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Prospective Science Teachers' Conceptions about Astronomical Subjects

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ABSTRACT *The main objective of this study was to identify prospective science teachers' conceptions on basic astronomical phenomena. A questionnaire consisting of nine open-ended questions was administered to 327 prospective science teachers. The questionnaire was constructed after extensive review of the literature and took into consideration the reported cumulative evidence. More evidence was also collected from individual interviews from a smaller sample of 33 participants. The analysis of both the quantitative and qualitative data indicated that prospective science teachers (PST) hold a number of conceptions about several astronomical phenomena, such as, the cause of the seasons, the stars as luminous objects, the lunar eclipse and the phases of the Moon, the shooting stars and the how the universe was created. Theoretical and or educational implications should follow.*

KEY WORDS: *Astronomical conceptions, physics education, prospective science teacher.*

Introduction

A number of studies carried out in different countries for different age groups focused on basic astronomical phenomena (Pfundt & Duit, 2006). Many researchers suggested that not only children (Baxter, 1989; Dove, 2002; Jones, Lynch & Reesink, 1987; Kikas, 1998; Klein, 1982; Osborne, Black, Wadsworth & Meadows, 1994; Sharp, 1996; Trumper, 2001a; Valanides, Gritsi, Kampeza & Ravanis, 2000; Vosniadou & Brewer, 1992, 1994), but also adults (Mant & Summers, 1993, 1995; Parker & Heywood 1998; Trumper 2000, 2001b; Ünsal, Günes & Ergin, 2001) have difficulties in explaining basic astronomical phenomena. It is unanimously argued that students' understandings improve as they get older, but some conceptions are resistant to change (Baxter, 1989).

The pioneer studies relating to this subject were on primary school students' conceptions of the Earth (Nussbaum & Novak, 1976; Nussbaum, 1979; Nussbaum & Sharoni-Dagan, 1983). Subsequently, the conceptions of pre-school students (Valanides et al., 2000), junior high school students (Baxter, 1989; Dove, 2002; Jones et al., 1987; Kikas, 1998; Osborne *et al.*, 1994; Sharp, 1996; Trumper, 2001a; Vosniadou & Brewer, 1992, 1994), high school students (Baxter, 1989; Lightman & Sadler, 1993; Trumper, 2001c), university students (Lemmer, Lemmer & Smit, 2003; Ünsal et al., 2001; Trumper, 2000) pre-service teachers (Bisard, Aron, Francek & Nelson, 1994; Cohen, 1982; Ojala, 1997; Trumper, 2001b) and in-service teachers (Lightman & Sadler, 1993; Mant & Summers, 1993; Parker & Heywood 1998) were investigated. Conceptions of the participants on topics such as "day and

night," "seasons," "solar and lunar eclipses," "the phases of the Moon," "the centre of the universe and its dimensions," "solar system, distances and dimensions, sunrise and sunset", and "the dark side of the Moon, and the Earth-day length of a lunar day" have been identified. The main results of these studies are summarized in the following sections:

Day and Night: Although most of the subjects gave the right answer (day and night occur as a result of the Earth's rotation on its axis), some other students explained that "day and night occur because the Moon or clouds block the sun light" or "day and night are caused by the Sun going around the Earth" (Baxter, 1989; Dove, 2002; Kikas, 1998; Osborne et al, 1994; Sharp, 1996; Trumper, 2001 a,b; Ünsal et al., 2001; Valanides et al., 2000; Vosniadou & Brewer, 1992, 1994).

The Seasons: Most of the subjects who believed that the seasons are caused by Earth's distance from the Sun, suggest that Earth orbits the Sun in an elongated elliptical path and that this is what causes Earth's distance from the Sun to vary enough causing the seasons. As a result, they believe that "while orbiting the Sun, when the Earth is closest to the Sun, summer takes place, and, when it is furthest away, winter takes place," and that "the seasons occur due to the Earth's orbiting the Sun". Moreover, it has been observed that, though in a smaller numbers, subjects think that "intense winter clouds block the heat coming from the Sun," or that "during summer the Sun moves to the other side of the Earth" (Baxter, 1989; Bisard et al., 1994; Dunlop, 2000; Lightman & Sadler, 1993; Trumper, 2000; Trumper, 2001 a,b,c; Ünsal et al., 2001).

The Solar and Lunar Eclipses: It has been emphasized that the subjects could not give a full explanation about the solar and lunar eclipses and could not explain the role of Earth's shadow or shape during the lunar eclipse. Many participants had difficulties in explaining the position of the Moon during the lunar eclipse. It has also been reported that they thought that during the solar eclipse the Moon is always in its full Moon phase. (Barnett, & Morran, 2002; Trumper, 2000; Trumper, 2001 a,b,c).

