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In-Service Science Teachers' Astronomy Misconceptions

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Abstract: Pre-service science teachers in Turkey began to take undergraduate astronomy course in 2010. Science teachers who graduated before 2010 did not have any astronomy course during teacher preparation program. However, science education curriculum has some astronomy topics. If science teachers hold some misconceptions they will most likely transfer them to their students. The aim of this study was to explore in-service science teachers' astronomy misconceptions. The participants were 60 in-service science teachers who had no astronomy instruction before. Astronomy Concept Test was used to collect data. Based on the results it is found that in-service science teachers hold several misconceptions related to astronomy. The results of this study show that in-service science teachers need some instructional support about astronomy content to improve their understanding of astronomy related topics in middle school science curriculum.

Keywords: Astronomy misconceptions, in-service science teachers, astronomy education

Fen Öğretmenlerinin Astronomi Kavram Yanılgıları

Öz: Türkiye'de fen öğretmeni adayları 2010 yılında lisans düzeyinde astronomi dersi almaya başlamışlardır. 2010 yılından önce mezun olan fen öğretmenleri öğretmen yetiştirme programı boyunca herhangi bir astronomi dersi almamışlardır. Ancak, fen eğitimi müfredatı bazı astronomi konularını içermektedir. Fen öğretmenlerinin kavram yanılgıları varsa bu kavram yanılgılarını muhtemelen öğrencilere aktaracaklardır. Bu çalışmanın amacı fen öğretmenlerinin sahip oldukları astronomi kavram yanılgılarını ortaya çıkarmaktır. Çalışmaya daha önce hiç astronomi eğitimi almamış olan 60 fen öğretmeni katılmıştır. Astronomi Kavram Testi veri toplamak için kullanılmıştır. Çalışmanın sonuçlarına göre fen öğretmenlerinin astronomi ile ilgili birçok kavram yanılgısına sahip oldukları tespit edilmiştir. Araştırmanın sonuçları fen öğretmenlerinin fen müfredatındaki astronomi konuları ile ilgili eğitime ihtiyaç duyduklarını ortaya koymuştur.

Anahtar Sözcükler: Astronomi kavram yanılgıları, fen bilgisi öğretmenleri, astronomi eğitimi

Astronomy has accepted as an undergraduate course for science teacher preparation program in 2006. The astronomy course is being taught at the last semester of the science education program. Therefore the first students who were able to take undergraduate astronomy course were 2010 graduates. That means science teachers that have graduated before 2010 did not have any astronomy course. Therefore most of the Turkish science teachers are expected to be lack of astronomy knowledge. That might be one of the reasons for astronomy to be ignored in Turkish middle schools for several years.

Approximately 10% of the old science and technology education curriculum (MEB, 2006) in middle school (grade 6, 7, 8) was dedicated to astronomy topics. In new education system of Turkey, grade 5 omitted from elementary school and added to middle school. In new science education curriculum (MEB, 2013) of middle school (grade 5, 6, 7, 8) approximately 13% of science education curriculum devoted to astronomy related topics (Table I). As can be seen the average number of astronomy topics in middle school has increased by 3%. Therefore it becomes more important to find out in-service science teachers' astronomy misconceptions. Brunsell and Marcks (2005) noted that when teachers does not have adequate knowledge their instruction are based on lower-level questioning and cookbook activities and they also misinterpret the nature of the discipline. Science teachers need to have sufficient astronomy content

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Table I
Astronomy Content for Middle School Levels.

Grade	Unit	Percentage
5	The Mystery of Earth Crust / Earth and Universe	16,7
6	Our Earth, Moon and Life Source Sun / Earth and Universe	11,1
7	Solar System and Beyond / Earth and Universe	11,1
8	Earthquake and Weather Facts / Earth and Universe	12,5
Average		12,85

knowledge to be able to teach science in middle schools. When teachers do not have good knowledge of astronomy they will either avoid teaching these topics or teach them inappropriately. As a result, science teachers may transfer many astronomy related misconceptions to their students.

