



JOURNAL  
OF BALTIC  
SCIENCE  
EDUCATION

ISSN 1648-3898 /Print/

ISSN 2538-7138 /Online/

**Abstract.** *The purpose of this research was to examine the effect of the 5E teaching model on the primary school pre-service teachers' (PSPTs) learning some astronomy concepts. The sample of this research consisted of 90 PSPTs in the 2nd year at a state university. The research was carried out on the pre-experimental methodology with a single research group. The data of the study were collected by concept cartoon form which included some astronomy concepts such as the Sun, star, planet, meteor, Solar System, constellations. The developed teaching materials about the chosen astronomy concepts were implemented in eight course hours. It was seen that most of the PSPTs had alternative concepts. A considerable decrease was determined when the pre and post-test results of the PSPTs were compared; it was found that learning based on the 5E teaching model had a positive effect on the conceptual change. It can be said that 5E teaching model was effective on remedying alternative concepts. In the future research about astronomy teaching may be conducted to determine the effects of 5E teaching model on remedying the alternative concepts and achieving conceptual change with the different education levels of students.*

**Keywords:** *concept cartoons, primary school, pre-service teachers, astronomy concepts, 5E teaching model, alternative concept.*

**Çiğdem Şahin, Ümmü Gülsüm Durukan**  
Giresun University, Turkey  
**Elif Arıkurt**  
Nebi Güney Middle School, Turkey

## EFFECT OF 5E TEACHING MODEL ON PRIMARY SCHOOL PRE-SERVICE TEACHERS' LEARNING ON SOME ASTRONOMY CONCEPTS

**Çiğdem Şahin,  
Ümmü Gülsüm Durukan,  
Elif Arıkurt**

### Introduction

Learning is directly correlated with individualistic differences. Likewise Bodner (1990)'s perspective, a meaningful teaching may not be realised with all of the students, however the teacher practises teaching well. The students give meaning to their new knowledge by associating them with their pre-knowledge and construct them in their minds (Osborne & Wittrock, 1983). While the students are constructing the concepts, they can develop alternative concepts which are scientifically wrong and called misconceptions or alternative frameworks (Driver & Easley, 1978) in literature. The existence of knowledge which does not comply with scientific facts in the students' pre-knowledge with reference to the topic they learn prevents realisation of meaningful learning (Osborne & Wittrock, 1983). The 5E teaching model, one of the models of constructivist learning theory, is frequently used in concept learning to have the students construct the concepts scientifically in their minds. In the research, it was determined that 5E teaching model was effective to provide student achievement and to remedy their misconceptions (Vincent, Cassel & Milligan, 2008). The studies intended for the 5E teaching model were carried out about such topics as cell (Wilder & Shuttleworth, 2005), floating- sinking (Vincent, Cassel & Milligan, 2008), buoyancy force (Şahin & Çepni, 2012), and so on.

From the literature about the teaching astronomy, it can be said that the participants possess various alternative concepts like many other abstract concepts (Blown & Bryce, 2010; Küçüközer, Bostan & Işıldak, 2010; Ercan, Taşdere, & Ercan, 2010; İyibil & Sağlam-Arslan, 2010; Kallery, 2011; Kurnaz, 2012). Many research conducted about teaching astronomy are mostly to determine student perception about basic astronomy topics and concepts (Klein, 1982; Atwood & Atwood, 1996, 1997; Kikas, 2005; Kalkan & Kiroğlu, 2007; Cin, 2007; Emrahoğlu & Öztürk, 2009; Frede, 2006; Kallery, 2011; Kurnaz, 2012; Wallace, Prather & Duncan, 2012; Karslı & Kara-Patan, 2016) and mental models (Vosniadou & Brewer, 1992; Liu, 2003; Panagiotaki, Nobes & Potton, 2008; İyibil & Sağlam-Arslan, 2010). However, same studies carried



out to remedy alternative conceptions (Küçüközer, Bostan & Işıldak, 2010; Trumper, 2006a; Ercan, Taşdere & Ercan, 2010) are quite few in number. One of these researches, Trumper (2006a) determined that activities based on constructivist theory were effective to remedy the prospective teachers' misconceptions about the Earth's, the Sun's, and the Moon's motions. In another research, Ercan, Taşdere and Ercan (2010) determined that teaching based on constructivist approach was positively important on the students' conceptual change and understanding key concepts such as star, planet, celestial body, meteor, The milky way, telescope. Similarly, in study of Küçüközer, Bostan and Işıldak (2010), significant difference was found between the two tests in favour of post-test and teaching was found to be effective in providing of conceptual change. In the literature related with 5E teaching model, there are not enough research which aimed at teaching astronomy topics and concepts. The limited researches about the using 5E teaching model in teaching astronomy indicate that it is a useful model to remedy alternative concepts.

Astronomy is a branch of science which has a close relationship with many branches of science such as physics, mathematics, and geography. Undoubtedly, what lies beneath these relations is that the individuals make a great effort to understand the universe, the Earth and the nature (Percy, 1998; Trumper, 2006b). Thus, Trumper (2006c) determined in his study that among the subjects which most drew the attention of the high school students were astronomy concepts and stated that the students were curious about the answers of such questions as "How it feels to be weightless in space", "How meteors, comets, or asteroids may cause disasters on earth" and "Black holes, supernovas, and other spectacular objects in outer space". The learners' great interest and curiosity in astronomy topics and concepts caused the researchers to focus on these topics. It is no doubt that the teachers have an important role to make astronomy education qualified. Therefore, firstly the pre-service teachers' alternative concepts about astronomy should be determined and implementations must be carried out for these concepts to be exchanged or remedy by scientific concepts. In this study, the alternative concepts of the Primary School Pre-Service Teachers (PSPTs) who are going to carry out the primary education about the basic concepts for astronomy in formal education environments about some concepts of astronomy were determined and they struggled to remedy these alternative concepts. It is believed that this study would supplement the lack of material pointed out in literature (Cin, 2007; Kurnaz, 2012) to some extent and the results of the study will light the way for the future studies.

