

Preservice Science Teachers' Beliefs about Astronomy Concepts

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Abstract The purpose of this study was to investigate preservice science teachers' conceptual understanding of astronomy concepts. Qualitative research methods were used. The sample consists of 118 preservice science teachers (40 freshmen, 31 sophomores, and 47 juniors). The data were collected with Astronomy Conceptual Questionnaire (ACQ) that includes 13 open-ended questionnaires, and measured various aspects of astronomy such as sun, planets, and moon. Moreover, semi-structured interviews were carried out in order to examine further thoughts of the participants. The results indicate that preservice science teachers have several misconceptions about astronomy concepts. Each misconception is generally based on a common incorrect astronomy knowledge. They have also difficulties with basic definitions and interpret visuals of astronomy concepts. Moreover, there is no difference among the levels of students concerning understanding of astronomy concepts.

Keywords Science Education, Astronomy Education, Astronomy, Preservice Science Teachers, Misconceptions

1. Introduction

Astronomy, which is one of the oldest science disciplines, has an important role in science education because it has a great influence on perceptions of our surroundings. It also has relation with natural phenomena and helps to scientific development [1]. Understanding of astronomy involves a number of related conceptual areas that are clearly important in relation to children's existing conceptual scopes [2]; they contain concepts of Earth, Universe, Space, Satellite, Galaxy, conception of day and night, seasons, solar system, property of stars etc. In recent years, the importance of astronomy teaching has been gradually increasing in science education, therefore, it has located in science curriculums.

Students' daily lives and experiences, their belief and learning environments, their efforts to grasp concepts using their as yet immature mental skills and other factors conflict with the nature of science itself as well as with the process of

how scientific knowledge emerges. In this process, students may have several conceptions about scientific facts [3]. Different researchers use different terms for descriptions of these ideas, such as misconceptions, preconceptions [4], alternative conceptions [5], children's scientific intuitions [6], children's science [7], common sense concepts [8] and spontaneous knowledge [9]. In this study, the misconceptions have been used as a term for determining incorrect ideas about astronomy concepts.

A number of studies that have been indicated that students enter the learning environment with many misconceptions about physics and astronomy [2, 10- 13].

Vosniadou [14] stated that children construct their knowledge of the nature on the basis of two information sources: observations of the world and latter explanations given by other people. In astronomy based units misconceptions are common, because students have no opportunity to observe directly. Students' common misconceptions about astronomy may come from factual misinformation, mythical concepts and language imprecision, misinterpreting sensory information, and incomplete understanding of scientific processes [15].

There are a number of studies about astronomy concepts focusing on different levels: early childhood education [16-20], elementary school students [21-23], high school students [2, 24-27], university students [28-37] and teachers [28,38]. The results of these studies indicated that students have misconceptions about basic astronomy concepts. The common misconceptions are as follows: the Moon does not rotate on its axis, Moon only revolves around the Earth and not around the Sun, reason for seasons is the elliptical orbit of the Earth's around the Sun, a planet is an old cold star and there is no difference between a star and a planet. In addition, it can be said that, it relates with students' misconceptions of celestial bodies with their understanding of relative size, motion, and distance.

In this study, we will examine preservice science teachers' conceptions about the astronomy subjects. Several researchers have studied pre-service teachers misconceptions in different astronomy concepts. For instance, Atwood and Atwood [39] studied the night and day

cycle notion of preservice elementary teachers. This study pointed out that the common alternative conception concerns the revolution of the earth around the sun. Trundle et al. [34] designed experimental research on pre-service elementary teachers about the moon phases. They questioned the effect of instruction about moon phases on the conceptual understandings of those students. Their study indicated that without instruction preservice elementary teachers have mostly a non scientific conception of the moon phases. Trumper [33] also focused on preservice elementary teachers' ideas about basic astronomy concepts. He investigated various astronomical concepts: night and day cycle, moon phases, size of the sun and the earth. This study indicated that pre-service elementary teachers have mostly a non-scientific astronomy concepts. Frede [30], studied preservice elementary teachers' conceptions concerning the celestial bodies and their movements, horizon and vertical and differences between a star and a planet. He indicated many alternative conceptions of preservice elementary teachers with their own words about the astronomical phenomena and definitions. Moreover, Kanli [21] conducted a study to determine the misconceptions of preservice physics and science teachers held extensive misconceptions especially about the reasons for seasons, the Moon's phases, the Moon's phase in the solar eclipse and the Sun's position in the sky.

Preservice science teachers education program is a very critical role to develop teacher candidates' conceptual development of scientific concepts because it has an important effect on students' ability to understand and construct new knowledge of scientific concepts [40]. Because of that, more researches are needed to determine the most effective methods for preparing preservice science teachers. To accomplish this, preservice science teachers' initial concepts should be identified correctly. Future teachers should be aware of their own conceptions about science subjects, because they will transfer their concepts to students.

