The Relationship Between Preservice Science Teachers' Attitude Toward Astronomy and Their Understanding of Basic Astronomy Concepts

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Abstract
Turkish preservice science teachers have been taking a two-credit astronomy class during the last semester of their undergraduate program since 2010. The current study aims to investigate the relationship between preservice science teachers' astronomy misconceptions and their attitudes toward astronomy. Preservice science teachers were given an Astronomy Attitude Test and a conceptual test at the beginning of their astronomy course. Three students from each of three attitude levels (low, medium, and high) were selected for interviews and asked to explain their conceptual test responses in depth. Generally, low-attitude students had more misconceptions and gave non-scientific, low-level explanations, whereas middle- and high-attitude students gave more scientific explanations. The results suggest that students develop negative attitudes about a subject in which they lack knowledge.

Key words*:* astronomy attitude levels, basic astronomy concepts, preservice science teachers

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Introduction

Preservice science teachers in Turkey do not take an astronomy course until the last semester of their undergraduate studies and generally have limited backgrounds on the topic. Therefore, they tend to enter this course with poor astronomy knowledge and various misconceptions (Bektasli, 2013b). Science education students who graduated in 2010 were the first to take an astronomy course as preservice science teachers. Most of their existing astronomy concepts are based on other science courses (such as physics), the media, or their amateur observations of the sky. Therefore, it is not surprising that they should hold some misconceptions related to astronomy.

Astronomy misconceptions have been reported in numerous studies (Bisard, Aron, Francek, & Nelson, 1994; Brunsell & Marcks, 2005; Trumper, 2000; Zeilik, Schau, & Mattern, 1998). Often they are so deeply rooted as to be difficult to change. Usually, students can overcome misconceptions as they learn further. However, if they still hold misconceptions when they become science teachers, it is a much more serious problem. Teachers will most probably transfer their misconceptions to their students, and misconceptions received from a teacher are more likely to be permanent. Such misconceptions may affect future students' attitudes toward science in a negative way and make it more difficult for them to understand astronomy.

Bektasli (2014) reported that science teachers have serious misconceptions related to astronomy. Teachers may feel uncomfortable teaching a topic that they do not fully understand themselves. Their inadequate astronomy content knowledge may result in some science teachers avoiding astronomy topics as much as possible, not wanting to convey inaccurate information to their students. Teaching astronomy with poor content knowledge will make teachers uncomfortable and diminish their self-efficacy, causing both teachers and their students to develop negative attitudes toward astronomy.

It is very interesting to have astronomy topics in the science education program at the end of the year at all grade levels. Teaching astronomy topics at the end of the year may, however, reduce the quality of instruction. Both teachers' and students' performance tends to decrease toward the end of the school year. In addition, science teachers usually strive to cover all the topics they are expected to teach, but if the pace of instruction is lowered by teacher illness, unexpected holidays, or some other cause, then there may not be enough time to teach astronomy. Therefore, it is crucial to plan the teaching of astronomy topics. To address this problem, it may be useful to change the order of topics and cover astronomy topics earlier in the year at some grade levels.

Students' Attitudes toward Science

Freedman (1997) observed that student achievement in science is related to positive attitudes toward science. It is important to develop positive attitudes toward science among young students, because attitudes are hard to change once they have become established, even at the middle-school level (Ajzen & Fishbern, 1980; Gibson & Chase, 2002). When students develop positive attitudes toward a subject, they are more inclined to enjoy it and continue learning it (Pell & Jarvis, 2001). However, students usually develop negative attitudes toward science (George, 2000; Reid, 2012). Durrani (1998) reported that the number of students who prefer to take science courses decreases as they become older, possibly reflecting the impact of negative attitudes toward science.