#### *Problem of Research*

The purpose of this research was to examine the effect of the 5E teaching model on the PSPTs' learning some concepts of astronomy. The research questions are "Does the 5E teaching model affect the PSPTs' learning situations about some concepts of astronomy such as the sun, star, planet, meteor, solar system, constellations?" and "How do the PSPTs' conceptual understandings of some concepts of astronomy change after the implementation of 5E teaching model?"

### **Methodology of Research**

#### *General Background of Research*

The research was carried out according to the single group pre and post-test design of pre-experimental methodology. In pre-experimental methodology, a single research group is often studied but no comparison between equivalent non-treatment groups is made. Treatment is carried out on a single research group during pre and post-test implementations (Cohen & Manion, 1994). The effect of the 5E teaching model to remedy the alternative concepts was investigated on a single research group in this research.

#### *Sample of Research*

The sample of the research consisted of the PSPTs in the 2nd year of the Education Faculty, Primary School Teacher Education at a university located in Eastern Black Sea Region. In the pre-test of the research 123 PSPTs joined, 121 PSPTs participated in the teaching sequence and 105 PSPTs participated in post-test. Therefore, the sample of research consisted of 90 PSPTs who participated both in the pre-test, teaching sequence and the post-test, because the pre and post-test scores were going to be compared.

In Turkey, Primary school teacher's job description can be done as follows: primary school teachers try and arrange learning environments in order to gain basic knowledge, skills and attitudes on basic sciences such as read-



ing and writing, basic citizenship, mathematics, social sciences, natural sciences, arts, sports areas etc. to students between 6 to 12 ages in the formal teaching process.

The knowledge and skills which the PSPTs gained throughout their education life about the field of astronomy can be listed as follows:

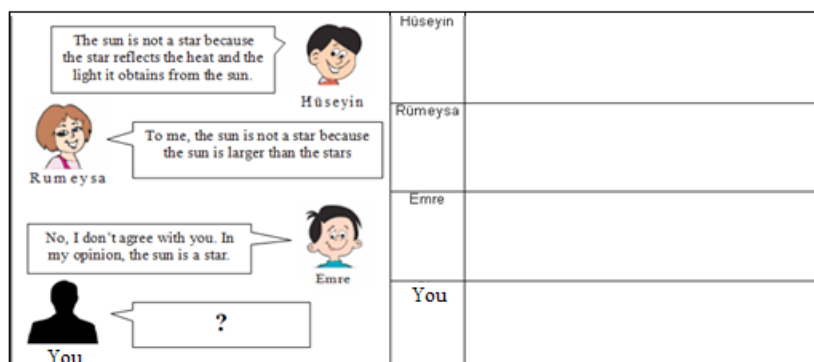
- Within the framework of life science course under the theme of Yesterday, Today, Future, the students learn the concepts of the Earth and the Sun in the 1st grade, the same concepts, their motions and what we can see when we look up the sky in the 2nd grade, the moon and its phases, the Earth and its motion and the Sun concepts in the 3rd grade (MNE, 2009).
- Within the framework of Science and Technology course under the field of the Earth and the Universe, the students learn the subjects related to the shape of the Earth and its structure properties in the 4th grade, the size of the Earth, the Sun and the Moon and their motions, and they can be able to distinguish these concepts from each other in the 5th grade (MNE, 2005).
- Within the framework of Science and Technology course, the materials which form the lithosphere, the place and the importance of these materials in our life will be studied. In the 7th grade, the students are introduced to the basic concepts such as galaxy, planet, star, comet, and constellation. They are also told about the solar system and optical instruments used for the space exploration. In the 8th grade, the formation of the Earth, plate tectonics, and the climate phenomenon in the atmosphere are mentioned and the importance of these events in our daily life will be addressed in Turkish education system (MNE, 2006).

The students are expected to comprehend the basic astronomy concepts which are presented in a spiral structure in teaching curricula with life science and science and technology courses in primary education.

#### *Instrument and Procedures*

In the literature to collect data about astronomy topics and concepts, such techniques as multiple choice tests (Trumper, 2003; Küçüközer, Bostan & Işıldak, 2010), open ended questions (Frede, 2006; İyibil & Sağlam Arslan, 2010), drawings (Hannust & Kikas, 2007), word association test (Ercan, Taşdere & Ercan, 2010) were used and therefore, the primary school students' and the PSPTs' mental models, understanding levels, and misconceptions related to the topics were revealed and their conceptual change processes were investigated. Conspicuously, the concept cartoons do not take place among the data collection tools of the studies in the literature. Keogh and Naylor (1999a) defined concept cartoons as teaching approach which presents alternative concepts in science and is formed by small texts where cartoon characters take part. Opportunities are given to the students with the concept cartoons to compare their scientific opinions with their opinions about the situations in daily life (Keogh & Naylor, 1999b). The abstract and complex science concepts are able to be explained easily by the characters in concept cartoons (Stephenson & Warwick, 2002). Each cartoon character about a new situation must be prepared in such a way that a character can assert a different opinion (Keogh & Naylor, 1999b; Stephenson & Warwick, 2002). The students are given an opportunity to inquire their own understanding and their misconceptions about the relevant concept and justify their own ideas by this way (Stephenson & Warwick, 2002; Kabapınar, 2005). Concept cartoons enable the students to meet the events which they have never realized before. Concept cartoons prepared must consist of common misconceptions and scientific facts (Kabapınar, 2005). Additively, it was stated in literature that concept cartoons were effective to reveal the preliminary knowledge of the students, though (Stephenson & Warwick, 2002). Therefore, it was decided that concept cartoons were used as data collection tool in this research.