Moon Phases: Some of the subjects explained that "the phases of the Moon are caused by the shadow of the Earth on the Moon," and some others that "the phases of the Moon are caused by shadows cast on its surface by other objects in the solar system, or that these objects block the Moon", or that "the phases of the Moon are caused by the Moon moving into the Sun's or other planet's shadow." Moreover, it has been reported that they mixed up the lunar eclipse with the phases of the Moon and had trouble in understanding how the phases of the Moon occur (Baxter, 1989; Bisard et al., 1994; Cohen, 1982; Dunlop, 2000; Lightman & Sadler, 1993; Trumper, 2000; Trumper, 2001a, 2001b, 2001c; Trundle, Atwood & Christopher, 2002).

The Centre of the Universe: It has been affirmed that most of the subjects stated that there was no centre of the universe. Yet, while some of them put the Sun at the centre of the universe, some small number of other subjects put the Milky Way there (Lemmer et al., 2003; Trumper, 2000; Trumper, 2001a, 2001b, 2001c). When they were asked about the "Dimensions [size] of the Universe", while most of the participants expressed that there was a limit to the boundaries of the universe, some others thought that the universe consists of only the Solar System (Dunlop, 2000; Lemmer et al., 2003).

The Sun, the Solar System, Distances and Dimensions, Sunrise and Sunset: Ligthman, Miller & Leadbeater (1987) surveyed 1,120 American adults and found that almost half of the participants believed that the Sun was not a star. Lemmer et al. (2003), by asking the question "what happens to the Sun after sunset till sunrise" found that 10.8% of the students believed that during the night the Sun disappears, or goes to somewhere else. Lemmer et al. (2003) reported that many subjects believed that the Sun is stationary, because the Earth and the planets orbit it. The Authors pointed out that during Geography classes in schools, while explaining day and night and the seasons, only the Earth's and planets' positions and their movements around the Sun are taken into consideration, and almost none of the text books mentions that the Sun is not the centre of the universe and revolves within one of the spiral branches of the Milky Way.

The Dark Side of the Moon and the Earth-Day Length of a Lunar Day: Parker and Heywood (1998) stated that although most teachers and prospective teachers are aware of "the dark side of the Moon," they cannot explain why it is so. As a result of a research relating to the question "why we see always the same side of the Moon," Dove (2002) stated that, after graduation, 46% of 12-year-old students in England gave the right answer: "because the Moon rotates on its axis at the same time that it takes to revolve around the Earth." Among the rest of the students, 14% stated that "the Moon does not rotate," and 11% stated "the Earth and the Moon spin in unison."

Based on evidence from these studies, it can be argued that grown-ups and younger subjects possess similar conceptions on astronomical subjects. Schooling was considered as a cause in explaining why students have difficulties in understanding astronomical occurrences. According to Vosniadou (1991), one common problem relates to reconciling everyday experiences, like observing the sunrise and sunset, with abstract models used to explain these experiences. Representing the three-dimensional space by employing two-dimensional diagrams (Parker & Heywood, 1998), using misleading diagrams (Ojala, 1997), using textbooks where diagrams and texts do not correspond (Pena & Quilez, 2001; Vosniadou, 1991), and using ambiguous terminology (Parker & Heywood, 1998) may have a puzzling effect on students' understanding and may lead them to generate some alternative conceptions as well.

A review of the literature revealed that most previous studies on astronomical concepts have focused on the conceptual understandings of elementary through high school students. Some studies included university students, but only few have focused on prospective teachers. The present study focused on prospective science teachers' understanding of astronomical concepts and tried to identify their existing conceptions relating to astronomical phenomena.

Methodology

This research was conducted on all prospective science teachers, in the Department of Science Education at the University of Balikesir, Turkey. In the study, there were 327 students, 159 of them received instruction related to astronomy at the university, while 168 of them did not receive such instruction. The topics covered during the astronomy course were stars, black holes, space energy, galaxies, solar system (including eclipses), the phases of the Moon, Kepler laws, re-

lativity motion at the space, space time, communication satellites, distance determination at space. It is the only course where the students of the science education department have the opportunity of getting instruction on astronomy topics.

The data obtained from this study were gathered by an open-ended questionnaire and one-to-one interviews to determine the conceptions of the prospective science teachers. The questionnaire consisted of nine open-ended questions that were selected based on evidence from four studies, namely, Barnett and Morran (2002), Lemmer et al. (2003), Trumper (2001a, 2001b), and Zeilik et al., (1998). Two questions about "shooting stars" and "formation of the universe" were modified to evaluate the influence of Turkish culture, religion, and the usage of the daily language on prospective science teachers' conceptions. The order of the questions in the questionnaire was as follows: Day-night cycle, seasons, formation of the universe, eclipses, shooting stars, centre of the universe, and the Moon phases. Six experts in physics education, two experts in physics, and two experts in astronomy judged the content validity of the questionnaire. The questionnaire was administered during normal class hours. Even though there was no time limit imposed, the questionnaire was completed in approximately 40 minutes.

After collecting and analysing data from the questionnaire, 33 students were individually interviewed. Among them, only 16 completed the astronomy course at the university. The students had been randomly selected for interviews, and had been clearly told that they did not have to participate, if they did not wish to do so. The interviews lasted between 20 to 25 minutes. The individual interviews were carried out with the aim of clarifying the meaning of their responses to the open-ended questionnaire. The students were asked to provide further explanations for some of their responses, and the interviews were recorded and then transcribed.

