-scientific or second-hand knowledge on astronomical subjects through beliefs, television, the Internet, and other popular media sources (e.g. astrology, UFO, aliens) (Candela, 2001; Impey, Buxer & Antonellis, 2012; Samarapungavan et al. 1996; Sharp & Kuerbis, 2006; Trumper, 2003, 2006a). As students come to the learning environment with their prior knowledge of basic astronomical concepts, it is inevitable that such prior knowledge involves misconceptions or alternative conceptions (Emrahoğlu & Öztürk, 2009; Nakhleh, 1992; Nicoll, 2001; Trumper, 2001, 2003; Ünsal et al., 2001). Also, students may have a complex web of prior beliefs and understandings about nature based on their daily life experiences, upbringing, social interactions, and popular culture (Candela, 2001; Donovan & Bransford, 2005 cited in Impey et al., 2012; Ornek, 2008). It is stated that many children have unprecedented access to quite sophisticated information about the Solar System (Sharp & Kuerbis, 2006). While learning astronomical concepts, students may take the non-scientific thoughts offered by the society to them for granted (Taşcan, 2013). This is because; the alternative conceptions which students have in regard to astronomical concepts negatively affect their perceptions and learning of astronomy (Bülbül et al., 2013; Kalkan & Kıroğlu, 2007; Kikas, 2005). This is why the relationship between what someone "knows" and what they "believe" is subtle and complex (Impey et al., 2012).

There are a lot of studies that reveal the astronomical misconceptions, knowledge levels, and mental models of in-service teachers, pre-service teachers, and students from different levels (Calderón-Canales et al., 2013; Ercan et al., 2010; Sharp & Kuerbis, 2006). While some studies highlight the importance and positive contributions of astronomical topics (Kikas, 1998; Sharp, 1999; Arnold et al., 1995), some other studies aim to reveal the development of astronomical concepts in students (Diakidoy & Kendeou, 2001; Kikas, 2005; Sharp & Kuerbis, 2006), deficiencies in the teaching of astronomical concepts, mistakes in astronomical topics in textbooks (Vosniadou, 1991; Ojala, 1997; Ünsal & Güneş, 2002), and so on. Indeed, since the Solar System cannot be observed directly, it is full of unknown concepts for students. Some studies have found out students' misunderstandings about astronomical concepts. Many studies have been conducted to determine student's knowledge on astronomy concepts at varied grades such as elementary school (Ercan et al., 2010; Vosniadou & Brewer, 1994; Sezen, 2002; Kikas, 2005, 2006; Mulholland & Ginns, 2008; Plummer, 2008; Küçüközer et al., 2009; Bryce & Blown, 2013) and tertiary education as well as pre-service teachers' knowledge on astronomy subjects (Trumper, 2001, 2003, 2006a, 2006b; Frede, 2006; Gülçiçek et al., 2003; Kalkan & Kıroğlu, 2007; Küçüközer, 2007; Emrahoğlu & Öztürk, 2009). It is reported that regardless of their educational levels, the majority of students do not have adequate scientific knowledge and they answer the questions based on their limited and incomplete scientific knowledge and especially their daily life experiences (e.g., Candela, 2001; Trumper, 2001, 2003, 2006a). It is seen that many studies conducted in Turkey and abroad state almost the same problems in regard to the astronomical perceptions, learning, alternative conceptions, etc. of students.

The astronomical literature includes studies aimed at investigating alternative conceptions or perceptions concerning basic concepts such as the movements of the Earth, the formations and sizes of the Sun, the Earth, and the Moon (Baxter, 1989; Ercan et al., 2010; Kikas, 1998; Samarapungavan et al., 1996; Vosniadou & Brewer, 1992, 1994), planets, stars, and their features (Calderón-Canales et al. 2013; İyibil & Sağlam-Arslan, 2010; Sharp & Kuerbis 2005; Sharp, 1996, 1999). Research exploring the mental models of students on astrological subjects reports that a great majority of students develop a variety of astronomical models (Calderón-Canales et al., 2013). All these situations show that astronomical concepts actually require three dimensional thinking and are not or cannot be comprehended very effectively. In general, these studies seem to agree that processes facilitate and enrich conceptual understanding by use of concrete practices, analogies, teaching materials, models (Calderón-Canales et al., 2013; Chiu & Chen, 2005; Glynn & Duit, 1995; Glynn et al., 2007; Demirci Güler & Yağbasan, 2008; Vosniadou & Brewer, 1994), and/or constructivist approach (Ward, Sadler & Shapiro, 2008), thus they should be used in teaching these phenomena and concepts.

Teachers usually need concrete examples to teach astronomical concepts that are not directly visible. When we look at the analogical studies in the field of astronomy, what we see first is the comparison of the structure of atom to the Solar System (Harrison & Treagust, 1993). It is seen that Johannes Kepler compares the working system of watch to planetary motion (Rule & Furletti, 2004). For example, you may need to use example of fairground octopus toy to explain the motion of the Earth both around its own axis and around the Sun (Demirci Güler & Yağbasan, 2008). There are examples related to astronomy among the studies dealing with analogy

(Blake, 2004) though they are few in number. They may set an example for contribution to the field through new studies like this study.

Eventually, we developed an analogy in the belief that interactive lecturing of the Solar System through an analogy which is based on situations from daily life would yield effective results. The fact that students can see the traces of their own lives will make lessons more enjoyable and the learning of concepts more lasting. By this means, it was aimed both to develop an analogy that will assist to eliminate the alternative conceptions of students about the Solar System and to propose an instructional strategy based on 5E learning model.

Purpose of the study

In this study, our purpose was to investigate the effects of analogies on the conceptual understanding and learning of students and their attitudes towards scientific subjects. We developed an analogy about the Solar System and implemented it to remove the seventh grade students' alternative conceptions. By this way, we expect to make a contribution to sample analogies for science teachers, science educators, even scientists who teach at the university level.

METHODOLOGY

Experimental design has several possible variations (Shadish, Cook & Campbell, 2002). One of these designs is a pre-experimental research design with one group pre-test/post-test design in which a single group of subjects takes a pre-test, then receives some treatment, and finally takes a post-test (Cohen, Manion & Morrison, 2007; Jackson, 2013; Örnek, 2007; Robson, 1998). A pre-experimental one group pre-test/post-test design (Cohen et al., 2007) is used in this case study. We studied with one group and there was no equivalent non-treatment group for comparison to be made. In Figure 2, one-group pretest-posttest design is showed.

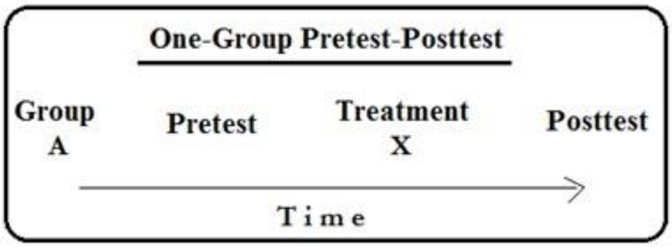

Figure 2. One-Group Pretest-Posttest (Örnek, 2007)

As seen in the Figure 2, one group of subjects is given a pre-test, the treatment, and lastly post-test respectively. The pre-test and post-test were administered before and after treatment of the analogical reasoning with 5E learning model. We compared the pre-test and post-test results after completing the instruction through 5E model strategy.