**Figure 1:** An example of a concept cartoon.

The research data were collected by concept cartoon form developed by the researchers to be used in pre and post-test and which include some concepts of astronomy and the relevant concepts. As data collection tool, 12 different concept cartoons about the concepts in astronomy such as "The sun and the star", "shape of the star", "The stars and the planets", "The brightness of the stars, their colour and size", "Meteor", "the planet", "location of meteor, star, and celestial bodies (the sky and the space)", "the structure of the solar system", "Shooting stars", "Constellation", "Light year", "The comet" were prepared. There were three characters who said different statements about the subject on the concept cartoons. While the PSPTs answering the concept cartoons were asked to identify the characters' statement true or false and to write only the answer (true/false) in the table next to cartoons. Besides the three cartoon characters in concept cartoons, there is "you" character which represents the PSPTs. So the PSPTs can express their own thoughts on "you" character's thought balloon. In order to help the students answer them easily, characters are called with names (Kabapınar, 2005). An example of cartoon character was presented in Figure 1. While concept cartoons were prepared, many alternative concepts which were determined in the studies about astronomy topics and concepts in literature were benefited from and identified alternative concepts/misconceptions were used in concept cartoon character statements. Besides that, some of alternative concepts were obtained in the textbooks. The gains about astronomy topics were examined in the primary school science and technology course instruction program. And, concept cartoons were prepared parallel to these gains in the instruction program.

**Table 1.** The gains belonging to the concept cartoons, alternative concepts and the studies where the alternative concepts were determined.

Gains	Alternative Concepts	The studies where the alternative concepts were determined
1 S/he expresses that the Sun is a star too.	The sun is not a star because the star reflects the heat and the light it takes from the Sun.	Kurnaz, 2012; Roald & Mikalsen, 2000;
2 "Star" suggests the shape in the Turkish flag. The stars are usually thought to be spherical.	We are told in the books we have read and the publications we have followed till now that the star is shaped like that ★	İyibil & Sağlam-Arslan, 2010; Kurnaz, 2012; Sharp, 1996
3 While doing observation, the students distinguish the stars from the planets.	Stars exist in the sky but the planets exist in the space.	Dunlop, 2000
4 They explain the difference between the meteor and the meteorite.	We learn the natural phenomenon with the help of the meteors.	Ercan, Taşdere & Ercan, 2010;
5 They know the features of the stars.	Stars are the smallest celestial bodies.	Ercan, Taşdere & Ercan, 2010; Sadler, 1998
	The hottest stars are red, yellow and white.	Küçüközer, Bostan & Işıldak, 2010; Zeilik, 1998
6 The planets are not the source of light and they exist in the space and they compare the size of the planets to the other celestial bodies.	We cannot see the planets but the people who travel to space can see them.	Ercan, Taşdere & Ercan, 2010
	The largest celestial objects are the planets.	



	Gains	Alternative Concepts	The studies where the alternative concepts were determined
7	Because we can observe them with a naked eye in the space, they notice that there are more celestial bodies.	Stars are seen in the sky.	Ercan, Taşdere & Ercan, 2010; Kurnaz, 2012
8	They know the place of the celestial bodies in the Solar System.		Cin, 2007; MNE, 2006; Sharp, 1996
9	They know that a meteor which enters with a great speed and burns in the atmosphere causes the shooting star.	To me, shooting star is the stars' changing location with their movement. Shooting star is the visible comet.	Küçüközer, Bostan & Işıldak, 2010
10	They give examples of known constellations. They also state that stars which make up constellation are called by a common name because they exhibit the same view when they are looked at from the Earth but not due to their common features or relationships.	Horoscopes are also constellations. Moreover, the most famous constellation is Halley. Daily horoscopes cannot be stars. Stars appear close together in the constellation.	Kurnaz, 2012; MNE, 2006
11	They also state that the long distances between the stars are expressed by a light year, unit of distance.	Light year is a unit of time. A light year is 100 years. Light year is a unit of time but it is a flow of time that occurs between when the sun rises and sets.	MNE, 2006
12	They also indicate that comets are named as stars but they are different from the stars.	Comet is a star because comets also emit light. Comets are stars because comets are made up of dust and gas like the other stars.	Kurnaz, 2012; MNE, 2006

Every concept cartoon has been developed in accordance with a pair of gain-alternative concept in Table 1. The views of two experts were consulted in order to provide the construct validity of the concept cartoons. The PSPTs completed the concept cartoon form about 60 minutes. The gains, the alternative concepts and the studies which determined alternative concepts were presented in Table 1.

#### *Development of Teaching Materials and Their Implementation Process*

The teaching materials based on 5E teaching model which included the star, the planet, meteor, celestial bodies, comet, constellation and light year topics of astronomy were developed. The reasons why the 5E teaching model was preferred was that; it was determined that 5E teaching model was effective in teaching various science concepts (Şahin & Çepni, 2012). And it was considered that the PSPTs would be using the applications based on the 5E teaching model in their teaching process after their graduation, as the 5E teaching model of constructivist theory is adopted and used in the updated Turkish curriculum of science and technology courses (MNE, 2006). Moreover, Trumper (2000) defended that the strategies like class discussion used were effective for remedying the misconceptions of the PSPTs and constructivist theory had an important role in teaching astronomy.