Astronomy is one of the oldest sciences. However, astronomy education and research related to astronomy education has been ignored for many years. Bailey and Slater (2004) reported that the number of astronomy education research is very limited therefore this area has a priority to be investigated. It seems very crucial at this point to increase astronomy education research to find out the problems and possible solutions. One of the main problems as stated in the current study is about searching for in-service science teachers' astronomy misconceptions.

Misconceptions in Astronomy

Middle school students come to classroom with many astronomy misconceptions. It is very important to deal with those misconceptions appropriately. Science teachers need to have strong content knowledge of astronomy to help students to overcome misunderstanding of scientific concepts. Therefore it might be helpful to find out students' as well as science teachers' astronomy content knowledge to find out their readiness to science classroom.

Many studies have been conducted related to astronomy misconceptions (Bektasli, 2013; Bisard, Aron, Francek & Nelson, 1994; Brunsell & Marcks, 2005; Trumper, 2006; Zeilik, Schau & Mattern, 1998). Most of the participants in those studies are either students or preservice teachers. The most common astronomy misconceptions that have been reported are related to day-night cycle (Lightman & Sadler, 1993; Trumper, 2000), dimensions (Bektasli, 2013; Trumper, 2000; Zeilik et al., 1998), distances of objects from Earth (Brunsell & Marcks, 2005; Trumper, 2000), Moon phases (Bisard et al., 1994; Trumper, 2000; Zeilik et al., 1998), Moon's revolution (Trumper, 2000), Moon's rotation (Trumper, 2000; Zeilik et al., 1998), position of Sun during daytime (Brussel & Marcks, 2005; Trumper, 2000; Zeilik et al.,1998), seasons (Bektasli, 2013; Trumper, 2000) and solar eclipse (Trumper, 2000; Zeilik et al., 1998). In addition, Bektasli (2013) reported that pre-service science teachers hold some misconceptions related to following astronomy concepts: black holes, constellations, difference between rotation and revolution, distances, Earth's and Moon's shape, evolution of stars, meteor shower, size comparison of planets and stars, stars, the time it takes sunlight to reach earth.

There is very limited number of studies that report in-service science teachers' astronomy misconceptions. Brunsell and Marcks (2005) conducted a study with 142 science teachers (43 elementary, 73 middle school and 26 high school teachers) to determine in-service science teachers' understanding of astronomy concepts. The authors applied Astronomy Diagnostic Test that was developed by Zeilik (2003) right before space science workshops to determine teachers' baseline content knowledge of astronomy. The mean scores were 35% (SD=13) for elementary teachers, 50% (SD=16) for middle school teachers and 64% (SD=12) for high school teachers. Brunsell and Marcks reported their results in four main categories: the sense of scale, the motion, gravity and general. The first category *sense of scale* has five questions associated with size and distance of celestial objects. The second category *motion* has seven questions about planetary motion, phases of the Moon, seasons and other incidents relate to motion. The third

category *gravity* has three questions about gravity. The last category *general* has six questions about physical science that are not associated with astronomy or another category described here. Results showed that in-service science teachers hold many astronomy misconceptions. The main implication of the authors was related to drawing an attention to importance of professional development of in-service science teachers.

Student misconceptions may come from different sources like real life experiences (Ozdemir & Clark, 2007; Sewell, 2002, Strike & Posner, 1982), religious views (Brickhouse, Dagher, Letts IV & Shipman, 2000) or teachers (Bektasli, 2013). In the case of astronomy, teachers may transfer misconceptions to their students if they do not have sufficient knowledge of astronomy. Therefore it is crucial for science teachers to deal with astronomy misconceptions that they have. As Brunsell and Marcks (2005) noted it is important to help in-service science teachers to improve their professional development so that they may overcome misconceptions that they have.

The Purpose of the Study

National Science Board (2004) reported that approximately 50% of public school science teachers in USA do not have a major or minor in any physical science field namely chemistry, geology/earth sciences, physics, natural sciences, and engineering, except biology/life sciences. This report is very dramatic because content knowledge of teacher is possibly one of the critical indicators for students' achievement in science classroom. In Turkey most of the science teachers graduated from either science education program or science related fields like biology, chemistry, or physics. However, none of these programs used to have an astronomy course before 2010.