On the other hand, in a constructivist approach, it is important that future teachers become aware of their own misconceptions in order to change them [30]. In the literature, studies about astronomical visuals, they generally focused participants drawing such as earth, moon, and lunar phases [e.g., 21,24]. Furthermore, there is still not enough work about conceptual understanding in astronomy concerning preservice elementary teachers. This study involves in depth analysis of the misconceptions held by preservice science teachers about various topics in astronomy, such as sun, planets, and moon. This study is designed to answer the following research questions:

1. What are the preservice science teachers' beliefs about astronomy concepts?
2. How preservice science teachers interpret the visuals of astronomy concepts?

2. Materials and Methods

In this study, qualitative reserach methodologies were used. This approaches helps the researchers to better understand the process of constructing meaning and describe them [41].

2.1. Sampling

The sample consists of 118 preservice science teachers (40 freshmen, 31 sophomores, and 47 juniors). Descriptive statistics is shown in Table 1.

Table 1. Descriptive statistics of preservice science teachers

Gender	Freshman(n)	Sophomore(n)	Junior(n)	Total
Female	28 (%24)	21 (%18)	44 (%37)	93 (%79)
Male	12 (%10)	10 (%8)	3 (%3)	25 (%21)
Total	40 (%34)	31(%26)	47 (%40)	118(%100)

2.2. Instrumentation

Astronomy Conceptual Questionnaire (ACQ) was developed to define the students' misconceptions and measure their conceptual understandings about astronomy subjects. Questions were prepared by researchers at the basis of the common conceptions that indicated in the literature and the Turkish Ministry of Education Primary School Science Curriculum (2013). The first version of the questionnaire consisted of 20 open-ended questionnaires. To test the content validity, the test was reviewed by three faculty members specialized in science education. After they examined questions, the questionnaire was given final form which contains 13 questions. Also, before testing for validity and reliability, a pilot study was implemented with 10 students to see students misunderstandings about the concepts. Two researchers analyzed students' answers. In this study, inter-rater reliability was calculated as 95%. The question below is an example from the ACQ (Figure 1).

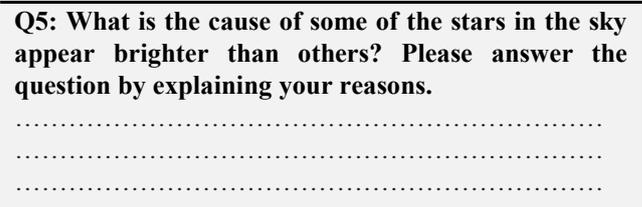


Figure 1. Example of an open-ended test item in the ACQ (Question 5)

In the analysis of the open-ended questions of ACQ, the students' responses were first defined thematically. Content analysis of the data was performed by two researchers. Moreover, the semi-structured interviews were carried out in order to examine further thoughts of the participants. Interviews were conducted with 12 students (6 females and 6 males) that approximately ten percent of participants.

2.3. Data Collection Procedure

First, an Astronomy Conceptual Questionnaire (ACQ) that includes 13 open-ended questions was administered to all students at the same time. Second, semi-structured interviews were carried out in order to examine the thoughts of the preservice teachers on astronomy concepts. For interviews, the students were chosen randomly. During the interviews, more detailed questions of the astronomy concepts were asked in order to reveal students understanding in more detail. The answers received were recorded by the researcher. Each student's interview lasted for approximately 20 minutes.

3. Findings

Preservice science teachers responses were categorized around five thematic topics: (1) descriptions of basic concepts associated with astronomy, (2) the sequence of basic astronomy concepts in terms of size, (3) misconceptions and beliefs about astronomy concepts, (4) students' interpretation about astronomical visuals, and (5) the interest to explore other celestial bodies. Results of this study were presented under these categories.

Table 2 indicates percentages of basic astronomy concepts that students' responses. According to these results preservice science teachers have many alternative concepts.

Looking at the table 2 it can be seen that the freshmen students have the most misconceptions. The answers of many students are: "Earth, Mars, Venus is the planet." or, "The Moon is a satellite" or "Galaxy mentioned, is something Milky Way came into my mind". They were trying to answer questions with examples and they answered without accurate definition. Some of the students' responses are given below:

"The universe is the world we live in, it has certain limits." (Student 15)

"Planets are stars in space." (Student 22)

"Space is part of the universe that we can see." (Student 45)

"Satellite is the light source of the planet." (Student 102)

"Galaxy is the name of system which is composed of substances between stars." (Student 73)

The students were asked to put in order of these concepts (universe, planet, satellite, space, and galaxy) in terms of size. Sequences made by the students are given in Table 3. Table 3 shows that in the students at all three levels have difficulties in sequencing these concepts. In this case, students have lack of knowledge about the basic concepts.