The content of the course was formed by preparing two plans. The activities that take place in the teaching materials developed and their implementation process were presented in Table 2.

In the first course plan, each PSPT was given a worksheet and the PSPTs were asked to answer the questions in the worksheet and then their answers were heard. However, the answers of the PSPTs were not interfered. In explore stage; the PSPTs watched a detailed video about space from a CD. After the video, the questions of "Which celestial bodies did you see? What might there be in the space apart from these?" were asked to the PSPTs and their answers were heard. In the explain stage, after the video, necessary explanations about the star, meteor, meteorite, the Earth, the Sun and the planets were given. In the elaboration stage, the PSPTs were asked to create their own space with play dough. During this activity, the PSPTs are divided into groups, the groups are distributed worksheets and each group gives a name to their group and work on the pastebord with play dough. The PSPTs were enabled to make celestial bodies such as planets, stars, and meteor. The lecture invited a PSPT from each group to the board to have them compare and explain what they have done. After all the groups completed their work, the lecturer gets the PSPTs to watch another video which included in the sizes of the planets and the stars



and comparisons between their sizes. In the evaluation stage, the structured communication grid worksheets were prepared about the concepts PSPTs have learnt were given to the PSPTs. The PSPTs answered them and then their answers were discussed.



**Figure 2: Examples from the PSPTs' applications from a play dough activity called "Space in Our Dream".**

Table 2. Information about teaching materials developed in the research, their intended purpose, the stages where teaching materials (TMS) are used in the 5E teaching model and implementation time.

Plan-1 which involves the Star, The Planet, and Meteor concepts				
Materials developed	Purpose	Gains (see Table 1)	Duration (min.)	The 5E TMS
A worksheet called "Astronaut –Taz"	To reveal misconceptions and determine their preliminary knowledge.	2,4	25	Engage
Watching a CD of Science Journal	To compare the sizes of star and planet and to go over opinions and teach concepts	1,3,4,5,6,7	45	Explore
Discussion activity of comparison of a Science Journal CD and the knowledge inherent in their minds	To enable the PSPTs to internalise by having them discuss what they watch in the video and their own knowledge and help them go over the expressions they use in daily life	1,3,4,5,6,7	30	Explain
A play dough activity called "Space in our Dream" and a video	To reveal the portrait related to the space in the minds of the PSPTs	3,7, 8	60	Elaboration
Structured communication grid	To go over misconceptions and to evaluate their learning conditions		20	Evaluation
Plan-2 which involves the Comet, the Constellation, and Light year concepts				
Materials developed	Purpose	Gains (see Table 1)	Duration (min.)	The 5E TMS
Work sheets	To examine the preliminary knowledge of the PSPTs about constellation and light year and to create curiosity.	10	30	Engage
Making a constellation map activity called "Which star group are you?"	To learn the concepts of constellation and light year	10, 11	60	Explore
Discussion	To give an explanation of constellation and light year concepts via discussion and to come up with an explanation related to constellation and light year	10, 11	35	Explain
A conceptual change text called "The story of a comet"	To go over opinions, to have them comprehend the difference between the comet and the shooting star and to teach a concept	9, 12	35	Elaboration
Semantic Features Analysis	To go over misconceptions		20	Evaluation

In the other course plan, concepts such as the comet, the constellation, light year were studied. In the engage stage in this plan, the questions of "Do you always see the stars in the sky in the same shape when you look up the sky?" "Can you group the stars you observe in the sky?" were asked to the PSPTs and their answers were heard.



The questions of "When is your birthday?" "Do you know your horoscope?" were asked to draw the attention of the PSPTs. Their answers were heard. Afterwards, they were asked whether the horoscopes called "Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius and Pisces" are stars or not. In the explore stage, the student groups were composed of 4 or 5 PSPTs. Each group determined a pseudo-name for their group. The scissors, glue, ruler and the constellation map to be made were distributed to each group. After the constellation map was done, the activity became a competition. Then, the Great Bear, a constellation determined by researchers, asked the PSPTs to explore the constellation of their own horoscopes. After the constellations were found, they were asked to explore the distance between these constellations. The group which completed this activity becomes the first and the group was given a prize. In the explain stage, with questions such as "What is a constellation?", "How is a constellation formed?", "Can you give examples to a constellation you know?" and "What is a light year?" the PSPTs were enabled to reinforce what they learned with the activity they did. Constellation and light year were explained in detail. In the elaboration stage, the misconception that "comets are stars" was tried to be exchanged with a conceptual change text (CCT) activity called "The Story of a Comet". Moreover, it was emphasised in the CCT that comet is not associated with shooting star event by taking into consideration the misconception that "shooting star is the comet which is visible" and it is stated that shooting star occurs when the meteor enters the atmosphere and it burns up into flames due to friction of the meteors. The evaluation of the course was carried out with the semantic features analysis. The developed teaching material was implemented in eight course hours (time of one course= 45 mins/8x45= 360 mins).

#### Data Analysis

The data collected from the concept cartoon form were analysed by content analysis method. The qualitative expressions which are the indicators of which alternative concepts the PSPTs possess in concept cartoons or whether they possess scientifically accepted knowledge or not, were analysed and they were coded under three categories as "True Answer (TA)" and "Alternative Concept (AC)" and "No Answer (NA)" and their frequency was calculated. While the answers of the PSPTs related to the opinions of the cartoon character in each concept cartoon were evaluated, the PSPTs' determination condition of whether the opinion belonging to a cartoon character was true or false were taken into consideration during the analysis. For example, if a PSPT wrote that Hüseyin's idea which is "The Sun is not a star because the star reflects the heat and the light it obtains from the Sun." is false the PSPT's answer was coded as TA. If a PSPT writes that Hüseyin's idea is true, the PSPT's answer was coded as AC. If he did not answer, it was coded in category NA.