In Turkey 13% of middle school (grades 5-8) science education curriculum is related to astronomy. Since science teachers are teaching astronomy topics they are expected to have adequate knowledge of astronomy. The aim of the current study is to search for in-service science teachers' astronomy misconceptions. Most of the Turkish in-service science teachers did not have any astronomy course before. Therefore they are expected to hold several astronomy misconceptions. The literature does not have any study related to Turkish in-service science teachers' astronomy misconceptions.

Most of the studies in the literature are related to preservice science teachers' or students' astronomy misconceptions. However, there is a lack of research related to in-service science teachers' astronomy misconceptions. Barba and Rubba (1992) searched for content knowledge of in-service (expert) and pre-service (novice) earth and space science teachers. In addition, Brunsell and Marcks (2005) conducted a study with science teachers and found that science teachers are lack of understanding of several astronomy concepts. Determining in-service science teachers' content knowledge in astronomy will be useful information for curriculum developers both in middle school and undergraduate science education program. In addition, the findings of the current study might be useful for Ministry of Education to develop and apply some development programs related to astronomy education for in-service science teachers.

Methodology

Sample

The participants of the current study are in-service science teachers that teach in public middle schools in Ankara. All participants have been teaching science for at least 10 years or more. That means none of them had an astronomy course during their undergraduate programs.

Teachers have been given Astronomy Concept Test (AstroCoT) that has been developed by the author (Bektasli, 2013). AstroCoT derived from basic astronomy concepts that are mostly related to topics

that are included in science education curriculum. The test has 18 multiple choice questions. In addition, participants have been asked to state if they were sure or not sure of their responses.

The main purpose for asking participants if they are sure or not sure of their responses is to find out if they really know the answer or tend to guess when they response. Statistically it is important to find out if participants really know the answer or if they just guess. Participants' responses were re-coded if they were not sure of their responses. Cronbach's alpha values are usually different before and after recoding the data. Bektasli (2013) reported the Cronbach's alpha value for AstroCoT to be 0.49 before recoding and 0.71 after recoding the data.

Data Analysis

The data was analyzed by using Statistical Package for Social Studies (SPSS) version 16.0. The Cronbach's alpha value was 0.62 before recoding the data. Based on the sure/not sure responses the data recoded and the Cronbach's alpha value increased to 0.72. If a participant gave a correct answer but not sure of his/her answer then the answer accepted as incorrect, because that means the participant guessed. Bektasli (2013), Baykul (2000) and Zeilik et.al. (1997) said that Cronbach's alpha value have different values before and after recoding the data.

The results of in-service science teachers' responses for each item are presented in Table II. As can be seen from the table, many in-service science teachers who gave correct answer were not sure of their responses so they tended to guess when they responded. In items 4, 6, and 14 half of the science teachers who responded correctly were not sure of their correct answers. In addition, 55% of in-service science teachers were not sure of their responses in item 10. In question 2, 7 and 16 more than 80% of participants gave correct answer. Most of these participants were sure of their responses. Based on the results it seems that most of the participants commonly tend to guess in most of the questions.

According to results presented in Table 2, it is clear that most of the science teachers have several astronomy misconceptions. This result was expected for in-service science teachers since they did not have any astronomy course before. However, it is important to find out and report those misconceptions. Science teachers teach astronomy topics every year. Since they hold some misconceptions it is more likely that they will transfer these misconceptions to their students. Students usually accept their teachers as a model, so what they teach is accepted by students to be true. Therefore it will be more difficult for students to deal with misconceptions that have been transferred by their teachers.

Science teachers' astronomy misconceptions are discussed in the following part. The results are presented for each item independently to give more detailed information related to participants' misconceptions. The results need to be evaluated as not teachers' insufficiency of content knowledge but as some information about the present situation and what needs to be done to solve this problem.

Results

In this part in-service science teachers' astronomy misconceptions are presented item by item in more detail to give a better description of their understanding of some astronomy concepts (see Table III). Result for each question is given by presenting the percentage for the correct answer first. After that the total percentage for each misconception is presented. As an example, in question 12, three statements are given and participants were asked to find out the correct statements. The third statement (statement III) of that question is "Planets are smaller than stars". The researcher added the percentages of all the choices that do not have the statement III to calculate the total percentage of participants who believe that this statement is incorrect. Statement III does not exist in choice A, B, and D therefore by adding up the percentages of these responses (3.3% for A, 28.3% for B, and 13.3% for D) it is found that approximately 45% of in-service science teachers believe that planets are bigger than stars.