Zeilik et al. (1997) noted that students generally develop negative attitudes regarding a course that they have never experienced before. Astronomy is a new course for preservice science teachers in Turkey. Therefore, it is important to select appropriate teaching methods and tools to help these students develop positive attitudes about the course. Bektasli (2013a) reported that students usually develop positive attitudes toward astronomy as they begin to learn the topic, dispel their misconceptions, gain an accurate conceptual understanding, and support this learning with observations.

Since attitudes depend on many variables, research on attitudes toward science has yielded varying results. George (2000) and Piburn and Baker (1993) reported that students' attitudes toward science deteriorate as students become older, but Reid and Skryabina (2002) did not find such a deterioration. Most studies have focused on only one or two of the variables that can affect attitudes (Gardner, 1995). Variables examined in previous research have included the attitude instrument itself (Reid, 2006), friends (George, 2000; Keeves, 1975; Osborne, Simon, & Collins, 2003), teachers and their instructional techniques (George, 2000; Osborne et al., 2003; Reid & Skryabina, 2002), and parents (George, 2000; Keeves, 1975; Osborne et al., 2003; Reid & Skryabina, 2002).

Bennett (2001) pointed out that, instead of getting lost in quantitative data on student performance, it can be better to deal with students' attitudes in depth so as to gain a better understanding of what the data signify. The present study supports Bennett's idea by interviewing nine students with various attitudes toward astronomy to determine if these different attitudes are associated with different understandings of astronomy concepts.

Zeilik, Schau, and Mattern (1998) noted that sometimes it is very hard for students to overcome their misconceptions because of how deeply rooted those erroneous understandings have become. Thus, it is also important to identify how deeply students' astronomy misconceptions are rooted and what has caused those misconceptions, which can in turn affect students' attitudes toward astronomy. In-depth interviews with students should provide useful information to answer these questions.

Methodology

Participants

The research sample included 78 preservice science teachers in their fourth year of undergraduate study. Nine students with different attitude levels were randomly selected for interviews. None of the participants had previously taken an astronomy course, although they had taken some physics courses in high school and in the first two years of their undergraduate program.

Instruments

Two tests were administered at the beginning of the semester. First, students were given the Survey of Attitudes toward Astronomy (Zeilik, Schau, & Mattern, 1999). The original survey had 34 items, but the version adapted to Turkish by Bektasli (2013b) contains 29 items. Second, students were given 10 multiple-choice astronomy questions derived from the Astronomy Concept Test (AstroCoT) (Bektasli, 2013b). The questions were discussed with experts and some corrections were made before their administration. At the end of each question, students were requested to indicate whether they were certain of their answers.

In the second part of the study, nine students, three from each of three attitude levels (low, medium, and high), were selected randomly for interviews based on the results of the attitude survey. Each interview lasted about 30 minutes. Students were asked to explain their answers to the astronomy questions so as to give a clearer indication of the underlying factors affecting their responses.

Data Analysis

The students' responses on the 29 attitude survey items were coded numerically as follows: *strongly agree* = 5, *agree* = 4, *neither agree nor disagree* = 3, *disagree* = 2, and *strongly disagree* = 1. Possible scores thus ranged from 29 to 145. For negative items, students' responses were reverse coded before reliability analysis. Cronbach's alpha for the 29 items as revised by Bektasli (2013a) was 0.89. Attitude scores ranged between 86 and 141, with an average of 116. The score range considered as low for 86 to 105, medium for 106 to 124 and high for 125 to 141.

Each correct response to an astronomy question was coded as 1 and each incorrect response was coded as 0, except that if a participant gave a correct answer but said that he or she was not sure of the response, it was coded as 0 instead of 1. This approach was used to reduce the risk that chance factors (i.e., guessing correct answers) could skew the data.

Results

In this section, students' responses to the conceptual questions are discussed. Students' misunderstandings of basic astronomy concepts are presented and analyzed in relation to astronomy attitude levels. Table 1 presents the percentage of correct responses for each question.