The PSPTs who possess different views than the cartoon characters wrote their opinions about the topic on the "you" character' thought balloon in the concept cartoon and by examining these expressions the alternative concepts were analysed descriptively. Researchers coded data by re-reading identifying codes, discussing with the other researchers for providing credibility of data analysis. Direct quotations were given in the text from the PSPTs' statements in order to enhance the validity of the data.

#### Results of Research

The findings obtained from the research were presented in this section in the tables prepared for each concept cartoon. Moreover, apart from these alternative concepts, alternative concepts which the PSPTs were determined to possess were presented with the support of quotations from the PSPTs' statements.

**Table 3. The findings obtained from concept cartoons about the sun and the stars.**

Characters in Concept Cartoons and the Statements of the Characters		Pre-test			Post-test		
		TA	AC	NA	TA	AC	NA
Hüseyin	In my opinion the sun is not a star because the star reflects the heat and the light it takes from the sun.	73	17	-	84	3	3
Rumeysa	To me, the sun is not a star because the sun is larger than the stars.	74	15	1	88	2	-
*Emre	No, I don't agree with you. To me, the sun is a star.	72	13	5	88	2	-

\*: The cartoon character who told the correct statement in the concept cartoon, TA: True Answer, AC: Alternative Concept NA: No answer, are the abbreviated forms of the statements



When Table 3 was examined, it was revealed that conceptual change has been realized. The frequency distribution of TA of the PSPTs about this concept cartoon before teaching was quite high. When the findings of post-test were examined, there were an increase PSPTs' answers in TA category but a decrease in their alternative concepts' frequency. Such alternative concepts which came out in the pre-test with answers given by the PSPTs in the "you" section of the cartoon as "The sun is not a star because the sun is seen in the sky but the stars are not visible." (PSPT24) and "the planets and the stars reflect the light." (PSPT113) were removed in the post test.

**Table 4. The findings obtained from concept cartoons about the shape of a star.**

Characters in Concept Cartoons and the Statements of the Characters		Pre-test			Post-test		
		TA	AC	NA	TA	AC	NA
Yeşim	In my opinion, the shapes of the stars are like that. (★).	45	44	1	78	10	2
Tuğra	To me, the shapes of the stars are like that (shapeless).	47	43	-	79	11	-
*Ömer	To me, the shapes of the stars are like that (O).	8	75	7	82	-	8

The PSPTs possessed an alternative concept in the concept cartoon about the shape of the stars before teaching sequence. They stated that the shape of the stars looked like the star (★) on our flag (Turkish flag) or they did not have a specific geometric shape. After teaching, conceptual change was realized and the frequency of alternative concepts decreased. Apart from these expressions, it was determined by the "you" cartoon character that the PSPTs possessed such alternative concepts as "Because the stars are planets, they are circular." (PSPT53), "The sun is in the shape of a circle." (PSPT26) and "The stars are worm-shaped" (PSPT39).

**Table 5. The findings obtained from concept cartoons about the stars and the planets.**

Characters in Concept Cartoons and the Statements of the Characters		Pre-test			Post-test		
		TA	AC	NA	TA	AC	NA
Hüseyin	The stars exist in the sky but the planets exist in the space.	34	51	5	75	13	2
*Rumeysa	The stars emit light but the planets do not give light.	50	27	13	82	8	-
Zeynep	To me, the stars are larger than the planets.	15	60	15	77	9	4

When Table 5 was examined, there was an increase answers in the TA category in favour of post- test. Moreover, it was determined by the "you" character in concept cartoon that the PSPTs possessed alternative concepts such as "we can't see the planets because they do not emit light." (PSPT65), "the planets could be big stars" (PSPT119) and "The stars exist on the Earth" (PSPT120). After teaching, the PSPTs could correct these alternative concepts in post-test.

**Table 6. The findings obtained from concept cartoons about the life cycle of stars, their colours and size.**

Characters in Concept Cartoons and the Statements of the Characters		Pre-test			Post-test		
		TA	AC	NA	TA	AC	NA
*Alp	The stars are not living beings, but they are born like a living being, they live and die like them.	43	41	6	70	19	1
Ezgi	To me, the hottest stars have warm colours such as yellow, red and orange.	40	30	20	80	8	2
Bahri	The stars are the smallest celestial bodies.	50	30	10	85	2	3

The frequency distribution of pre and post-tests in concept cartoon about the life cycle of stars, their colours and size revealed in Table 6 that the PSPTs possessed alternative concepts but these alternative concepts decreased after teaching sequence. It was determined by the "you" character in concept cartoon that the PSPTs possessed alternative concepts in pre-test apart from the given alternative concepts such as "stars are not living





beings because they do not disappear." (PSPT26), "stars are not born and they don't die, but they only change location." (PSPT61), "The hottest part of the sun is red, and then comes orange and yellow." (PSPT70), "stars do not have colours" (PSPT78), "stars die because of shooting stars." (PSPT80), "stars are not the source of heat. We cannot classify them as hot according to their colours." (PSPT85) and "stars are not living beings and they do not have any colours. The sun is a star and larger than some planets." (PSPT123).