As in analogical studies (Bilaloğlu, 2006; Demirci Güler, 2007; Glynn, 2007; Karadoğu, 2007; Tsai, 1999), there are also studies in which different teaching situations (Ercan et al., 2010; Sharp & Kuerbis, 2005; Ültay & Çalık, 2016) and experimental designs (Bilgin & Geban, 2001; Glynn, 1989, 1991; Sülün et al., 2005; Ward et al., 2008) are used for the teaching of astronomical subjects. The inclusion of analogies about the Solar System in this study by applying a constructivist approach required the use of an experimental design. However, because of sample size and the nature of sample, it was appropriate to carry out the study with a pre-experimental design approach with one group pre-test/post-test method.

The sample of this study consisted of 20 students (about 13-14 years old) attending the seventh grade of a middle school in a city of the Black Sea Region in Turkey. Data were obtained from pre-test and post-test results, document analysis of the reflective writings of the students, and informal classroom observations conducted during the lessons. In this way, data triangulation was made, thereby ensuring reliability and internal validity (Marriam, 1988; Cohen et al., 2007).

Process

The study was conducted in the following steps:

i. First, we analyzed the 7th grade Science and Technology course syllabus. "The Solar System and Planets" was determined as the subject. As stated before, students have some difficulties to understand the topic. Even we once observed that a final-year science student had difficulties in presenting the sequence of planets. The suitability of the subject to use analogy and the levels of understanding of the students on this subject drove us to carry out such a study about the topic. In Turkey, astronomical subjects start to be taught as of pre-school period. In the new curricula, students are expected to achieve different levels of learning of astronomical concepts at different educational levels. In these curricula, the following subjects are taught in the following grades in Table 1.

Table 1. Subjects taught in the curricula (MEB, 2006, 2013, 2015)

Preschool;
the concepts of night and daytime
Elementary school;
1st grade; the concepts of the Earth and the Sun
2nd grade; the movements of the Earth and the Sun and what is expected in the sky
3rd grade; the Moon and its phases, the Earth and its movements, and the Sun
4th grade; the figure and the features of the Earth
Middle school;
5th grade; The Earth, the Sun, the Moon, the sizes and the movements of the Earth, the Sun, and the Moon
7th grade; The Solar System and Beyond: The Space Puzzle, celestial objects such as star, planet, meteor, satellite, comet, and star clusters, the Solar System, and satellite observations
8th grade; the formation of the Earth, plate tectonics, and weather events in the atmosphere

Basic knowledge concerning basic astronomical concepts is given in a spiral structure through life science and science courses in elementary school and middle school. In this spiral structure, students are expected to understand basic astronomical concepts and have increased interest in the Universe and space (MEB, 2006; Türkoğlu et al., 2009). As a matter of fact, it is very likely for students to construct alternative conceptions regarding astronomical concepts in their minds through the curricula they undergo and the experiences they have in their daily lives until the 7th grade. Thus, the students included in the sample of this study are likely to have alternative conceptions about the Solar System.

ii. Second, the objectives of the chapter were determined by using the science curriculum.

iii. An analogy model to teach concepts of the Solar System and planets was developed by the researcher. According to the definition of Duit (1991), similarity in analogy can be absolute similarity, relational similarity, or similarity in appearance. In the present study, the analogy was created based on similarity in appearance. There is an analogical map to make sense on the given analogy. A teacher enables his/her students to perceive similarities and differences. In addition, the dialogue used along with analogy is provided to ensure permanence in Table 2.

iv. An instruction plan for teachers to teach these subjects was planned according to 5E learning model. This plan has all information about the activity with analogy containing objectives, teaching materials, instructions, and evaluation

Table 2. Analogical mapping for the analogy

Analog Feature	Comparison	Target Feature	Dialogue
The Solar System	Compared to	District	
The Sun	Compared to	Head of District (mukhtar)	
Planets	Compared to	Neighborhood of the Sun	
Satellites	Compared to	Children of planets	
Gases around Planets	Compared to	Perfume	
Mercury	Compared to	Gnome and infertile Lives alone Has a very hot home	Hi, neighbors. How are you? I am sitting near to the Mukhtar Sun. My home is very hot. I live alone, because I do not have any children. I am called as "Gnome Mercury", because I am too small amongst you.
Venus	Compared to	Twin of the Earth Lives alone Uses perfume CO_2	Hi, neighbors. How are you? My name is Venus. I am called as twin of the Earth. I am the second neighbor of the Mukhtar Sun. I use the perfume with CO_2. I live alone and I do not want anyone around me.
Earth	Compared to	Uses perfume Has little girl, Moon	Hi, friends, I am the Earth. I like to wear sprightly only amongst you. I use a perfume. I love it very much because it is full of oxygen. I am the third neighbor of the Mukhtar Sun. I live with my little girl The Moon.
Mars	Compared to	Beautiful in Red Dress Has two children	Hi, neighbors. Everyone calls me "beautiful in red", because my all dresses are in red. I live with my two children. I am the 4^{th} neighbor of the Mukhtar Sun.
Jupiter	Compared to	Agha of a Tribe, Huge Man Has 63 children	Hi, neighbors, I am the huge man Jupiter. I am the tallest and the hugest one amongst you. I live with my 63 children in my tribe. I am the 5^{th} neighbor of the Mukhtar Sun.
Saturn	Compared to	With fancy hat a cold fish Has 56 children	Hi, neighbors. I am fancy Saturn with fancy hat. I know Jupiter is bigger than me, but I am the second one in terms of size. I am a cold fish. I do not give countenance to anyone easily. I have 56 children. My elder son's name is Titan. He is the eldest son. I am the 6^{th} neighbor of the Mukhtar Sun.
Uranus	Compared to	Has a cyclical suit with 10 hoops Uses poisonous perfume Has 27 children	Hi, neighbors. I am Uranus. I wear a cyclical suit with 10 hoops. I use a perfume with poison. No one gets close to me. I have 5 big and 22 small children. I am the 7^{th} neighbor of the Mukhtar Sun.
Neptune	Compared to	Twin of Uranus with bright green dress Has 13 children	Hi, neighbors. How are you? I am sitting too far to the Mukhtar Sun. I am the twin of Uranus. The color of my dress is bright green. I have 13 children.

questions (Appendix 1). The plan based on the principles of 5E model consists of *Enter*, *Exploration*, *Explanation*, *Elaboration*, and *Evaluation* and presents each step of the model with embedded analogies. As we stated before, 5E model is one of the most effective models that can be utilized to promote students' conceptual understanding and learning of scientific concepts. In addition, since the science curriculum in Turkey takes it as a basis (MEB, 2006, 2015), the teacher can use this model more easily while implementing the plan during the instruction.