Prospective science teachers' (PST) conceptions were investigated by analyzing their responses to the open-ended questionnaire and the data gathered trough interviews. The methodology used in analyzing the data was a categorization of the responses that were considered as having identical meanings.

Results

Day - Night Cycle

Almost all the participants regardless of whether they had taken the astronomy course or not gave an academically sound and acceptable explanation relating to the question "What do you think causes the Day – Night Cycle?" Thus, they stated that *"the rotation of the Earth on its own axis causes day and night."* On the other hand, 6% of the non-instructed and 9% of instructed students stated that the day-night cycle is caused because "*the Earth revolves around the Sun*." Similar results were also reported by Trumper (2001b) and Ünsal et al., (2001).

Seasons

The question on "what causes the seasons" was asked to discover the ideas of students about the seasons. One third of the non-instructed PST (32%) and half of the instructed PST (55%) gave a correct response in the category *'the tilt of the Earth's axis.'* Table 1 presents PST' conceptions relating to the seasons.

Table 1
Conceptions Relating to the Seasons (n=327)

Conceptions	Non-instructed n=168(%) (%)	Instructed n= 159 (%)
The tilt of the Earth's axis	32	55
The Earth revolves around the Sun	33	24
Distance from the Sun	20	16
The Earth revolves around the Sun and rotates on its axis	9	-
Uncodable	6	5

In the category, 'the Earth revolves around the Sun' (33%, 24%, respectively non-instructed and instructed), they mostly stated that "*the Earth revolves the Sun in an elliptic orbit. When the Earth goes nearer to the Sun summer occurs, and when it wanders away winter takes place.*" Similar views were also reported by other previous studies (Bisard et al., 1994; Trumper, 2000; Ünsal et al., 2001). In the category 'Distance from the Sun' (20%, 16%, respectively), they mostly gave the explanation that "*the existence of seasons is closely related to the distance of our earth from the Sun. When the Earth goes closer to the Sun, summer takes place, when it goes away from it, winter takes place.*" These conceptions were also found by Trumper (2000) and Trumper (2001b).

During the interviews, two of the non-instructed students and four of the instructed students provided the accurate explanation that "*due to the tilt of the Earth's axis, the seasons occur. The existence of seasons depends on the amount of sunlight reaching the Earth. For example, the northern hemisphere that is tilted towards the Sun is warmer, because sunlight travels more directly to this hemisphere. Northern Hemisphere gets more sunlight, therefore, it is summer in the Northern Hemisphere; it is winter in the Southern Hemisphere.*" Five of the non-instructed students and three of the instructed students showed the Earth's revolving around of the Sun as the cause of the seasons. These students referred to their textbooks, or to their primary and secondary school teachers as the main sources of these views. The following excerpt from the interview with Student 10 exemplifies this idea:

Student 10: Earth orbits the Sun…as a result seasons take place.

R: Why?

Student 10: "[Slight pause]…well I know, it like this, but … I learned it like that at primary and secondary school. Our teachers always told so, it was written also in books I guess. If it is in the book, it must be surely right.

R: If the Earth did not orbit the Sun would not the seasons occur?

Student 10: [Slight pause]…they would not; because in order to happen it is necessary to circle the Sun.

Ten of the first group and eight of the second insisted that that the reason of the occurrence of the seasons was the changing distance between the Earth and the Sun. Some of them employed an 'electrical heater analogy' to explain their ideas, as it is clearly stated in the following excerpt from the interview with student 57.

Student 57: In my opinion,… the occurrence of the seasons is all about the distance (being away) and nearness (being closer). What I mean is when the Earth is closer to the Sun, it is summer and when it is farther, winter takes place.

Researcher (R): Why?

Student 57: Because, while the Earth is orbiting the Sun, it follows an ellipse path. Because of this, it sometimes goes closer to and sometimes wanders away from the Sun. Because of this, seasons occur. I mean closing and increasing the distance has an effect here... We can exemplify this like, well you know to a stove, let it be an electrical heater. Let it to be stationary on a corner of a room,...when we are away from it, we can not get enough heat to warm ourselves, but when we go closer, we get much more heat. Seasons resemble this. When the Earth goes closer to the Sun, summer takes place, when it goes away from it, winter takes place.

Centre of the Universe

PST were asked to choose one of the options (The Earth, The Sun, The Milky Way Galaxy, The Universe does not have a centre in space) about the centre of the universe and to explain their choices in the question. 73% of the non-instructed students and 80% of the instructed students answered correctly that, according to current theories, the universe does not have a centre in space. To explain their choices, they mostly expressed that "*the universe is infinite, it has no boundaries, therefore, there is no centre of it,*" or "*we cannot entirely comprehend the universe at the moment, therefore, we cannot talk about the centre of it*". 23% of the non-instructed students and 13% of the instructed students referred to the Sun as the center of the Universe. They mostly expressed that "*the planets revolve the Sun therefore the Sun is the centre of the universe.*" This conception that the Sun is at the centre of the universe has also been disclosed by Lemmer et al., (2003), Trumper (2000), and Trumper (2001b).