**Table 7. The findings obtained from concept cartoons about meteor.**

Characters in Concept Cartoons and the Statements of the Characters		Pre-test			Post-test		
		TA	AC	NA	TA	AC	NA
Yeşim	The meteors form a pit where they fall.	83	1	6	90	-	-
*Tuğra	The meteors which reach the Earth after entering the Earth's atmosphere are called meteorites.	77	1	12	90	-	-
Serap	We learn the natural events with the help of the meteors.	60	17	13	88	2	-

It was determined in the concept cartoon about the meteors in Table 7 that the distribution of correct answer frequency of the PSPTs was quite high before teaching sequence. When the distribution of frequency after teaching sequence was examined, the PSPTs who could not answer or who possessed alternative concepts gave true answers.

**Table 8. The findings obtained from concept cartoons about the planets.**

Characters in Concept Cartoons and the Statements of the Characters		Pre-test			Post-test		
		TA	AC	NA	TA	AC	NA
Hüseyin	We can't see the planets. The people who travel to the space can see them.	45	44	1	71	18	1
*Zeynep	The planets do not emit light.	53	29	9	79	11	-
Emre	The planets are the largest among the celestial bodies.	51	30	9	71	15	4

When the findings of pre-test and post-test about planets in concept cartoon were examined, it was revealed in Table 8 that the true answers given by the PSPTs in post-test increased considerably. Moreover, it was determined by the "you" character in concept cartoon that such alternative concepts possessed by the PSPTs as "stars are on our world" (PSPT79), "the sun is the largest among the celestial bodies." (PSPT103), and "we cannot classify the celestial bodies according to their sizes." (PSPT23) were exchanged after teaching sequence.

**Table 9. The findings obtained from concept cartoons about the location (the sky and the space) of a meteor, star, planet and celestial bodies.**

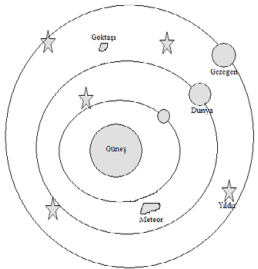
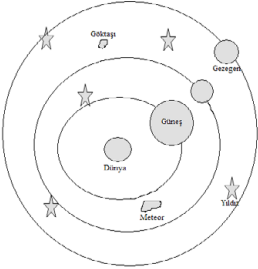
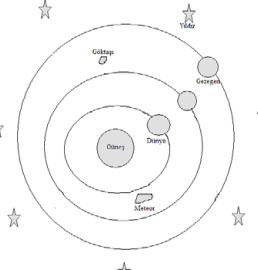
Characters in Concept Cartoons and the Statements of the Characters		Pre-test			Post-test		
		TA	AC	NA	TA	AC	NA
*Erkan	When we look up the sky, we can see the meteor, the planets and the stars.	18	70	2	34	53	3
Nagihan	No, we can only see the stars in the sky. The meteor and the planets exist in the space.	14	71	5	40	49	1
Yağmur	The planets and the stars are the same celestial bodies and exist in the sky. The meteor is found in the space.	55	26	19	84	6	-

When the pre and post-test results of the PSPTs in concept cartoon about the location (the sky and the space) of celestial bodies as meteor, stars and planets were compared, it was revealed in Table 9 that there was an increase in the answers towards post-test. Such alternative concepts of the PSPTs in pre-test determined by



the “you” character of concept cartoon. PSPT65 said, “We cannot see the meteor the planets because they do not reflect the light.” PSPT10 stated, “We can only see the stars when we look up the sky.” PSPT103 said, “Stars are the non-living light sources and they can fall to the Earth.” and PSPT29 said, “all the planets are in the sky but meteors are in the space.” The alternative concepts determined were exchanged considerably after teaching sequence.

**Table 10. The findings obtained from concept cartoons about the structure of a solar system.**

Characters in Concept Cartoons and the Statements of the Characters		Pre-test			Post-test			
		TA	AC	NA	TA	AC	NA	
Can		To me, it is the most correct figure.	42	44	4	40	45	5
Fatih		To me, the celestial bodies exist like that.	71	14	4	80	10	-
*Bahri		No, they exist like that.	34	50	6	46	39	5

When the findings obtained from the concept cartoon about the structure of the Solar System were examined in Table 10, it was revealed that there was not a distinctive difference between the pre and post-test results of the PSPTs, in other words, the PSPTs still possessed the same alternative concepts after teaching sequence.

**Table 11. The findings obtained from concept cartoons about shooting star.**

Characters in Concept Cartoons and the Statements of the Characters		Pre-test			Post-test		
		TA	AC	NA	TA	AC	NA
Ahmet	To me, shooting stars is that stars move and replace their places.	39	50	1	40	45	5
*Can	The meteors which enter into the atmosphere cause shooting stars.	32	56	2	62	23	5
Gülây	No, I don't agree with you. Shooting stars are visible comets.	85	5	-	81	9	-



When the pre and post-test results of the PSPTs about shooting star in concept cartoon were examined, it was revealed that there was not a considerable change between the results. Especially the PSPTs still possessed the following alternative concept after teaching sequence: "To me, shooting stars is the stars' changing places." Such alternative concepts of the PSPTs in pre-test determined by the "you" character of concept cartoon were exchanged after teaching sequence. PSPT89 said, "When stars run out of energy, they die and we see this activity as a shooting star.", PSPT16 stated "Meteor can cause the star to fall by hitting it.", PSPT10 and PSPT73 said "Shooting star reveals that star has run out of light.", PSPT48 said "shooting star is observed when a comet changes its place.", PSPT50 stated "Stars do not shoot. Why we see the stars shoot is that the Earth rotates around its axis". PSPT75 said "it is due to the particle the comet leaves behind when it falls." and PSPT110 said "It is the disappearance of the stars by burning up". The PSPTs did not make any explanations to the "you" character which involved alternative concepts.