The analogy proposed in the study was used at the Exploration stage of 5E model. With the analogy given at this stage, it was aimed to make students establish a relationship between the new situation and existing concepts by considering their prior knowledge and alternative conceptions and reach the mental preparation stage to construct the new knowledge. As a matter of fact, alternative conceptions are defined for 5E learning model.

v. According to the objectives of the unit, a pre-test with five open-ended questions was prepared and administered to the students before the instruction started.

vi. After the pre-test, the course was taught by the researcher. Besides informal observations, the course was videotaped (all permissions were taken before the observations and video recording). This is because; the researcher wanted to observe and determine progression of the children in psychomotor behaviors during the lessons. It took 14 hours for the entire unit to be covered.

vii. The post-test was administered 6 days later following the end of the course. The post-test intended to measure at what level the students were able to apply their previous knowledge to new situations and their success levels in capturing recently taught concepts. Therefore, the purpose was to determine the students' levels of understanding.

viii. Finally, after two weeks from the post-test, the researcher asked the students to write their opinions and views about the course and the analogy used during the lessons to evaluate their emotional improvement by their reflective writings. It was a kind of open-ended question: "Please, explain your opinions about the instruction with analogies".

It should be noted that interviews (Blake, 2004; Bryce & Mac Millan, 2005; Cin, 2007; Harrison & Tregaust, 1993) or tests or open-ended questions (Bülbül et al., 2013; Glynn & Takahashi, 1998) are also used besides experimental designs in the studies in which analogies are used. In this study, open-ended questionnaire questions, reflective writings, and classroom observations were used for data collection by taking the features of the subject and the sample into consideration.

Data analysis

The test questions were written by using Bloom's Revised Taxonomy (Bloom et al., 1956; Anderson et al., 2001) to figure out the students' alternative conceptions and levels of understanding the Solar System. The levels of the test questions are as following:

- Question 1 (level of knowledge –remembering–) aimed to figure out students' existing conceptions and alternative concepts.
- Question 2 (level of analysis –analyzing–) aimed to determine students' ability of distance discriminations for the planets.
- Question 3 (level of analysis –analyzing–) aimed to measure students' levels to align planets according to their sizes.
- Question 4 (level of knowledge –remembering–) aimed to assess students' level about the satellites and the planets' satellites.
- Question 5 (level of comprehension –understanding–) aimed to assess students' knowledge about planets' features and the results of their specific characteristics.

The pre-test and post-test results were analyzed according to four levels of understanding developed by Saglam-Arslan and Kurnaz (2009). As is known, a different sort of leveling is employed in different studies on levels of understanding (Abraham, Gryzybowski, Renner & Marek, 1992; Barnett, 2002; Çalık, 2006; Değirmençay, 2010; Marek, 1986; Örnek, 2008; Saglam-Arslan & Devecioğlu, 2010; Tekbıyık, 2010). In accordance with the nature of the study and 5E learning model, the following leveling was employed: "Sound Understanding, Partial Understanding, Specific Alternative Conception, and No understanding/answer". Accordingly, the features of the leveling of the student answers that were examined descriptively are indicated in the Table 3.

The pre-test and the post-test results were analyzed according to the levels described above by the researcher. The answers were presented in the related tables. In the analysis process, inferences were made with respect to these tables and supported with descriptions.

Table 3. Categories used to determine the students' levels of understanding

Level of understanding	Score	Criteria for Scoring
No understanding/answer	[0]	Leaving blank, unanswered questions, repeating questions, unclear response or short answers with no explanation
Specific Alternative Conception	[1]	Answers far from being scientific information
Partial Understanding	[2]	Answers that include only one aspect but not all aspects of valid answers, not fully coinciding with scientific information but having proper attributions
Sound Understanding	[3]	Answers that include all aspects of a valid answer, including scientific definitions

In addition, to compare the pre-test scores and post-test scores, we used Binomial sampling distribution through SPSS 22.0 software package. We utilized the Sing test, which is the application of the Binomial sampling distribution for a small number of cases. This is because; the sample of the study consists of 20 students. The p value is compared with the significance level. When p value is smaller, the result is significant. We used the Wilcoxon Matched Pairs Signed-Ranks Test (the T test) to compare the pre-test and post-test scores to identify the significant difference between the pre-test and the post-test.

The opinions of a domain expert and the opinions of the science teacher of the class where the study was carried out were taken to ensure the content validity of the pre-test and the post-test. The student opinions were directly included in the analysis to ensure the reliability of the data obtained from the reflective writings that were analyzed descriptively. The classroom observations involved information reflecting the classroom atmosphere. The data for the writings of the students are presented by codes (e.g. S-A, S-B).

RESULTS

The findings of the study are given in three parts as listed below: i) Data from the pre-test and the post-test, ii) Data from the reflective writings of the students and iii) Data from observations, both informal observations and video-taped observations.

The students' levels of understanding and test analysis

The students' answers were categorized according to the levels of understanding in Table 4 along with the pre-test and the post-test results with frequencies.

For each question, the answers of the students were interpreted as follows:

For Question 1: "What is there in the Solar System?"

According to the Table 4, only one student gave the answer at level [3] by saying "the Sun, planets and satellites". Most of the students (13 students) gave answers at level [2], which means that they do not contain fully correct information. In Table 5, there are the possible answers of the students at levels [3] and [2].

As it can be seen in the Table 5, majority of the students did not know the concept of satellite in the pre-test. There are also some answers which were categorized at level [0] "No understanding/answer" such as "*There is heat and light in the Sun*" and "*There is core and layers in the Sun.*" Only six students knew the Solar System as some parts or contents of the Sun. According to the post-test results (see Table 4) for Question 1, only six students gave answers at level [3] despite the analogy. On the other hand, 14 students gave answers such as "the Sun and satellite", "planet and satellite", or only "planet" at level [2].

For Question 2: "Which planets are the nearest and the furthest ones to the Sun?"

According to the Table 4, just one student's answer was at level [3] for the pre-

Table 4. The levels of understanding and frequencies for the pre-test and the post-test

	The Levels of Understanding for the Pre-test				The Levels of Understanding for the Post-test			
	[3] f	[2] f	[1] f	[0] f	[3] f	[2] f	[1] f	[0] f
Question 1	1	13	3	3	6	14	0	0
Question 2	1	7	7	5	15	2	2	1
Question 3	1	6	3	10	9	5	4	2
Question 4	1	0	1	18	20	0	0	0
Question 5	0	2	0	18	7	6	5	2

Table 5. The students' answers at levels [3] and [2] for Question 1

	Pretest		Posttest	
	level [3]	level [2]	level [3]	level [2]
Answers	f	f	f	f
The Sun, planets, satellites	1	-	6	-
The Sun and planet	-	7	-	-
The Sun and satellite	-	-	-	2
Planet and satellite	-	-	-	1
Planet	-	2	-	11
Satellite	-	-	-	-

test results. However, 19 students' answers were undesired at levels [0] and [1]. In the post-test, the question 2 was revised as "Put in order the name of the planets according to their distances to the Sun." According to the Table 4, 17 students' answers were at levels [3] and [2]. While examining the answers at level [2], it was noticed that the students put the planets in order correctly except for the last two or three planets. On the last lines, some students had incorrect answers such as "The nearest: Mercury, The furthest: Neptune". Twelve students gave the furthest planet answer as "Pluto". However, Pluto was known as the smallest planet in the Solar System and the ninth planet from the Sun. Today, Pluto is called a "dwarf planet." A dwarf planet orbits the Sun just like other planets, but it is smaller. A dwarf planet is so small that it cannot clear other objects out of its path.

For Question 3: "What is the order of the planets from the biggest to the smallest?"