Table 1. *Percentage of Correct Answers on Astronomy Questions*

Question	Related Astronomy Concepts	Percentage of Correct Answers
1	Meteor shower; distance and dimness	74
2	Source of light	66
3	Location of the Sun	26
4	Seasons	78
5	Planetary motion	51
6	Size of the Sun	27
7	Earth's rotation; size of planets and stars	31
8	Constellations	9
9	Sun-to-Earth distance in different seasons	13
10	Shape of stars	16

Meteor Showers

Approximately 74% of participants answered this question correctly. When interviewed, students with low attitude levels tended to give non-scientific responses, whereas medium- and high-attitude students provided explanations of what they had learned from previous classes, scientific magazines, or other forms of media, such as documentaries. All three low-level students believed that meteor showers occur when a star changes position and dies:

Stars change position by slipping. They are born, live, and they die. (Student 50)

Stars go somewhere else when they slip. We know that stars die when they slip. (Student 66)

There seem to be two possible reasons for students' responses here. First, meteor shower is *yıldız kayması* in Turkish, which can be translated as a *slipping star*. Therefore, the language itself may direct students to this misunderstanding. The second reason might be related to observations. It is common in Turkey to say, "Hey, look! A star has just slipped; make a wish!" People are not aware that they are really observing not a star but a meteor.

Relationship between Distance and Dimness

Similarly, low-attitude students gave non-scientific explanations for the relationship between the distance and dimness of stars. They believed that the amount of light emitted by a star is more important than the distance. One student explained, "*I don't think that seeing a star bright is related to distance, because all of them are quite far from us. It is more related to the brightness of the star itself*" (Student 50).

On the other hand, medium- and high-attitude students tended to give more scientific explanations, but still based on their observations. They stated that when a source of light moves farther away from us, it becomes dimmer. A high-attitude student said, "*Farther stars look dimmer because light comes dimmer from a farther point. We see a light bulb dimmer from a farther point*" (Student 2).

Are Planets a Source of Light?

Medium- and high-attitude students clearly stated that planets are not a source of light but simply reflect sunlight. On the other hand, low-attitude students stated in their explanations that the Moon is also a planet and reflects the sunlight. Even though this answer is partially true, they believed that the Moon is a planet. Following is one excerpt from an interview:

> Student 7: *Planets are not a source of light; they reflect the sunlight. For example, the moon reflects the sunlight.*
>
> Researcher: *Is Moon a planet?*
>
> Student 7: *Yes, the Moon is a planet.*
>
> Here is another exchange with a low-attitude student:
>
> Researcher: *Why do you think that planets are not a source of light?*
>
> Student 7: *Because the Moon is also a planet, but it is not a source of light; it reflects the sunlight.*

The Location of the Sun

This is one of the questions with which students had the greatest difficulty. Only 26% gave the correct answer. One low-attitude student said, "*The Sun is at the center of the universe because it is the biggest star*" (Student 50). Middle-attitude students attempted to give a more scientific response. One of them still did not have adequate knowledge to explain the answer, stating, "*I think the solar system is not at the center of the Milky Way because the universe is expanding*" (Student 76). Another middle-attitude student remembered the answer but could not give an explanation: "*Our Solar System is not at the center of the Milky Way; I have learned that before*" (Student 21). High-attitude students also stated that the Sun is at the center of the Milky Way, but were not sure of their responses.

What Causes Seasons?

Most students answered this question correctly, stating that the phenomenon of different seasons is not related to the position of the Moon. A low-attitude student said, "*The position of the Moon does not affect the seasons because the Moon is not a source of light*" (Student 7). One high-attitude student believed that the position of the Moon did affect the seasons. That student stated, "*The axial tilt of Earth is constant so it should not affect seasons. … The position of the Moon affects seasons but I do not know how*" (Student 4).

Kepler's Laws of Planetary Motion

Low-attitude students thought that Earth revolves around the sun at a constant speed. Two middle-attitude students stated that the speed is not constant and gave an explanation by reference to Kepler's laws; the other middle-attitude student was not sure. High-attitude students were not sure of their answers but thought that the speed may not be constant. One high-level student said, "*Planets do not revolve at constant distances from the Sun; therefore their speed will not remain constant*" (Student 4).