Formation of the Universe

It was the aimed to find out the ideas of the students on the formation of the universe by asking the question "what do you think about how the universe was formed?" Most of the participants mentioned Big Bang or gave religious explanations. Table 2 presents prospective science teachers' conceptions on the formation of universe.

Table 2

Conceptions Related to the Formation of Universe (n=327)

Conceptions	Non-instructed n=168 (%)	Instructed n= 159 (%)
Big Bang	28	52
Religious explanations	19	17
Exploding of the dust clouds	7	8
Exploding of a colossal mass	5	4
Confusing with Solar system's formation.	8	4
The universe has always existed and it will exist forever.	6	-
No explain	22	14
Uncodable	5	1

In the category 'Big Bang', non-instructed PST (28%) usually explicated their answer with "*I have read that as a result of Big Bang, it began. This is the theory accepted by scientists, for me it is logical too*". Instructed PST (52%) stated that the universe

began with the Big Bang. Most of these students also offered a brief description of the physical conditions (as pressure, heat, and size) after the explosion. In the category 'religious explanations,' PST (19%, 17%, respectively) made references to God (Allah), as responsible for the formation of universe. They explained their response as "*There is a creator (Allah) of the universe. He created the universe.*"

During the interviews on the subject of the origin of the universe, all the students, no matter what their answer was in the questionnaire, stated that they believed that the universe was created by Allah. Most of them expressed the view that the universe most probably began with the Big Bang, and that the blast itself was Allah's doing as well. The following excerpts from student 67's interview are representative examples of the students' views.

Student 67: There are evidences for the Big Bang, I have read somewhere, and you see the universe is expanding. We can reach this conclusion by the spectrums of the lights coming form the stars. If the universe is expanding, that means it is possible that there was an explosion at the beginning. Yes, yes there must be ... a lot of stars, galaxies scattered around. Well, their energy sources belong to themselves; you see how such a big event happens? While there was a stationary space, how the expansion could have taken place. Haven't it...there must be an enormous reason ... you see to make the universe expand, how can such an energy ...?

R: What do you think the reason could be?

Student 67: Look we can say, well, I think Allah created it and wanted it to expand, and it is expanding, I can say. I think this theory is such a theory that brings the religion and science together.

R: How?

Student 67: Well the explosion took place ... that means there is a beginning of the universe and there must be someone who must have done this of course. See, he is Allah.

A small number of the students supported theories, like the Big Bang, were extravagant and the universe was created by Allah. The following excerpts from student 47's interview indicate students' views.

Student 47: I have heard of Big Bang, but it is not convincing.

R: What part of it is not convincing?

Student 47: Well, I am not completely sure. I do not believe, I have read somewhere, it was not convincing enough to be clear.

R: Well, what do you think how might to have it began?

Student 47: Allah must have created it. See, it is also in the Qur'an (the holy book of Islam) ... I do not exactly remember, but, you see, it was created in 6 days, yes yes...in fact even if the Big Bang theory is right; it was also Allah's doing. Who can say otherwise?

There is not such finding as references to God for explaining any astronomical events among the researches conducted with university students and prospective science teachers in the literature. Yet, Brickhouse, Dagher, Letts and Shipman. (2000), and Valanides et al. (2000) found religious explanations among younger students.

Stars

The question on "where are the stars during the day" was asked to discover the ideas of students about the stars. Table 3 presents prospective science teachers' conceptions on the stars.

Table 3
Conceptions Related to the Stars (n=327)

Conceptions	Non-instructed n=168 (%)	Instructed n= 159 (%)
At the same place	67	74
Stars reflect Sunlight as planets	19	11
Stars are constantly moving in the space	5	4
Stars move, change location or burn out	-	2
Due to clouds we cannot see them during the day	1	-
The stars move together with the Earth	1	-
No explain	4	5
Uncodable	3	4

Most of the non-instructed and instructed PST gave an explanation in the category 'at the same place' (67%, 74%, respectively). They mostly provided the explanation "*at the same place, but during the day due to the Sunlight they cannot be seen.*" In the category 'stars reflect Sunlight as planets,' PST (19%, 11%, respectively) mostly provided the explanations "*the stars are like the planets, they are seen during the night, they reflect the Sunlight," or "they are in the sky, but we cannot see them during the day, because they do not generate light themselves. They only reflect light coming from the Sun during the night.*" This conception has not been identified in other studies to the best of our knowledge. Some of the other categories (Stars are constantly moving in the space and stars move, change location or burn out) in Table 3 have also been found by Lemmer et al. (2003).

During the interviews, whilst most of the students maintained the correct view that "*the stars are at the same place, but during the day due to the Sunlight they cannot be seen,*" three of the non-instructed students and one of the instructed students considering the stars like the planets or Moons (satellites), expressed the view that the stars reflect light from the Sun. The following excerpt from the interview with student 10 is qan example of these students' views.