Table II

Percentages of In-service Science Teachers' Responses to AstroCoT.

The Correct Answer is Boldface Italic.

Item	A	B	C	D	E	Guess*
1	3.3	***63.3***	21.7	1.7	8.3	16
2	1.7	***81.7***	3.3	11.7	1.7	14
3	20	8.3	***58.3***	3.3	8.3	34
4	***26.7***	3.3	55	1.7	13.3	50
5	3.3	6.7	26.7	***56.7***	6.7	18
6	13.3	30	25	***13.3***	18.3	50
7	3.3	***95***	0	1.7	0	4
8	***38.3***	55	0	0	5	17
9	1.7	0	***11.7***	15	71.7	29
10	13.3	***18.3***	5	51.7	11.7	55
11	41.7	3.3	36.7	10	***6.7***	5
12	3.3	28.3	3.3	13.3	***48.3***	28
13	13.3	0	5	0	***78.3***	19
14	15	10	18.3	***16.7***	31.7	50
15	***28.3***	20	11.7	28.3	3.3	18
16	0	1.7	6.7	***85***	3.3	14
17	***60***	3.3	5	15	13.3	11
18	10	10	13.3	25	***36.7***	41

** Percentage of participants who gave correct answer but not sure of their responses*

Brunsell and Marcks (2005) noted that it is more efficient and meaningful to look at individual test items instead of general combined scores. That gives a chance to researcher to discuss each question in depth. Therefore in the following part, analysis of individual items is reported.

Question 1: Based on the first item of the test, it is clear that some participants hold various misconceptions about stars. As seen in Table III, 25% of science teachers believe that stars are not solid, 34% think that the number of stars does not change by time, and 32% agreed that stars do not born, live and die. In item 1, clearly some of the science teachers do not have adequate information related to some features of stars.

Question 2: In item 2 science teachers seem to have good information of astronomy related to distances between objects. However, 18% of participants believe that Sun is not the closest star to Earth. These participants either did not know that Sun is actually a star or do not have any idea about distances. In addition, Pole Star is one of the most popular well known star, that might be the reason for some science teachers (12%) to think that the Pole Star as the closest star to the Earth.

Question 3: Approximately 34% of participants who gave correct answer were not sure of their responses. Some science teachers (20%) believe that satellites are source of light. This misconception might be coming from observations. People see the shining Moon frequently in the sky and that may lead them to consider the Moon as a source of light. It is clear that some science teachers do not know that the Moon is actually reflects the sunlight. Another misconception related to that item is that all the planets have satellites (%15). Since the Earth has a satellite, some science teachers seem to think that all other planets have satellites too.

Question 4: Results derived from item 4 shows that science teachers hold serious misconception about formation of Earth. About 70% of science teachers believe that the Earth was formed from the Sun, which is technically not possible. A considerable amount of science teachers (18%) believes that the Sun is located at the center of Universe. These teachers are probably do not have an idea about dimension of the