Size of the Sun

Low-attitude students thought that the size of the sun would remain constant. Medium-attitude students said that if the size of the sun were to change, Earth would be affected. Another medium-attitude student offered a more scientific explanation: "*The energy of the sun will be exhausted because of the chemical reactions that occur in the sun; therefore the amount of substance in the sun will decrease and its energy will not be infinite*" (Student 37).

The third medium-attitude student also thought that the size of the sun will not remain constant because solar explosions cause pieces to become separated from it. On the other hand, a high-attitude student stated that the size of the sun will change over time because scientists given such an explanation. Also, that student said that since stars are born, live, and die, then the size of the sun will change over time. Another high-attitude student believed that solar explosions will not affect the size of the sun in the short run, but that its size may change in the long run. Finally, the third high-attitude student said, "*According to my idea, the sun is a star. Stars are born, live, and die; however, the sun does not die. I am in a conflict now*" (Student 4).

In Which Direction Does Earth Rotate?

Students were asked if the following statement is true or false: "*When you look over the North Pole, the earth rotates clockwise*." Students of all three attitude levels tried to answer the question by saying that Earth rotates either from east to west or from west to east. In the interviews, students were given the New Year event as an example to help them answer the question. They all know from media reports that countries in the Far East, such as Japan or China, are the first in the world to celebrate the New Year, followed by the Middle East, then Europe, and finally the Americas. When they reflected on this event, they were able to realize that Earth rotates counterclockwise as viewed from above the North Pole.

Are Planets Bigger Than Stars?

All levels of students thought that some planets would be bigger than stars. Some students gave that answer based on probability, indicating that since the universe is so big, there should therefore be some planets bigger than Earth. Other students were affected by pictures in textbooks, magazines, or other media. They stated that we usually see stars as dots and planets as big in such pictures. This is an interesting and crucial observation, because in some textbooks the sizes of the planets and the sun in our solar system are not drawn precisely.

Do Stars That Form Constellations Have Common Features?

Most of the students at different attitude levels believed that stars that form a constellation have common characteristics. Only one medium-attitude student said that they do not have common features, adding, "*I think we name and categorize them based on their shapes*" (Student 21).
All nine students believed that constellations are not observed at the same point in the skyevery night. Their main argument for that response was Earth's rotation.

In Which Season Is the Sun Closest to Earth?

Students answered this question based on their experiences. Since all students live in the northern hemisphere, they believed that the sun is closest to Earth in summer than in winter. However, when confronted with conflicting information, they began to think further and examine their responses. The following conversation involved a high-attitude student:

Student 4: *I answered that question based on temperature. It is very hot in July and very cold in January.*

Researcher: *When it is summer here, it is winter in the southern hemisphere. Then, when we ask them the same question, will the answer change?*

Student 4: *Yes, the answer will change according to them.*

Researcher: *If you were living there, what would be your answer then?*

Student 4: *Then my answer would be that the sun is closest in January and farthest in July.*

Researcher: *Then there is a conflict here, right?*

Student 4: *Yes, I know myself, I knew that I was thinking wrong.*

What Shape are Stars?

All three different levels of students agreed that the shape of a star is not a pentagon, but they could not state a general shape for stars. Here is an example from a low-attitude student:

Student 50: *Stars are not pentagons; we perceive them as pentagons, but they are not.*

Researcher: *Then what are their shapes?*

Student 50: *They can be round like the sun or may be other shape, but I did not think of them as exact pentagons. For example, they can be in the shape of a snowflake.*

Conclusions and Implications

As Ajzen and Fishbern (1980) and Gibson and Chase (2002) reported, it is difficult to change attitudes. Therefore, it seems important to search for any relationship between students' attitudes toward astronomy and their conceptual understanding of basic astronomy concepts. Doing so may help to uncover reasons for the development of negative attitudes toward astronomy. Student achievement in science seems to be one of these reasons. Kind, Jones, and Barmby (2007) noted that developing positive attitudes toward science plays a significant role in student success; if students develop positive attitudes toward science, they will have a better chance of succeeding in science. The results of the current study support this idea. Medium- and high-attitude students showed a better understanding of astronomy than low-attitude students. It appears that students develop negative attitudes about a subject in which they hold various misconceptions.