Student 10: During the day, there is daylight, stars are bright too ... considering the stars reflect the Sunlight to us. So, during the day there is already daylight, therefore, they cannot be seen. During the night, because it is dark, they can be seen by reflecting the Sunlight.

R: How do you know the stars reflect the Sunlight?

Student 10: The Sun is a source of light, others reflect the light coming from it.

R: Others?

Student 10: Well planet, star etc.

Shooting Stars

The question on "in a clear night while watching the sky, Ahmet screamed with

an excitement 'a star glided!' What do you think Ahmet meant by saying 'a star glided?" was asked to discover the ideas of students about the shooting star.

Table 4 presents prospective science teachers' conceptions on the shooting stars. One third of the non-instructed PST (31%) and half of the instructed PST (56%) gave an explanation in the category 'moving of a meteor in the Earth's atmosphere' and their explanation was in this way: "*this event was not about the stars, but was the burning of a meteor in Earth's atmosphere, due to the effect of the friction.*"

Table 4
Conceptions Related to the Shooting Stars (n=327)

Conceptions	Non-instructed n= 168 (%)	Instructed n= 159 (%)
A meteor moving in the Earth's atmosphere	31	56
The shooting star was considered as an event related to the stars	50	36
Moving of a meteor in space	7	3
No explanation	8	3
Uncodable	4	2

In the category 'the shooting star considered as an event related to the stars,', half of the non-instructed PST (50%) and one third of the instructed PST (36%) tried to explain the event as having something to do with the stars. They explained mostly their responses as "*it is dying away, burning out of a star when eventually its energy runs out, while this is happening a flashing takes place Ahmet must have seen that*," "*the stars keep a trajectory when a star leaves this route a flashing takes place.*" There were also interesting arguments among the explanations of this group, such as, "*the stars are meteors charged with energy, when their energies run out, they break off from their locations and move towards Earth,*" "*the head on collision of two stars,*" and "*the stars reflects Sunlight, when they run out of energy, they die away.*"

During the interviews, seven of the non-instructed students and twelve of the instructed students explained the shooting star incident correctly. These students described it, as "*it is an occurrence, when a meteor enters Earth atmosphere and it burns*". A further ten of the non-instructed and three of the instructed students considered the shooting star event as something to do with stars. Some of these students mentioned a piece broken off from a star. For example:

Student 13: In my opinion the shooting star is a piece broken off from a star. There it is not a 'gliding star' or so. It is not a star what glides, it is a piece broken off a star in my opinion.

R: Why is a piece broken off from a star?

Student 13: A piece is broken off a star or there is something like excess, like an explosion, it happens due to that. We see an explosion; it is called a shooting star.

The other students mentioned dying of a star and losing of stars' energies. For example:

Student 60: A star has died, it has left its trajectory, it moves towards emptiness or towards a black hole. At the same time, light is generated. This is what we see here. Black holes pull (absorb) everything. When a star leaves its trajectory, black hole pulls it.

R: Why does a star leave its trajectory?

Student 60: When its energy runs out, when it begins to die away (burn out), it leaves the trajectory in my opinion. Well, it cannot hold its position there any more, when its energy runs out.

In addition, all the students interviewed stated that they had believed some of the common unscientific views about the stars such as *"everyone has a star up there and when one dies his or her star dies too, actually dying of a star takes place as a shooting star,"* while they were children, but they stated that now they do not believe such views and consider them as superstitions.

Eclipses

The question on "why the lunar and solar eclipses do not happen every month?" was asked to discover the conceptions of students about the eclipses. Table 5 presents prospective science teachers' conceptions on the eclipses. A few of non-instructed PST (2%) and one third of instructed PST (32%) gave responses in the category 'The Earth's and the Moon's orbit plane are not same'. Their explanation was in this way: "*eclipses do not happen every month, because of approximately six degree difference between the Earth's and the Moon's orbit bases.*"

Table 5
Conceptions Related to the Eclipses (n=327)

Conceptions	Non-instructed n= 168 (%)	Instructed n= 159 (%)
The Earth's and the Moon's orbit plane are not on the same plain.	2	32
The Earth's and the Moon's speeds or their completing times of a cycle	34	30
The Earth, the Moon and the Sun to align on the same line	24	8
Eclipses don't take place due to the tilt of the Earth's axis	6	11
When a planet blocks the Sun or the Moon the eclipses take place	4	-
Order of the universe	4	-
Actually they take place every month but we cannot see	-	4
No explanation	19	10
Uncodable	7	5

One third of the non-instructed and instructed PST (34%, 30%, respectively) gave an explanation in the category. 'The Earth's and the Moon's speeds or their completing times of a cycle,' and their explanation was in this way: "*eclipses do not happen every month, because of difference between the Earth's and Moon's speeds or their completing times of a cycle.*"

During the interviews, the question about eclipses was one of the most troublesome for the students. Eight of the non-instructed and four of the instructed students had no idea. Student 42 said: "*This is the first time I am confronted with such a question. I gave some thought to it, why it can be, but I could not find a logical explanation. Well I have no idea on this subject.*"

Nine of the non-instructed and seven of the instructed students stated that the eclipses do not happen every month, due to the difference between the speeds or

touring times of the Earth and the Moon. The following excerpt from student 33' interview is quite representative of the students' conceptions.