In the post-test, the question 3 was revised as "Put in order the planets according to their sizes". According to the Table 4, the post-test results indicating the situation after instruction through analogy embedded 5E learning model show that 14 students' answers were at levels [3] and [2]. Jupiter was given as the biggest planet answer by six students and Mercury as the smallest one by just one student. Some of the students gave the answer "Pluton" for the smallest planet, and some gave the answer "Neptune".

For Question 4: "Which planet has more satellites?"

As is seen in Table 4, only one student's answer as "Jupiter" at level [3] in the pre-test. The others' levels of understanding were at level [1] and [0]. In the post-test, however, all students' answers were at level [3] for question 4.

For Question 5: "Which planet has cloud of CO2 (carbonic acid gas) around itself? What are the effects of the cloud on that planet? Please explain."

According to Table 4, only two students' answers were at level [3], and 18 students' answers were at level [0] in the pre-test. After teaching with analogy, 13 students' levels of understanding increased to levels [3] and [2]. In Table 6, the students' levels of understanding are provided based on the pre-test and the post-test results.

According to the answers of the students, most of them know that Venus is surrounded by CO_2 gas cloud. However, they did not definitely realize the effect of the cloud. They failed to explain the correct answer by stating, "*Because of cloud of CO_2, Venus is warmer*". According to the pre-test results in the Table 6, most of the students could not give answers at level [3] or [2]. After teaching with analogy, the students' levels of understanding eventually turned to level [3] or level [2]. Additionally, in the pre-test, most of the questions were skipped whereas nearly all of the questions were answered in the post-test.

Lastly, there is a comparison of the pre-test and post-test results through Wilcoxon matched Pairs Signed-Ranks test to find out the significant difference. Table 8 summarizes the difference between the pre-test and the post-test scores.

The sum of negative ranks, T, is ,00. The other way to show any significant difference is to use p-value, which is from the Wilcoxon Signed Ranks test. According to the result of the Wilcoxon matched Pairs Signed-Ranks test, there was a significant difference between the pre-test and post-test scores (*z=-3,922, p < .01*). In Table 8, we can conclude that the significant difference results in post-test's favor because of mean rank and sum of ranks. According to the results, there is a remarkable increase in all of the answers, which indicates the achievement of the students. Therefore, it can be said that the analogy used along with 5E model promoted students' conceptual understanding and learning of the concept. This indicates the effectiveness of the instruction with analogy embedded in 5E learning model and shows that the students' levels of understanding of the Solar System were improved.

Table 6. The students' answers at levels [3] and [2] for Question 5

	Pretest		Posttest	
	Level [3] f	Level [2] f	Level [3] f	Level [2] f
Venus. Cloud makes greenhouse effect on this planet. In spite of being the second nearest planet to the Sun, it is the hottest planet.	-	-	6	-
Venus.	2	-	-	-
It is surrounded by CO_2 gas.	-	-	-	3
There is greenhouse effect.	-	-	-	2

Table 7. Computations for Wilcoxon Matched-Pairs Test and the Sign Test

Pair Number	Pre-Test	Post-Test	Difference Between Post- and Pre-Tests	Rank of Difference	Positive Ranks	Negative Ranks
1	0	73	73	18.5	10.5	
2	0	30	30	2.5	1.5	
3	0	50	50	9	3.5	
4	5	78	73	18.5	12	
5	5	80	75	20	14	
6	10	30	20	1	1.5	
7	10	80	70	16.5	14	
8	10	58	48	8	5	
9	15	80	65	14.5	14	
10	15	85	70	16.5	16	
11	15	70	55	12.5	8.5	
12	15	50	35	5.5	3.5	
13	20	73	53	10.5	10.5	
14	25	90	65	14.5	17	
15	30	60	30	2.5	6	
16	35	68	33	4	7	
17	35	70	35	5.5	8.5	
18	40	93	53	10.5	18	
19	45	100	55	12.5	19.5	
20	55	100	45	7	19.5	
Total					**210**	**0**

Table 8. Wilcoxon Signed Ranks

		N	Mean Rank	Sum of Ranks	z	p
Pretest score	Negative Ranks	0[a]	,00	,00	-3,922	.000
Posttest score	Positive Ranks	20[b]	10,50	210,00		
	Ties	0[c]				
	Total	20				

Note: a. Post-test < Pre-test
b. Post-test > Pre-test
c. Post-test = Pre-test

Students' reflective writings

According to the students' opinions about the instruction from their reflective writings, their opinions included two basic points. One of the groups (almost all of the students) were very pleased by the course and the analogies. However, there were two students who were dissatisfied with both the analogies and the course. The statements of the students are as follows:

- Nearly half of the students noted that they enjoyed during the instruction, especially when the analogies were used. Most of them stated that these analogies were very instructive and concrete to comprehend the related subjects. Some students wrote that they mostly enjoyed the analogy for planet: "*two people living in a neighborhood*" (S-C, S-N and S-R). Most of the students said that it was very easy to recall the matters. S-E, S-H, and S-O stated that the satellite analogy, in which satellites of the planets are described as children of human beings, was more enjoyable and effective. S-J and S-L admitted that they did not enjoy the course in the beginning. However, while the teacher was using the analogies, they were getting more enthusiastic about attending the lesson. They also added that the course was very enjoyable, and the analogies were lasting to remember the subjects. S-D and S-I stated that they extremely enjoyed the speaking of the characters in the analogy and were not bored during the course. S-J wrote his idea as following: "*…if you had lectured the subject by telling 'Neptune is the furthest planet to the Sun…', we would not remember anything about that. However, when you used these matters (the analogy) to teach these subjects, it (the course) was more enjoyable and instructive for us.*" S-A, S-F, S-G, S-I, S-K, S-M, S-P, and S-O approved that teaching with analogies was very effective and enjoyable. They pointed out that during the course they were interested in those subjects and especially the analogies.
- There were only two students that did not precisely understand the subject. For instance, S-S admitted that she did not enjoy the course, because it required memorizing almost every subject. She also commented on the teaching method of the teacher. According to her, the level of students was too high to use that method and analogy. However, using another teaching method could be more effective to teach these subjects. S-B admitted that he did not understand some analogies. While he partly understood the analogy for satellites of the planets, he could not comprehend the analogy for planet.

Classroom observations

During the instruction, the students' behaviors were video-recorded in the classroom. According to the video recordings, most of the students were pleased with the instruction and analogies. The analogies attracted their attention and worked usefully to motivate students from the beginning to the end of the course. It was noteworthy that the students were willing to engage and participate during the class. Moreover, the students' attention was highly increased while using analogies, and they were actively involved in the lessons. Furthermore, towards the end of the course, the students were very enthusiastic to take part in the talk of analogy characters. It was observed that nearly all of the students answered all of the questions in the table, which were prepared to summarize what they had been taught during the class.

DISCUSSION AND IMPLICATIONS

In this study, we investigated the effects of analogies on students' learning of astronomical concepts and their conceptions of the Solar System. According to the pre-test results, nearly all of the students' responses lacked conceptual understanding about the subject and included some alternative conceptions.