**Table 12. The findings obtained from concept cartoons about a constellation.**

Characters in Concept Cartoons and the Statements of the Characters		Pre-test			Post-test		
		TA	AC	NA	TA	AC	NA
*Serap	The group of stars that are seen together are referred to as constellation	64	20	6	84	5	1
Ömer	To me, horoscopes are also constellations. Moreover, the most famous constellation is Halley.	25	55	10	83	6	1
Ceren	To me, daily horoscopes cannot be stars.	40	35	15	80	8	2

When the pre and post-test results related to constellation in concept cartoon were examined, it was revealed that there was a considerable change between the results. The PSPTs possessed the alternative concepts which were determined by the "you" character in the pre-test but conceptual change was provided after teaching sequence: PSPT64 said, "Horoscopes have nothing to do with the constellation. Whatever star moves in front of the moon, the person's horoscope is interpreted according to that star."

**Table 13. The findings obtained from concept cartoons about light year.**

Characters in Concept Cartoons and the Statements of the Characters		Pre-test			Post-test		
		TA	AC	NA	TA	AC	NA
Erkan	To me, light year is a time unit. A light year is 100 years.	40	20	10	60	22	8
Nagihan	I agree that light year is a time unit. But, it is the time between when the sun rises and sets.	48	30	12	75	15	-
*Yağmur	I don't agree with you. Light year is a unit of distance.	48	33	9	66	24	-

When the pre and post-test answers of the PSPTs about light year in concept cartoon were analysed in Table 13, it was revealed that there was an increase in favour of post-test in which the PSPTs stated that light year was a unit of distance. Moreover, such alternative concept determined by the character "you" in concept cartoon in pre-test, as stated by PSPT14, "Light year is not a unit of distance because it is a year." was exchanged considerably when the post-test answers were analysed.

**Table 14. The findings obtained from concept cartoons about comets.**

Characters in Concept Cartoons and the Statements of the Characters		Pre-test			Post-test		
		TA	AC	NA	TA	AC	NA
Sibel	In my opinion, the comet is a star because the comets emit light.	8	75	7	41	46	3
Fatih	To me, the comets are stars because the comets are made up of gas and dust just like the other stars.	15	52	23	53	36	1
*Bahri	I don't agree with you. The comets are not stars.	11	75	4	52	34	4



In Table 14 it was seen that there was a considerable increase in favour of post-test between the pre and post-tests frequency distributions related to a comet in concept cartoon. It was revealed that such alternative concept in pre-test, as stated by PSPT64 "It is not a star which is made up of dust and gas, but a planet." and by PSPT71, "Comets are formed by burning up dust and gas." and PSPT12, "the light of the comet is due to the light emitted by its tail." were exchanged after teaching sequence.

## Discussion

Effect of the 5E teaching model on the PSPTs' learning outcomes related with the astronomy topics and concepts were discussed at below in detail:

The findings revealed that PSPTs' alternative concepts such as "Sun and star", "the shape of the star", "stars and planets", "the life cycle of the stars, their size and colour", "Meteor", "Planet", "the location of meteor, star, planet and celestial bodies (the sky and the space)", "shooting star", "Constellation", "Light year", "The comet" concepts were removed considerably in this research. Moreover, it was determined that the PSPTs' alternative concepts were different from in the literature like "When stars die, they become shooting stars", "Stars do not have a colour", "Stars are worm-shaped", and "Shooting star is the disappearance of stars by burning up". The PSPTs' these alternative concepts were exposed via the "you" character in concept cartoon. It can be stated that the alternative concepts can be determined by concept cartoons. It was seen that the determined PSPTs' alternative concepts with concept cartoons related with stars and their features are similar to the ones in the literature such as "Stars have (★) shape." (Sharp, 1996; İyibil & Sağlam-Arslan, 2010; Kurnaz, 2012), "Stars and planets reflect light" (Emrahoğlu & Öztürk, 2009; İyibil & Sağlam-Arslan, 2010), "The sun is not a star because the sun is seen in the sky during day time but stars are not seen in day time" (Sharp, 1996; Küçüközer et al., 2010). Such expressions of the PSPTs as "the sun is a star and it is larger than some planets" or "The sun is the largest among the celestial bodies." revealed that the PSPTs did not have adequate knowledge about the size of the celestial bodies and their comparisons and they had some alternative concepts. At this point, with the worksheet called "Astronaut-Taz" in Plan-1, the preliminary knowledge of the PSPTs about the celestial bodies were determined by having them draw pictures or write their opinions about them. In the explore stage, the PSPTs watched a CD where they could observe the three dimensional model of celestial bodies. After the PSPTs watched the video, the discussion which they had about the size of the celestial bodies was effective for remedying their alternative concepts. Moreover, it can be stated that this activity helped the PSPTs to remedy the alternative concepts which they had about the shape of the stars.

The most frequently encountered alternative concept about light year is that light year is not a unit of distance but is a unit of time. It can be stated that the term "year" in light year was associated with the unit of time by the PSPTs. In the activity called "Which Star Clusters are you?" in Plan-2 in the research, the PSPTs made a map of constellation and they measured the distance between their constellation and the constellation belonging to their classmates' in their group and wrote it down in the light year column. It was revealed that this activity was effective to remedy the alternative concepts about the light year.

It was determined that the PSPTs could not give clear information about constellation and they usually possessed alternative concepts. It was determined with creating constellation map activity called "Which star clusters are you?" in Plan-2 that alternative concepts not only about light year but also constellation were considerably removed. The PSPTs analysed the constellation created by star clusters which appeared to be together on their maps. They internalized that their horoscopes were also constellation.