Student 33: It can be something to do with their spinning speed or touring times. Yes... if it is like this, it does not happen every month.

R: Why?

Student 33: Well, the length of the Moon's journey around the Earth and the length of the Earth's tour around the Sun, because these are different, they do not align every time. The Moon's orbit and Earth's orbit are not entirely the same ... himmm ...

R: What happens, when their speed and touring times differ?

Student 33: (He took a pen and paper and drew a diagram in which the Sun was in the centre, and the Moon and the Earth were on opposite sides of the Sun.) Here, according to the diagram, the Moon might be here and the Earth might be here. Then, they do not be in an alignment. To align it takes a very long time, therefore, it does not happen every month.

R: When we look at the diagram you drew, you separated the Moon from the Earth. What was the Moon to the Earth?

Student 33: Its satellite (Moon).

R: What does satellite mean?

Student 33: Well the Moon orbits the Earth ... himmm, wait a minute. The diagram is wrong; the Moon does not go there. I should have drawn it next to the Earth. Then how will it be? ... It must be every month! Why it does not happen? Are you sure it does not?

R: Yes.

Student 33: Why does not it? ..., himmm, I do not know, but I am very curious now.

Moon Eclipse

The question on "what do you understand from 'the Moon eclipse,' please explain it with a diagram" was asked to discover the conceptions of students about the Moon eclipses. To the first part of the query, most of the students (79 % of the non-instructed and 86% of the instructed) offered an accurate explanation that "the Earth goes between the Moon and the Sun, and the shadow of the Earth prevents the Moon from being seen." In the incorrect explanations, 14% of non-instructed and 6% instructed gave the answer: "*the Sun goes between the Earth and the Moon, and the Moon is left behind the Sun, for this reason the Moon cannot be seen.*"

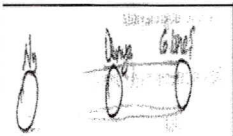
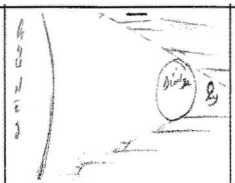
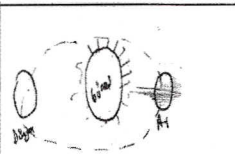
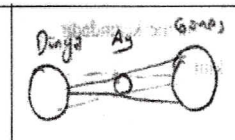
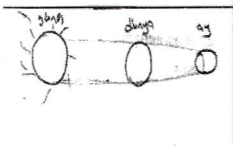
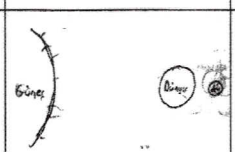
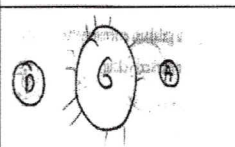
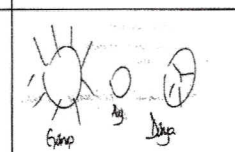
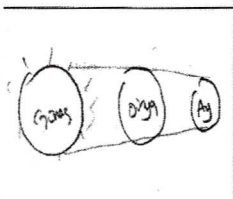
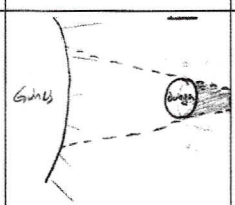
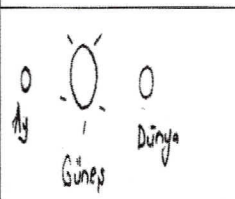
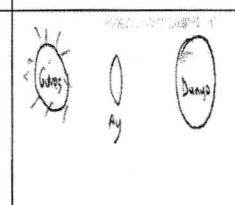
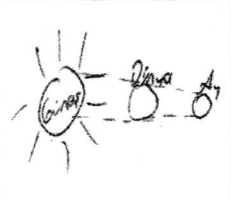
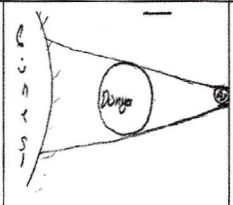
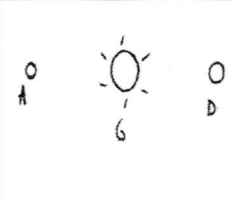
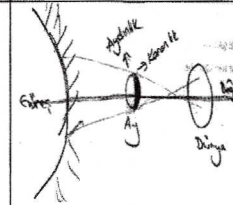
There is not a similar finding among the studies conducted with university students and prospective science teachers in the literature. Yet, Bakas and Mikropoulos (2003) found similar explanation (drawing) among younger students. 7% of the non-instructed and 8% of the instructed confused the lunar eclipse with the solar eclipse. They also offered the explanation: "*the Moon goes between the Sun and the Earth, and prevents the Sun from being seen*".