However, in Turkey, these subjects and concepts start to be taught in the 5th grade. The students' levels of understanding (see Table 4) and the pre-test results (see Table 7) show that students do not have adequate knowledge of these subjects and they hold a lot of alternative conceptions. At this point, it should be noted that a science teacher told the researcher that astronomical concepts included in the 7th grade curriculum is taught just before the beginning of the summer holiday. However, the same teacher acknowledged that these subjects are not or cannot be taught effectively as it is just before the holiday and there is the looseness of summer period. Indeed, a similar finding is reported by Ekiz and Akbaş (2005). First of all, it shows that it is necessary to review the curriculum and make some modifications in the curriculum to be able to have enough time to teach those topics. It is very likely that this is a problem encountered by a lot of teachers. On the other hand, teachers should take the most of the responsibilities in this matter. However, unless teachers' conceptual knowledge is adequate, these kinds of problems will continue to increase. Even if different samples were used, probably similar results would be obtained in regard to the levels of students' understanding obtained in the pre-test. Teachers should be very cautious while teaching these subjects.

Many studies carried out on astronomical subjects agree that regardless of their educational levels, the existing ideas of a lot of students and even teachers on astronomical subjects include misconceptions or alternative conceptions (Sharp & Kuerbis, 2006; Candela, 2001; Trumper, 2001, 2003, 2006a). In this sense, discussions will be about misconceptions about the concept and how to remove these misconceptions.

Firstly, let's consider the question, "why and how do alternative conceptions emerge on astronomical subjects?" In fact, the teaching of astronomical subjects starts at very young ages (MEB, 2006; Sharp & Kuerbis, 2006). While I am teaching the concept of "the Moon" to my children as a mother, I frequently use the expression, "Look! The Moon ball". I observe that my children use the expression "The Moon ball" more frequently than the concept of "the Moon". I think that when I combine the concept of "the Moon" with the concept of "ball" and give it as "The Moon ball" (with an expression easy on the ear) to my children, they embark on the effort of examining the Moon in a more observing fashion. I believe that in this way they can have a more positive attitude towards the nature and the Universe. Actually, is it possible that we cause alternative conceptions in students without noticing?

Although the students failed to answer the pre-test questions, most of them were able to answer the post-test questions. Moreover, while the students did not answer most of the questions in the pre-test, they amazingly answered the questions in the post-test. For example, for the question 5, the students were expected to answer the question by interpreting their knowledge. However, they wrote only the concept without any interpretation in the pre-test. On the other hand, they added their interpretations in the post-test. We concluded that in the pre-test, their knowledge was at the level of remembering. They improved their knowledge to the level of comprehension, as stated in the increased levels of understanding (see Table 4).

According to Suzuki (2003), the actual reason why the students have lack of knowledge of astronomical concept is that they do not have any point of view regarding the outside of the Earth. Accordingly, if no visual support is provided, students' lack of spatial thinking and three dimensional thinking skills may lead to a failure in reaching the desired levels of achievement regardless of the amount of the analogies used. For that reason, teaching tools such as analogy that helps students comprehend should be used besides visual materials such as simulations or animations in the teaching of abstract subjects or concepts or those subjects or concepts that require three dimensional thinking (Calderón-Canales et al, 2013; Cin, 2007; Crider, 2015; Demirci Güler, 2007; Parker & Heywood, 1998; Rigas & Valanides, 2003; Stavy, 1991; Vosniadou, 1991; Vosniadou & Brewer, 1994). This is because; it is a truth that when students fail to visualize concepts and images, analogical reasoning may be limited (Gentner & Smith, 2012). Because analogies bring students to concrete operational level, they are more useful for students (Brown & Clement, 1989; Dilber & Duzgun, 2008; Gabel & Sherwood, 1980; Harrison & Treagust, 1993). Besides, if a student is at formal operational level, s/he may have an adequate comprehension of the target (Johnstone & Al-Naeme, 1991). As Gentner and Smith (2012) state "analogical reasoning has typically been considered a high-level reasoning process; for this reason, analogy has traditionally been thought of as a deliberate, conscious activity". Therefore, the use of visuals is suggested both to inspire students and to convey understanding of the Universe with visual metaphors and models for astronomical education (Crider, 2015).

The obvious difference between the pre-test and the post-test results of the students implies that teaching based on 5E learning model performed by use of analogy was effective. It can be said that 5E learning model, which allows students to construct their own knowledge through certain mental activities over their prior knowledge and new knowledge and reveals the alternative conceptions of students, had positive effects on this process. As a matter of fact, it is emphasized in a lot of studies that different learning models of the constructivist approach such as 3E, 4E, and 5E make a positive contribution to the construction of knowledge (Çalık, 2006; Özsevgeç, 2007). Besides, it makes us think about the effectiveness of the analogy on the conceptual understanding of students (Brown & Clement, 1989; Choi & Chang, 2004; Cosgrove, 1995; Dagher, 1994; Duit, 1991; Paatz et al., 2004; Wong, 1993). For example, the students were able to explain the effects of CO_2 cloud in the post-test, whereas they could not provide any answer in the pre-test. Surely, the fact that it was the first experience of the students with such instruction could have been influential on this situation. In this sense, it may be necessary to determine to what degree teachers have used analogies and 5E model in their classes before and to what degree students are familiar with them. In addition, the fact that the teaching was conducted by the researcher rather than the students' own teacher may have caused a failure in achieving success to a great extent.

According to the students' reflective writings, most of the students stated the most effective characteristics of analogy. Different students stated different features of analogy. For example, S-C, S-N, and S-R stated describing planets with neighborhood as the more enjoyable matter in analogy. The answers of these students were correct while ordering planets in the post-test. S-E, S-H, and S-O stated that they enjoyed the analogy about satellites. However, S-S wrote that the levels of the analogy were lower than his knowledge level. Of course, it cannot be expected for all students in a class composed of a lot of different characters to benefit from or like the teaching provided to the same degree (Kesercioğlu et al., 2004). This may have been caused by a lot of factors from the student's liking or disliking the science course to his liking or disliking the related subject. It might be useful to find out these factors that affect students' understanding. However, it should be noted that the analogies used in this study had important contributions to the motivation levels of the students. This result is supported by research reporting that use of analogy can improve students' interests, attitudes, and motivations besides their conceptual understanding (Bilaloğlu, 2006; Duit, 1991; Kaptan & Arslan, 2002; Paris & Glynn, 2004; Sağırlı, 2002; Şahin et al., 2001).

In this study, we noticed that the students easily related the characteristics of the planets with neighborhood of district. We considered that the analogy prompted their existing neighborhood relations knowledge and made them relate the gained knowledge with recently learned subject. Because all of the students live in a social cultural environment, they experience these kinds of interactions and relationships in the Turkish social structure. Presenting concepts by relating them with the phenomena, events, or concepts that students encounter in their daily lives has a positive influence on the clarity and permanence of the learned concepts (Karadoğlu, 2007; Kikas, 2005; Vosniadou, 1991). We concluded that these kinds of analogies from daily life experiences are more permanent and meaningful. Because learners recall their pre-existing knowledge through meaningful learning, analogical learning seems to enable them to compare their pre-existing knowledge with the new one (Duit, 1991; Dagher, 1994; Gentner et al., 1997; Gentner & Smith, 2012; Glynn, 2008; Kikas, 2005). For conceptual understanding, we used length-weight images in an analogy (e.g. gnome Mercury, giant Jupiter). In addition, we used the following analogy: "Jupiter with 63 children as the landlord of a tribe; Mercury has no child". As in the neighbor example, we found that it is also very useful to remember the characteristics of planets. If students are familiar with the analogies used in their daily life experiences, we can conclude that it is easy for them to recall relations (Fraser, 2005; Gentner et al., 1997; Kikas, 2005). By doing this, we want to support the students with image frames to have them relate humans and planets with one another. In this study, we found that these kinds of images are very instructive. These sorts of practices are recommended in different studies, too.