It was determined that the PSPTs could not understand the structure of the comets and the comet concept was explained differently with the concepts of star and planets. During these explanations, especially the use of a star concept and perception of comet as a type of a star can be associated with the term "star" which is used to name the concept (Kurnaz, 2012). In this context, the CCT called "The Story of a Comet" in Plan-2 was used to draw the attention of the PSPTs on the difference between the comets and the stars. It was determined that CCTs were quite successful in removing alternative concepts related with celestial bodies (Şahin, Bülbül & Durukan, 2013). But, CCT related to alternative concepts about comet was not encountered in literature. Kurnaz (2012) conducted a study about comets and he suggested that carefully prepared conceptual change activities should be used to correct the alternative concepts of the PSPTs and it was proved in this study that CCT was effective to remove the alternative concepts about comets. Similarly, when shooting star was taken into consideration, it was revealed that the PSPTs expressed this event as the movement of a comet or a star. The PSPTs who were able to establish a



correlation between the concepts of shooting star, comet and star changed their alternative concepts which they expressed during the pre-test after teaching sequence considerably with the help of CCT.

The activities used in the research were not effective in realizing conceptual change and development related to the solar system at a satisfactory level. The PSPTs maintained the alternative concepts which they had acquired with the solar system after teaching sequence. All of the alternative concepts which were not exchanged after teaching are called hard-core concepts. Moreover, such alternative concepts were maintained by the students after teaching (Duit & Treagust, 2003). In the research, the PSPTs did a play dough activity called "Space in Our Dream" to teach the solar system and then they watched the video about solar system. The PSPTs were enabled to compare their own solar systems with the video they watched and to discuss the faults in their models. The PSPTs were not asked to make a solar system again. Although watching videos were effective in comparing the size of the stars and the planets for the PSPTs, it was not effective for the PSPTs to understand the placement of the stars and the planets in the solar system. Therefore, few of the PSPTs realized conceptual change about the solar system but most of them were not able to realize conceptual change. In this context, the teachers/ the lecturers were suggested that they should use the activities intended for actual practises with their PSPTs, as in the constellation activity, during the teaching sequence about astronomy.

It is revealed in the concept cartoon about planets, the PSPTs attributed some features of stars to the planets. Similarly, it was determined in literature (Emrahoğlu & Öztürk, 2009; İyibil & Sağlam-Arslan, 2010; Şahin et al., 2013) that PSPTs possessed alternative concepts about stars. They thought that stars were planets. Moreover, it can be stated that they brought the relations built between planet and star concepts to unscientific dimensions such as "Planets can be big stars". In this research, the findings from the post-test of concept cartoon where the difference between a star and a planet was discussed point out that the alternative concepts the PSPTs possessed were corrected after teaching sequence. The PSPTs gave true answers in the post-test about meteor in concept cartoon. When the position of meteor, star and planet concepts were taken into consideration, it was understood that PSPTs did not have adequate knowledge about the concepts and they could not differentiate between the concepts (Emrahoğlu & Öztürk, 2009).

The PSPTs generally had alternative concepts at first. After teaching sequence of 5E teaching model, the number of alternative concepts of the PSPTs was decreased but the PSPTs' some alternative concepts were not removed completely. It was not possible to remove the alternative concepts completely all the time (Arıkurt, 2014; Şahin et al., 2013). This situation which was encountered among the results of conceptual change studies reminds that while constructing the knowledge of the students about the topic, they were affected by the resistant nature of alternative concepts against change as well as their daily life experiences or cultural values (Kurnaz, 2012). The PSPTs' stating that the sun was the largest celestial body while comparing the sizes of the celestial bodies or perception of the star as the figure on the Turkish flag by drawing the star as pentagonal (★) bears an evidence to this situation. The first evidence supports the result of daily life experiences, and the other evidence supports the result that cultural factor was effective in the concepts' being restructured by the students (Kurnaz, 2012).

## Conclusions

When the findings were generally evaluated, it was seen that most of the PSPTs had alternative concepts about astronomy concepts. A considerable decrease was determined in the number of alternative concepts of the PSPTs after teaching sequence. It can be said that 5E teaching model was effective on remedying alternative concepts of the PSPTs. The PSPTs learned new knowledge and they showed a conceptual change and development related with some astronomy concepts. In the future research about astronomy teaching, it may be conducted to determine the effects of 5E teaching model on remedying the alternative concepts and performing conceptual change with the different education levels of students. And also, it should be identified the effect of the teaching sequences on students' alternative concepts in long term.

Another result of the research was that the use of such activities and teaching plans enriched by alternative assessment and evaluation methods has been effective in teaching process. It is suggested that the teaching materials developed in this research can be used in other research or the teachers can use them in their own learning process. The similar teaching materials for other astronomy concepts can be developed and investigate the effects on students' learning. Besides that, in this research alternative concepts of the PSPTs were determined with concept cartoons. As parallel, it can be stated that concept cartoons can be used as diagnostic or formative test for determining of the alternative concepts as well as conceptual change.



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Received: June 28, 2016

Accepted: February 23, 2017

**Çiğdem Şahin**

PhD, Assistant Professor, Giresun University, Department of Mathematics and Science Education, Giresun, Turkey.  
E-mail: hcsahin38@gmail.com

**Ümmü Gülsüm Durukan**

Research Assistant, MD, Giresun University, Department of Mathematics and Science Education, Giresun, Turkey.  
E-mail: u.g.durukan@gmail.com

**Elif Arıkkurt**

MD, Science Teacher, Nebi Güney Middle School, Ministry of National Education, Antalya, Turkey  
E-mail: elf\_bulbul\_ktu@hotmail.com