Table III
Science Teachers' Astronomy Misconceptions

Item	Percentage of Correct Answer	Misconceptions	Percentage of Misconceptions
1	63	a) Stars are solid	25
		b) The number of stars does not change by time	34
		c) Stars does not born, live and die	32
2	82	a) Pole Star is the closest star to Earth	12
		b) The Sun is not the closest star to Earth	18
3	58	a) All planets have satellites	15
		b) Satellites are source of light	20
4	27	a) Earth was formed from the Sun	70
		b) The Sun is located at the center of the Universe	18
5	57	a) Structure of the atmosphere does not affect formation of seasons	27
6	13	a) Planets revolves at constant speeds around Sun	55
		b) Solar System is located at the center of Milky Way	43
7	95	a) It is Mars or Mercury that causes tides	5
8	33	a) Neil Armstrong is the first man who traveled to space	55
9	12	a) Distinction of revolution and rotation	88
10	18	a) Meteor shower is displacement of a star	17
		b) Black holes are infinite vacuums	77
		c) Comet is a star	18
11	7	a) Stars' shape is pentagon	13
		b) The Moon's shape is a sphere	78
		c) Earth's shape is a sphere	45
12	48	a) Everything we see in the sky at night are stars	6
		b) Planets are bigger than stars	45
		c) Only Saturn has a ring	17
13	78	a) Jupiter is not the largest planet in our solar system	5
		b) Universe is not expanding	13
14	17	a) Stars that form a constellation have common features	28
		b) Constellation are observed at the same point every night	42
		c) In our solar system Earth is the only planet that has an atmosphere	25
15	28	a) Earth is closest to Sun in summer	48
16	85	a) The sunlight reaches the Earth in two minutes	7
17	60	a) We can see all sides of the Moon from Earth	8
		b) Dimension of Sun is constant and cannot change by time	32
		c) Planets revolves around Sun at constant distances	18
18	37	a) Planets revolves in circular orbits	23
		b) Sun does not move only planets revolves around Sun	23
		c) Earth rotates clockwise	45

Universe. In addition, about 27% of the participants who gave correct answer to item 4 guessed when they responded. Therefore it is clear that most of the science teachers are lack of the content in this question.

Question 5: Approximately 57% of the participants gave correct answer to this question by stating that the position of the Moon does not affect formation of seasons. It is very dramatic that around 27% of in-service science teachers think that structure of the atmosphere does not affect the formation of seasons. These teachers probably did not think about the green house effect.

Question 6: Only 13% of the participants gave correct answer to that question. 55% of the participants stated that planets revolve at constant speed around the Sun. It is obvious that these participants have serious misconceptions about Kepler's Law of planetary motion. About 43% believed that Solar System is located at the center of Milky Way. It is very interesting that almost half of the participants do not know the location of our solar system in Milky Way.

Question 7: Almost all teachers (95%) gave correct answer to this question by stating that Moon is the sky object that causes tides. Tides is one of the topics in science education curriculum in middle school so teachers were expected to give correct answer to that question. Two teachers think Mars and one teacher thinks Mercury as the sky object that causes tides.

Question 8: In item 8 the name of the first man who traveled to space was asked. Based on the results, 33% of participants marked Yuri Gagarin and 55% marked Neil Armstrong. Neil Armstrong's name is quite popular compared to Yuri Gagarin, and that might be one of the reasons for participants to select that name as their correct answer. Another reason might be that the participants may not know the distinction between going to space and Moon.

Question 9: Item 9 was actually testing if participants know the distinction of rotation and revolution. Based on the results, it is obvious that 88% of participants do not know the distinction of rotation and revolution. Even these two terms have different meanings, they usually used interchangeably in daily life. The finding of this study is consistent with Atwood & Atwood (1995) who said that preservice elementary teachers used the word rotation inappropriately instead of revolution.

Question 10: About 17% of participants think that meteor shower is displacement of a star. In this question, the misconception is most probably coming from the language itself. As Bektasli (2013) noted in Turkish the term meteor shower is mostly misused as displacement of a star. Based on the results, 77% of participants believe that black holes are infinite vacuums. Similar misunderstanding that comes from the use of language exists for black holes. In addition, approximately 18% of participants think that comet is a star. In Turkish the term "*kuyruklu yıldız"* which can be translated as "*star with a tail"* is used for comet.

Question 11: Only 7% of science teachers gave correct answer to item 11. It is interesting that 13% of science teachers think that stars have a shape of pentagon. In addition, 78% believes that the Moon's shape is a sphere. Moreover, 45% of participants believe that Earth's shape is a sphere. Science teachers' responses seem to be based on their own observations. Especially for Moon when they observe it in the sky they might be seeing a sphere instead of geoids. Another reason for that might be that in Turkish science education curriculum the term sphere is used instead of geoids.

Question 12: In item 12, 48% of participants gave correct answer. However, 45% believes that planets are bigger than stars. That might be again because of individual observations. Teachers see stars very small on the sky or the posters. Since stars are farther, in solar system posters planets are usually shown very big compared to stars. Moreover, 17% of participants think that among planets only Saturn has a ring. The main reason for that seems to be that almost in all pictures Saturn is the only planet that is shown with ring.