In general, astronomy misconceptions arise due to a lack of good astronomy knowledge. The participants in this study stated that their astronomy knowledge was based on amateur observations, media (e.g., documentaries or magazines), or prior knowledge from various physics courses. None of the participants had taken any astronomy course prior to the present study. Even though these participants were relatively novice astronomy learners, some of them had developed positive attitudes toward astronomy.

Low-attitude students tended to give more non-scientific explanations, usually based on their observations or misconceptions. Medium- and high-attitude students were more likely to offer scientific explanations or to explain their answers by reference to laws of physics, such as Kepler's Law of Planetary Motion. In contrast, low-attitude students did not mention Kepler.

Students at all three attitude levels gave incorrect explanations about meteor showers, describing them as involving the displacement and death of a star. Two important points arise here, as noted earlier. First, this explanation is most probably based on students' observations. Meteor showers appear in the sky for a short time, during which the meteor changes position and then suddenly disappears. Second, the students' misunderstanding of meteor showers as the motion of a star derives from the Turkish language itself, since the term for a meteor shower in Turkish literally means *slipping star*. A similar misunderstanding exists with regard to constellations. Students at all attitude levels believed that stars that form constellations have common features. Again, the Turkish word for constellation is *takım yıldızı* or "stars team". It seems that it would be helpful to rename some astronomy concepts in Turkish.

Another finding of this study concerns textbooks and other printed media. In many textbooks, the sizes of planets and stars are not shown in their correct relationship. In the present study, participants said that in some pictures they saw planets bigger than stars. In some textbooks, the sun and other planets are shown together in pictures of the solar system. It does not seem realistic to show Earth and the sun in the same picture, because the sun is so big that approximately one million Earths could fit into it. Similarly, none of the students were able to state a general shape for stars. They knew that stars are not pentagons, but in daily life a star is usually shown as a pentagon, such as on many national flags.

Students' real-life experiences and observations seem to be very significant in forming and shaping their conceptual understanding and attitudes. Students at all attitude levels thought that the sun is closer to Earth in summer. The main reason for this seems to be that they live in the northern hemisphere. They experience summer as hot and winter as cold, so they assume that the Sun must be closer in summer; they are not aware that the greater heat is related to the angle of sunlight beams reaching Earth. Interestingly, none of the students interviewed gave any explanation related to the angle of sunlight beams.

Another real-life experience that affected conceptual understandings of astronomy was related to observation of the Moon. Low-attitude students thought that planets were a source of light and tried to explain this by reference to the Moon, stating that the Moon is a planet. Obviously, their explanation is based on their observation of the Moon. In contrast, medium- and high-attitude students were able to explain that the planets reflect sunlight. None of these students mentioned the Moon in their responses.

It is crucial for preservice science teachers to develop positive attitudes toward science. If teachers have positive attitudes toward science, they will probably display that orientation to their students. Developing positive attitudes is related to conceptual understanding of scientific concepts. Therefore, science teachers who have adequate content knowledge of astronomy will most probably develop positive attitudes toward astronomy. They will then be in a better position to help their students develop similarly positive attitudes toward astronomy, beginning at an early age. This is essential because attitudes are hard to change. If science teachers help young students to develop positive attitudes toward astronomy, those students will probably like science more. On the other hand, if youngsters develop negative attitudes toward science, they will probably not like science and will probably prefer not to study science in the future.

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