We concluded that analogy is a very instructive method to teach scientific concepts and to enhance the learning of students (Gentner, 1983; Gilbert, 1989; Glynn et al., 2007; Wong, 1993; Stavy, 1991; Vosniadou, 1991). The students were successful in making relation between analogy and their daily life experience. By this way, the conceptual conflicts of students may be prevented. Moreover, learning will be more meaningful and permanent to understand abstract and complex concepts. In addition, analogy is more useful for teachers to have students comprehend scientific concepts and to teach effectively in a more enjoyable course (Cin, 2005; Glynn, 2008; Harrison & Treagust, 1993; Küçükturan, 2003; Treagust et al., 1998). As educators, we aimed to make the students think more logically during the instruction to understand and remember the analogy and the context because the analogy would be more logical and easier to recall the relationships between the subjects.

Now, let's continue with the question of why and how alternative conceptions on astronomical subjects could be removed.

Firstly, it should be noted that when an alternative conception held by a student interacts with another one, a new meaning is likely to emerge if the current concepts are meaningful (Nakhleh, 1992; Schmidt, 1997). Secondly, it is said that there is a "competition" between scientific and alternative concepts within students' minds (Stavy, 1991). For example, though the "Earth-Sun-Moon" System seems to be an easy subject, students' spatial thinking is necessary to comprehend the context (Jones et al., 1987; Sharp, 1996; Suzuki, 2003; Trumper, 2001; Vosniadou & Brewer 1992, 1994). It is reported that the reason for students' failure in developing even a simple mental model for the "Earth-Sun-Moon" System is their lack of reasoning and the level of spatial thinking (Callison & Wright, 1993 cited by Mulholland & Ginns, 2008; Calderón-Canales et al., 2013). This is consistent with the findings of a lot of studies on astronomy regarding students' levels of understanding and mental models (Calderón-Canales et al., 2013; Sharp & Kuerbis, 2006). By the way, it is known that conceptual change does not always occur in the desired way and in the positive direction (Ercan et al., 2010).

The test results show that in the pre-test, almost two-third of the students were at levels [1] and level [0] in aligning the planets from the nearest to the furthest. In the post-test, the levels of understanding of 17 students went up to levels [3] and [2]. Similarly, most of the students could not classify the planets based on their sizes in the pre-test, whereas in the post-test there were 14 answers at levels [3] and [2].

This implies that the students' initial alternative conceptions and imperfect knowledge about the Solar System caused the students to fail in doing the requested aligning both in the pre-test and in the post-test. On the other hand, the positive results of instruction through analogy were determined via not only the statistical analysis of the test scores (see Table 7, Table 8) but also in-class observations. However, it can be said that not all of the students achieved the desired success in the post-test. This may have resulted from the nature of the achievement test administered. It is known that multiple-choice tests are used in many studies aimed at determining student success. Indeed, multiple-choice tests do not precisely indicate what students know and do not know. As an open-ended test was administered in the study instead of a multiple-choice one, the students may have failed to write the names of planets because they could not remember the names of planets exactly, which, I think, may have sounded like "names in a foreign language" to them. This is because; we, all educators, think that multiple-choice tests include clues. In general, those students who had not understood the topic of planets by name or who did not remember names may have failed in aligning them correctly. The number of the questions in the achievement test may have been influential on this situation, too. Though the students knew and remembered the existence of planets by size, they might have had difficulty in aligning them by name. At this point, the researcher thinks that concepts should be taught repeatedly several times. More importantly, if there had been written materials, visuals, or maps including the Solar System in the classroom environment, the students could have acquired more knowledge from such visuals. The effectiveness of visuals has an important role in the learning of knowledge.

IMPLICATIONS

Various comments may be made on the situations that have an influence on the success or failure of students based on their levels of understanding of science concepts. At this point, situations leading to the alternative conceptions of students should be focused on. Then the effectiveness of teaching situations that can be used for eliminating students' alternative conceptions, misconceptions, misunderstandings, or lack of knowledge should be discussed. Or, it may be discussed what different actions may be taken to enhance the effectiveness of these materials or teaching methods.

As is known, meaningful learning has to be achieved to ensure conceptual change. To achieve permanent and meaningful learning, on the other hand, learning process has to be structured well, and abstract concepts have to be made concrete. This is because; astronomy is inherently a visual science and has such a strong visual component (Crider, 2015; Partridge & Greenstein, 2003). To this end, it is suggested to make use of visual materials, auditory materials, analogies, and models (Crider, 2015; Demirci Güler, 2007; Duit, 1991; Kikas, 2006; Rigas & Valanides, 2003; Rosvick, 2009). In addition, astronomy is a fertile academic discipline for the teaching and learning of visual literacy (Crider, 2015). Moreover, the misconceptions and alternative conceptions of students should be determined at the beginning of teaching process; such alternative conceptions should be taken into consideration while arranging teaching activities; and mnemonic techniques that have an important influence on permanent learning and remembering should be used (Tay, 2004). This is because; learners have either very low or no motivation to change or re-construct their existing ideas (Chin & Brown, 2000). Therefore, appropriate learning activities should be arranged, and scientific conceptions should be strengthened despite students' alternative conceptions (Dikmenli & Çardak, 2004; Özkan et al., 2002). For that reason, more effective results could have been obtained if pictures, dramas, or plays had been employed while using the analogy embedded into 5E learning model.

We can easily say that the analogies in this study are just some examples to use during teaching and learning activities. It is recommended that these kinds of analogies should be developed and used for meaningful learning during teaching and learning activities for other contexts. Furthermore, the number of analogies in textbooks and written materials for students should be increased. Before all, it should be remembered that textbooks, teachers, and teaching materials have an important influence on the emergence of alternative conceptions in students (Aubrecht & Raduta, 2005; Cin, 2007; Dikmenli & Çardak, 2004; Kikas, 1998; Özkan et al., 2002; Ünsal & Güneş, 2002). It is known that especially textbooks contain alternative conceptions and thus fail to facilitate the conceptual learning of students (Hawkes, 1996; Taber, 1995). Furthermore, it is reported that books rarely take students' prior knowledge into account (Kim & van Dusen, 1998). Hence, the nature of the textbooks used by students inevitably influences their levels of understanding.

While developing analogies, teaching principles and tenets should be considered, and analogies should not lead to alternative conceptions but give a chance to students to relate the new knowledge with their prior knowledge (Fraser, 2005; Gentner & Smith, 2012). It is also necessary for conceptual change. Especially daily life experiences and concrete examples should be used. It is a truth that these kinds of analogies are useful to remove students' alternative conceptions. For the subjects that require students to engage in spatial thinking and have a point of view of the outside of the Earth (particularly astronomy), the levels of spatial thinking and reasoning of students should be taken into consideration, and the learning environment should be enriched with different techniques. Many studies suggest that using well-planned analogies is one of the most effective ways to reinforce student understanding (Aykutlu & Şen, 2011; Roland, 2006; Chiu & Chen, 2005; Glynn et al., 2007; Dilber & Duzgun, 2008). Today, a popular and effective approach especially for astronomical education is using interactive plots and diagrams to help students "experiment" with concepts (Crider, 2015).