Question 13: Most of the science teachers (78%) responded correctly to item 13 by stating that Jupiter is the largest planet in our solar system and the universe is expanding. Only 5% think that Jupiter is not the largest planet in our solar system. None of the participants think that Earth is bigger than Sun. Finally, 13% do not believe that universe is expanding.

Question 14: About 17% gave correct answer to item 14. About 28% believe that stars that form a constellation have common features. It is obvious that many science teachers do not have idea about how constellations are formed. Around 42% believes that constellations are observed at the same point every night. Based on this result, it can be concluded that science teachers are lack of some content knowledge about rotation of Earth on its axis and its revolution around the Sun. Finally, 25% of participants think that in our solar system Earth is the only planet that has an atmosphere.

Question 15: In item 15, participants were asked to determine the months that the Earth is closest and farthest to Sun. About 28% gave correct answer to this question. Another 28% believe that the Earth is closest in June and farthest in December. In addition, 20% believe that the Earth is closest to Sun in July and farthest in January. Moreover, around 12% believe that the Earth is closest to Sun in December and

farthest in June. In conclusion, 48% believes that the Earth should be close in summer and far in winter. On the other hand, around 43% believes the opposite that the Earth should be close to Sun in winter and far in summer.

Question 16: Results show that 85% of in-service science teachers know that the time it takes the sunlight to reach the Earth is about 8 minutes. Only 7% of participants think that sunlight reaches the Earth in 2 minutes.

Question 17: In item 17, 60% of science teachers gave correct answer by stating that they cannot see all sides of the Moon from Earth. Only, 8% of the participants believe that they can see all sides of the Moon from Earth. Moreover, 32% believe that the dimension of the Sun is constant and cannot change by time. Finally, about 18% believe that planets revolve around the Sun at constant distances. It seems that these science teachers misinterpret Kepler's Laws of planetary motion.

Question 18: About 37% of in-service science teachers responded correctly to the last question. Approximately, 23% believe that planets revolve in circular orbits. In addition, another 23% of participants believe that Sun does not move only planets revolve around the Sun. Finally, 45% believes that the Earth rotates clockwise.

Conclusion and Implications

Slater, Safko, and Carpenter (1999) said that teachers usually avoid astronomy topics because they do not have adequate knowledge of astronomy. In addition, Brunsell and Marcks (2005) reported that many science teachers are lack of astronomy content knowledge. The results of the current study are consistent with Slater et al. and Brunsell and Marcks' findings. Some in-service science teachers that participated in that study said that they usually do not teach some topics that are related to astronomy. Science teachers stated two main reasons for that. According to first reason teachers accept that they are lack of astronomy content knowledge and therefore they feel inadequate for teaching astronomy related topics. Based on the second reason some teachers stated that astronomy topics are usually at the end of the year in the program so they usually skip these topics either because of the decrease in the number of students attending the classroom or students' concentration to the science lesson.

Plummer and Zahm (2010) reported that many students do not get any astronomy instruction during middle and high school years. The result of Plummer and Zahm is consistent with the present study. Based on the results of the current study it is clear that many middle school students do not have an efficient astronomy instruction in science classroom. One of the main reasons for that seems to be that science teachers do not have strong content knowledge of astronomy.

Based on the results of the current study it is noticeable that in-service science teachers need to improve their astronomy content knowledge. Approximately 13% of the new science curriculum in grades 5 through 8 is dedicated to astronomy topics however most of the in-service science teachers did not have any astronomy course before. Therefore it is not surprising that science teachers hold many astronomy misconceptions.

Hannust and Kikas (2007) said that young children had some astronomy knowledge. Children from early ages begin to build astronomy knowledge mostly based on their observations and about what other people like parents tell them. When children come to school they bring together many misconceptions. It is crucial for science teachers to have strong astronomy content knowledge to help children with astronomy misconceptions they hold. Therefore Ministry of Education needs to educate current science teachers about astronomy. Science teachers usually have some education seminars at the end of the school year. Astronomy course needs to be one of these courses. Teachers can be given some astronomy content knowledge during day time and then they can make some observations during night. All science

teachers that have participated in this study requested a seminar along with some observations to improve their astronomy content knowledge.

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