The diagrams drawn by the students for the second part of this question are shown in Table 6. Group A in Table 6 represents those who showed the alignment correctly, but showed the sizes and distances (between the Sun and the Earth, and the Earth and the Sun) of the Sun, the Earth and the Moon almost the same. Group B characterizes those who accurately placed the Sun, the Earth, and the

Moon on the right order, and they also showed the sizes and the distances proportional. Group C represents those who drew the Sun between the Earth and the Moon, and while they used non-proportional models of the Sun, the Earth, and the Moon, they also showed the distances between them almost the same. Group D represents those who confused the lunar eclipse with the solar eclipse, and drew the sizes and distances almost the same.

Table 6

Students' Diagrams about the Moon Eclipse

A- non-instructed 70%, Instructed 64%	B- non-instructed 9%, Instructed 22%	C- non-instructed 14%, Instructed 6%	D- non-instructed 7%, Instructed 8%
			
			
			
			

Almost all the students who were interviewed drew diagrams that could be categorized within the group A. When they were asked why they drew such diagrams, they all pointed out textbooks and primary school teachers as the affecting factor of their understanding and drawings. The following excerpt from student 49's interview indicates this kind of view.

> *Student 49: This diagram is in the books. To show the lunar eclipse, there are diagrams like this in books. I may have most probably been affected by books too. In fact, our teachers in primary school used to draw such diagrams on the board, while they*

were explaining the lunar and solar eclipses. In our university, our professor drew like this in the optic class. Our professor drew very similar diagram on the board.

R: Well, let us examine the distances and sizes on your diagram.

Student 49: I did not take the sizes and distances into consideration. I drew like this just to explain the event. You see, in order not to be seen, the Earth will go between the Moon and the Sun. In fact, this is important, it should be explained that the sizes and the distances do not reflect reality, while we draw diagrams to explain eclipses. In so much that in the textbooks, this should be written.

R: Let us look at your diagram again. According to your diagram (the distances are same) the Moon will collide with the Sun, while it is orbiting the Earth.

Student 49: Yes you are right. As I said, I did not think about the sizes and the distances... it is necessary to draw accurate. When I become a teacher, I will pay attention to this ha ha ha (laughs)

During the interviews, two students from each group stated that, during the lunar eclipse, the Sun should pass between the Moon and the Earth. They drew diagrams supporting this view. The following excerpt, taken from the interview of student 43, is an interesting example of this view.

Student 43: For the lunar eclipse, the Moon should not be seen. In other words, it is necessary that the Moon must be blocked. The Sun does this. The Sun enters between the Earth and the Moon ... it prevents the Moon from being seen from the Earth.

R: What does Moon (satellite) mean?

Student 43: Well, the Moon is our satellite and it orbits us. In other words, it is the orbiting of something by another, and we call these satellites (Moon).

R: Then, when we look at the diagram you drew, the Moon was separated from the Earth.

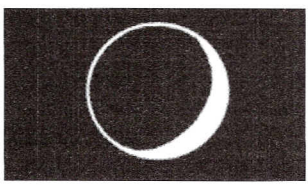
Student 43: Well, it might be like this, their speeds are different. The Moon toured more than once, I think that is why, it is because their speed is different ... yes, it might be so. Then, it can travel around it later.

R: How can the Moon travel around (orbit) the Earth later?

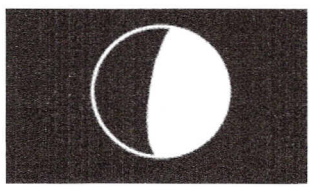
Student 43: Wait a minute ... it has been probably wrong, the Moon needs to travel around the Earth ... then, how will the lunar eclipse take place?

Moon Phases

The question on "the diagrams given below show the Moon's appearance on any one night and a couple of nights after that night. What do you think what could be the reason for this change?" was asked to discover the conceptions of students about the Moon phases.



One night



A few nights later

Table 7 presents prospective science teachers' conceptions on the Moon phases. One third of the non-instructed PST (30%) and instructed PST (29%) gave response in the category: 'The Moon revolves around the Earth'. These students pointed out the Moon's orbit around the Earth as a reason for this change in appearance. They mostly explained that "*because of the Moon's journey around the Earth, and the Sunlight reflected by the Moon, the seen parts of the Moon change*"

Table 7
Conceptions Related to the Phases of the Moon (n=327)

Conceptions	Non-instructed n= 168 (%)	Instructed n= 159 (%)
The Moon revolves around the Earth	30	29
Phases of the Moon were confused with the Moon eclipse	38	36
Movements of the Earth	18	14
No explanation	11	15
Uncodable	3	6

One third of the non-instructed PST (38%) and instructed PST (36%) gave response in the category 'Phases of the Moon confused with the Moon eclipse.' Their explanation was in this way: "*the Earth enters between the Moon and the Sun, and prevents the Moon receiving Sunlight. The farther the Earth moves aside, the larger part of the Moon is seen*". This conception has also been found by Bisard et al., (1994), Trumper (2000), Trumper (2001b), and Trundle et al., (2002).