This paper reports on the classroom use of an analogy activity about the Solar System based on a constructivist view of 5E learning model. Therefore, it can be said that this constructivist-based study allowed the students to actively construct and transform their knowledge. This is because; it is known that especially the constructivist-based teaching model allows students to acquire and accumulate knowledge actively (Driver et al., 1994; Vosniadou & Brewer, 1992). As a conceptual change method, analogies are advised to use in science education (Gentner & Smith, 2012). Moreover, this may fail to achieve expected results as many educators have pointed out (Huddle, White & Rogers, 2000; Çalık, 2006). Although many activities have been devised to reinforce conceptual change, teachers and pupils may accept them in different ways (Bell, Osborne & Tasker, 1985; Aykutlu & Şen, 2011). For this reason, we recommend that teachers should know these differences to devise an excellent teaching process because in-service teachers and/or pre-service teachers may have inadequate knowledge of how to combine different teaching methods with materials (Cin, 2007; Çalık & Ayas, 2005; Fensham, Gunstone & White, 1994; Matthews, 2002). On the other hand, it should be certainly known that the use of an analogy does not always result in the success of the analogy (Brown & Clement, 1989; Dagher, 1994; Gabel & Sherwood, 1980; Pitmann, 1999). Particularly when learners take an analogy unfamiliar to them, they may not be able to relate it with the real situation. After all, the result will be miscellaneous conceptions. For this reason, it is stated that using analogy with other alternative teaching methods will be more instructive (İpek & Çalık, 2008; Kurnaz & Çalık, 2008). As 5E learning model was used here, it can be said that teaching through 5E had positive influences on the learning of students. As a matter of fact, teaching involving the use of 5E is recommended in many studies.

The biggest responsibility for achieving conceptual change belongs to teachers (Harrison & Treagust, 1993). Teachers should develop well-planned analogies according to the tenets of analogies. Therefore, use of learning strategies that will enable students to actively participate in the learning process will ensure learning and remembering (Emrahoğlu & Öztürk, 2009). For all these reasons, teachers are expected to receive adequate education on astronomical subjects before they start their professional lives. Incomplete or incorrect knowledge of astronomical subjects held by teachers may cause misconceptions or alternative conceptions, which are very difficult to remove, in students (Cin, 2007; Taşcan, 2013). As such deficiency has been noticed, educational faculties in Turkey, just like in a lot of universities across the world, have started to offer astronomical education to pre-service teachers.

Computer-based instruction can also be recommended for the use of analogies to ensure conceptual understanding. As it is known, dynamic computer analogies may be developed to enhance conceptual learning (Chiu & Chen, 2005; Glynn, et al., 2007; Hong-Kwen & Kok-Aun, 1997; Murray, Schultz, Brown, Clement, 1990). To help students to construct conceptual bridges more effectively, it is suggested to use analogies in web-based science instruction (Glynn et al., 2007). Thus, we emphasize that instructional technologies should be used more effectively to enhance student learning. In this way, they can develop conceptual understanding and easily overcome alternative conceptions.

Studies on analogy highlight the positive contributions of analogy use by giving the used analogies as examples (Cosgrove, 1995; Dupin & Johsua, 1989; Gentner, 1983; Gentner & Smith, 2012). There are a lot of proved examples. These analogy examples should be used in textbooks and teaching materials. In this way, it will be possible to see the implementation of different examples not only in Turkey but also worldwide and to develop new examples over the existing ones. Thus, these kinds of analogies should be shared by disseminating the teaching materials. Besides highlighting the benefits of use of analogy, its area of usage should be broadened. A clear example of this is the water circuit-electric circuit analogy of Glynn et al. (2007), which we all know.

It is now acknowledged that learning astronomical subjects is important not only for students but also for adults. Conducting research on "astronomical literacy" may contribute to the determination of the teaching situations to be formed in this matter. As stated before, beliefs and cultural and social values play an important role in the formation of astronomical concepts. Thus, awareness of astronomical literacy at social level may influence not only us but also those who are around us in terms of "perspective on scientific method". This is necessary to learn about the rational way of thinking and experimenting that has been so successful in revealing the underlying rules of the natural world (Impey et al., 2012).

LIMITATIONS

At the end of this study, what is thought-provoking is that students may keep their alternative conceptions about the Solar System despite their advancing ages, as indicated in a lot of studies. Accordingly, regardless of the methods employed, it may be recommended to carry out tests even at advanced learning levels to understand whether such methods contribute to effective and lasting understanding. This is because; identifying to what degree alternative conceptions have been removed by an intervention (e.g. an activity performed for the teaching of a subject) is as important and necessary as determining whether or not alternative conceptions exist. Indeed, it is reported in a lot of studies that similar alternative conceptions exist in older people, too. For that reason, latitudinal and longitudinal research would be more useful. Actually, if a delayed test had been conducted in the present study, more positive results could have been obtained to prove the effectiveness of the method we used. That may be accepted as the most important lack of the study. In these kinds of studies in which a different teaching method including different teaching materials is used, the effectiveness of such method may be tested through a delayed test.

Many studies dealing with the use of analogy recommend students to produce their own analogies (Duit et al., 2011; Rule & Furletti, 2004; Şahin et al., 2001). In fact, giving the responsibility for the formation of analogies to students helps them achieve and improve conceptual understanding (Harrison & Jong, 2005; Wong, 1993). Even students are expected to obtain new analogies based on the existing analogies. It is argued that this enhances the conceptual development and brings permanence (Duit, 1991; Karadoğu, 2007; Şahin et al., 2001). If such an approach had been adopted in the present study, more effective results could have been obtained. As a matter of fact, there are some models regarding analogies such as Bridging Analogies (Brown & Clement, 1989; Gentner & Smith, 2012), Analogy Teaching Model (Dupin & Johsua, 1989), Teaching-With-Analogy (TWA) (Glynn, 1991; Glynn, 2007), and General Model of Analogy Teaching (Zeitoun, 1984) to explain more concepts. These models show that analogy is one of the effective conceptual techniques for meaningful learning (Gentner & Smith, 2012; Glynn, 2007; Glynn et al., 2007). Apart from that, more positive results could have been gained if visuals such as simulations or animations, models, dramas, and plays had been used in the present study. This is because; it is known that the inclusion of such situations in the teaching process makes the use of analogies for teaching concepts more effective (Bilaloğlu, 2006; Cosgrove, 1995; Çalık et al., 2011; Gentner & Smith, 2012; Karadoğu, 2007). This is why different elements such as role play, game cards, and concept maps are used in studies involving the use of analogy (Blake, 2004; Coll & Treagust, 2001; Şaşmaz Ören & Erduran Avcı, 2004; Tsai, 1999).

It is stated that research involving a pre-experimental one group pre-test/post-test design may contain problems about validity (Cohen et al., 2007; Jackson, 2013; Örnek, 2007). Therefore, as in a lot of studies on astronomy, a control group is recommended. Moreover, two- or three-stage tests could have been used to identify the alternative conceptions of the students. It is reported that increasing the number of stages or the number of questions allows obtaining more reliable results about the knowledge levels of students in a study which aims to determine the alternative conceptions and misconceptions of students (Göncü & Korur, 2012). If the study had involved a quasi-experimental design with a larger sample, the effectiveness of the use of analogy embedded into 5E learning model could have been indicated more efficiently. As a result, satisfactory results were obtained in the present study even though the study has some limitations.