During the interviews, it has been observed that although all the students were aware of the fact that the Moon reflects the Sunlight, they had trouble in explaining the phases of the Moon. It has been seen that most of the students from both groups generally confused the phases of the Moon with the Moon eclipse. For example:

> *Student 36: The Earth is moving aside in my opinion. As the Moon left behind the Earth, it cannot receive the light. For this reason ... when we look at these two diagrams, they show that the Moon is getting away from the shadow of the Earth. These diagrams, ... himmm, yes ... in other words, they are positions after the lunar eclipse in my opinion.*

Conclusions and Discussion

In conclusion, this study examined the conceptions of prospective science teachers on basic astronomical concepts. While this study corroborates previous research concerning conceptions, it also sheds light on some new conceptions along with those that are commonly known in literature. These conceptions are "stars reflect sunlight as planets," "eclipses do not happen every month because of difference between the Earth's and Moon's speeds or their completing times of a cycle," and "The Sun goes between the Earth and the Moon, and the Moon is left behind the Sun, for this reason the Moon cannot be seen." Furthermore, in this study, two questions concerning "shooting stars" and "formation of the universe" were used to expose the influence of Turkish culture, religion, and the usage of the

daily language. The conceptions, *"The shooting star considered as an event related to the stars" and "Allah (God) created the Universe,"* were obtained.

The results show that prospective science teachers have some conceptions on several central topics in basic astronomy, regardless of whether they had taken the astronomy course or not. This shows that formal instruction is not effective on conceptual change. Therefore, it is necessary that university level astronomy classes must be supported by conceptual change activities. Particularly for conceptions on seasons, Moon phases, the eclipses, differences between the stars, the planets and shooting star, the course must be throughout supported by conceptual change activities.

The diagrams drawn by the participants show that they did not pay attention to the sizes of the Sun, Earth, and Moon, or to the distances between them. They generally pointed out their textbooks and primary school teachers as being responsible for this. The diagrams used in the textbooks of primary-secondary education and universities of Turkey support this claim. The diagrams used for the eclipses in some of these books are given in Figure 1.

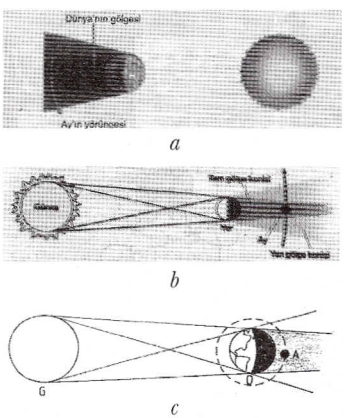


Figure 1: The Diagrams Used for the Lunar Eclipse in a) Primary Education Textbook b) High School Textbook, and c) University Textbook

For the given diagrams, there is no explanation or advice that the dimensions (the sizes and the distances) are not proportional. It can be argued that, while drawing the diagrams for the lunar eclipse, the students might have been affected by textbooks, as they claimed at the interviews. Moreover, there is neither enough explanation nor diagram to explain why the lunar eclipse does not take place every month in the textbooks. In high school and university level textbooks, the 5.2^{o} tilt of the Moon's orbit is pointed out as a reason why this event does not occur every month. Yet, they do not offer any diagram that shows this. It clearly shows that the instruction at university, and information in text books, were not effective enough, since only 32% of the instructed PST gave the correct answer to this question. To use three-dimensional diagrams and animations, instead of two-dimensional ones, has become a necessity, all the way through, and in every level of instruction on astronomy (Barab, Hay, Barnett & Keating, 2000; Hansen, Barnett & MaKinster, 2004; Parker & Heywood, 1998).

Another notable result of the study is that although a very small number (17% of the non-instructed and 19% of the instructed) of the students offered the explanation *"There is a creator (Allah-God) of the universe. He has created it."* In responding to the question of "How do you think the universe began" all the students, regardless of their answers in the questionnaire, stated that Allah (God) created the universe during the interviews. Education on any subject will be affected by student's having both scientific and religious views on the subject. Brickhouse et al. (2000), as a result of their research, stated that some of the students more plainly understand the relationship between the science and religion, and develop more clear views on the common points at the end of a course, (although the duration of the course was short). However, presenting scientific and religious views together during a class needs more careful deliberation, since some unexpected and unwanted circumstances may arise. For example, Alters and Nelson (2002) stated that some teachers might have some strong religious beliefs, or vice versa, and during teaching they might be affected by these beliefs, and accordingly may affect the students. Likewise, this study revealed that some prospective science teachers have both scientific and religious knowledge. Therefore, it is a wonder how these prospective science teachers will be affected by their scientific and religious knowledge, and how they will shape a classroom discussion in their classes in the future. In fact, whether the scientific and religious views should be simultaneously utilized or not during teaching is an important predicament that needs to be answered by science educators.

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