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APPENDIX

There is only the main steps for a course plan according to 5E model.)

Enter (Engaging):

At the beginning of the course, the teacher should ask the following questions to determine the students' levels about the subject. By this way, the teacher should get students to confront their pre-existing ideas. The teacher should use all needed figures and pictures about the Solar System to make it more understandable.

1) What is the shape of a star like? Is it like the star on Turkish flag?
2) Which star is the biggest one in the Solar System?
3) Please give some examples from star cluster.
4) Is comet a star?
5) What are the differences between a planet and a star?

By these questions, the teacher makes inferences about students' backgrounds.
The teacher explains and asks: "We all like watching the sky at night.
All right, are there only stars in the sky?"
After the students' answers, the teacher asks some other questions such as:
"Is there any planet or only the Earth?"
After all the questions, the teacher explains students that they will find out all the answers at the end of the course.
The exploration step will be conducted.

Exploration:

Today, our main subject is the Solar System.

1) Do you know the Solar System, satellite, galaxy, etc.?
2) What are the planets in the Solar System?

After these kinds of questions, the following activity is performed together.

Activity: *Neighborhood unit of the Solar System*
Materials: The analogy about the Solar System (see Table 2)
Procedure: The analogy model is given to a student for him/her to show it to all students in the classroom by walking.

1. Briefly explain the characteristics referred to in the analogies about the Solar System.
2. Hand out conversation cards about each character to students.
3. Students loudly read the conversation cards of the planets that are similar to people's conversations.

Ensure that students find out the similarities and relationships between planets and spoken human characters.
After this activity, the teacher draws a table on board and asks questions about planets.
For each planet, the characteristics are written by students as in the following table.

(Appendix) Table I. Planets and their characteristics

Distance to the Sun (from near to far)	According to Size (from big to small)	The number of satellites possessed (from big to small)
Mercury	Jupiter	Jupiter (63)
Venus	Saturn	Saturn (56)
Earth	Uranus	Uranus (22 small-5 big)
Mars	Neptune	Neptune (13)
Jupiter	Earth	Mars (2)
Saturn	Venus	Earth (l)
Uranus	Mars	-
Neptune	Mercury	-

Explanation:

The teacher should benefit from various resources to enrich the explanation. Here, we refer to
The Kids Astronomy (see www.kidsastronomy.com)

Our solar neighborhood is an exciting place. The Solar System is made up of all the planets that orbit our Sun. The Solar System consists of planets, comets, moons, asteroids, minor planets, dust, and gas. There are eight planets in the Solar System. Their characteristics are listed as following:

1) Mercury: The planet Mercury is the closest of the planets to the Sun. Because this planet lies so close to the Sun, and as a result somewhat near to the Earth, it is visible to observers on the Earth in the late evening or early morning sky. This planet is often called a morning star. This is because; Mercury shines brightly in the early morning just before the sun rises. Because of its proximity to the Sun, Mercury's evolution took a slightly different course than that of the other planets. The planet Mercury is too small and has too little gravity to hold onto an atmosphere. Mercury is so close to the Sun that any atmosphere is quickly blown away by the Sun's solar winds. That means that there is almost no air on Mercury. Mercury has no moons.

2) Venus: Venus and the Earth are almost the exact same size. Venus is in many ways Earth's sister planet. Like the Earth, Venus has an atmosphere. However, Venus' atmosphere is far thicker than that of the Earth. Venus lies much closer to the Sun. Owing to its closer proximity to the Sun, Venus' temperature should have been only slightly warmer than that of the Earth. Venus is made up of almost the exact same types of materials as the Earth and in about the same amounts. Venus has volcanoes, mountains and sand, just like the Earth. Venus is a deadly world where the surface temperature is hot enough to cook a meal in mere minutes. Venus does not have an ozone layer. Venus has no moons.

3) Earth: The Earth is the biggest of all the terrestrial planets. There are currently almost 7 billion people living on the Earth. About 30% of the Earth's surface is covered with land, while about 70% is covered by oceans. The Earth has one moon. Its name is Luna.

4) Mars: You may sometimes hear Mars referred to as the "Red Planet." This is because; the surface of Mars is red. Mars' mild temperament is more like the Earth's. Mars has rivers, streams, lakes, and even an ocean. Mars has higher mountains and deeper canyons than any other planet. As Mars' atmosphere slowly depleted into outer space, the surface water began to permanently evaporate. Today the only water on Mars is either frozen in the polar caps or underground. Mars has two moons, and their names are Deimos and Phobos.

5) Jupiter: If you traveled to Jupiter on vacation, you would be very heavy. This is because; Jupiter is such a large planet and so has more gravity. Jupiter is by far the largest planet in the Solar System. The Earth could fit inside Jupiter more than 1000 times. Jupiter is a very stormy planet. There are storms found throughout the atmosphere, and most of the storms seem to never end. Jupiter is considered a gas giant because it does not have a solid surface. There are three rings in all. They are faint and are only able to be viewed when Jupiter passes in front of the Sun. Jupiter has 50 official moons and 12 provisional (unofficial) moons.

6) Saturn: Saturn is bigger than the Earth.You would weigh more on Saturn than you do here. In many ways, Saturn is similar to Jupiter, but it is much smaller. It is the second largest planet in the Solar System and it is a gas giant like Jupiter. Saturn is most well-known for its rings. However, it is not the only planet with rings. Jupiter, Uranus and Neptune also have rings. Saturn has 53 official moons and 9 provisional (unofficial) moons. Saturn is the furthest planet from the Earth that can be seen without the help of a telescope.

7) Uranus: It would take you many years to fly a rocket to Uranus. When you arrived you would weigh less because Uranus' gravity is not as strong as the Earth's. Like Jupiter and Saturn, Uranus is a gas giant. However, Uranus is a little different. Unlike all the other planets and most of the moons in the Solar System, Uranus spins on its side. Uranus is an extremely cold planet. It has been called the "ice giant." It is believed that Uranus is made up of rock and ice and has a large rocky core. Uranus also has rings. The rings of Uranus are made up of black dust particles and large rocks. Uranus has 27 moons.

8) Neptune: Neptune is the smallest of the four gas giants in the Solar System. For many centuries, people did not know that this planet even existed. It was discovered by Johann Galle and Heinrich D'Arrest in 1846. In Neptune's atmosphere, there is a large white cloud that moves around rather quickly. The "scooting" of this cloud around the atmosphere has led it to be named "Scooter." Neptune is a very windy place. No other planet in the Solar System has winds that are as strong as Neptune's. Neptune has six rings which circle the planet. These rings are believed to be fairly new. Neptune has 13 moons that we know of. Because Neptune is so far away, it is difficult to see any of these worlds. There are probably many more moons orbiting this blue planet which we have not yet discovered. Perhaps you will be the astronomer who discovers some of these worlds.

Elaboration:

1) Where do the planets' names come from? Research, please.
2) Get some information about famous astronomers? Please, share the knowledge with us.

Evaluation:

Ask some questions for students. Use all needed figures and pictures about the subject.