Table 2. Percentages of students concerning their understanding of basic astronomy concepts

Subject	Misconception(s)	F(%)	S(%)	J(%)
Universe	Universe and space are the same concept.	22.5	19.5	14.9
	The universe is a border that covers all substances.	15.0	19.5	12.8
	Universe and Milky Way are the same concept.	7.5	12.9	8.5
	Universe contains everything which has just living things.	15.0	12.9	10.6
	The universe is the earth we live in.	15.0	12.9	14.9
	All the planets are all called to universe.	10.0	9.7	4.2
	Universe is the name which is given to the gap in space.	10.0	12.9	8.5
Planet	Planets are celestial bodies which have satellite.	15.0	6.4	12.8
	Celestial body, which life is in, is called the planet.	20.0	12.9	8.5
	Planets are stars in the sky.	12.5	19.5	10.6
Satellite	Satellite is a planet.	15.0	6.4	8.5
	Satellite is a star.	7.5	6.4	4.2
	Satellite is the helper of the planet, it helps to rotate planet's orbit.	7.5	3.2	4.2
	Satellite is the planet's light source.	7.5	12.9	10.6
Space	All areas except the Earth are called space.	25.0	19.5	12.8
	Space is finite, the universe is infinite.	5.0	12.9	2.1
	All areas except the universe are called space.	7.5	12.9	6.3
Galaxy	Galaxy is the dust clusters in space.	15.0	12.9	8.5
	Galaxy is the name of the outer space.	7.5	3.2	2.1
	Galaxy is called the orbit of the planet.	10.0	6.4	4.2
	Galaxies are small planets orbiting around the planet.	7.5	9.7	6.3
	Galaxies is the empty space between the planets and the stars.	5.0	3.2	4.2
	Galaxies are circular objects in space.	15.0	12.9	10.6
	Galaxy covers the entire space.	7.5	6.4	4.2

Note. F: Freshman, S: Sophomore, J: Junior

Table 3. Percentages of students concerning the sequence of basic astronomy concepts

Putting in Order	Freshman(%)	Sophomore(%)	Junior(%)
Universe>Galaxy>Space>Planet>Moon	10.0	9.7	10.6
Space>Universe>Galaxy>Planet>Moon	7.5	12.9	6.3
Universe>Space>Planet>Moon>Galaxy	7.5	6.4	8.5
Galaxy>Space>Universe>Planet>Moon	7.5	9.7	6.3
Universe=Space>Galaxy>Planet>Moon	12.5	16.1	12.8
Universe=Planet>Space>Galaxy>Moon	12.5	9.7	10.6

Table 4. Percentages of students misconceptions about astronomy concepts

Category	Misconception(s)	F(%)	S(%)	J(%)
Properties of meteors	If an object falls to Earth, it is a meteor.	12.5	16.1	14.9
	Meteors are always too big.	15.0	12.9	10.6
	Meteors are always too small.	10.0	19.5	10.6
	Meteors with a core are the black body.	5.0	16.1	10.6
Differences between the planets and stars	The planet has its own brightness.	15.0	19.5	14.9
	Stars are always smaller than planets.	15.0	12.9	10.6
	Planets do not move the stars slide.	5.0	19.5	6.3
	Stars consist of rocks and dust clouds.	5.0	9.7	4.2
Properties and Brightness of stars	If we look at the world we cannot see the planet, but we can see stars.	17.5	16.1	10.6
	Some stars reflect more light from the sun, so these stars shine more than others.	12.5	12.9	4.2
	The brightness of stars depends on how much light reflect from the Moon.	5.0	6.4	2.1
	All night long stars reflect light which they receive from the sun during the day.	17.5	19.5	10.6
	The stars reflect the light which they receive from the Moon. Because in the day time, it does not appear.	10.0	12.9	8.5
Cause of the Moon Phases	The stars reflect the light of the other celestial bodies.	5.0	12.9	10.6
	Because of the Moon's rotation around its axis, the phases of the Moon change.	17.5	16.1	12.8
	The Moon on different phases is seen because of the Earth's shadow falling on the Moon.	20.0	19.5	14.9
	Because of the tidal events, the phases of the Moon change.	5.0	3.2	2.1
Properties of the Sun	The Moon produces its own light. The phases of the Moon change because of the Moon's light intensity.	15.0	12.9	8.4
	The sun is a planet.	15.0	25.8	12.8
	The sun is both a planet and a star.	5.0	6.4	2.1
Center of the universe	The sun is neither a planet nor a star.	7.5	9.7	8.5
	Earth is the center of the universe, because there is only life on Earth.	12.5	12.9	10.6
	Sun is the center of the universe, because all the planets are around it.	20.0	19.5	14.9
	Milky Way is the center of the universe, because it contains stars, planets and satellites.	7.5	6.4	8.5
Day and night circle	None of them, because black hole is the center of the universe.	2.5	6.4	4.2
	If the Earth did not rotate its own axis, the life would not be in the world.	12.5	12.9	14.9
	If the Earth did not rotate its own axis, seasons would not occur.	7.5	12.9	8.5
Seasons	The Sun goes around the Earth is the cause of the day and night.	17.5	19.5	14.9
	Seasons occur thanks to the rotation of the Earth on its axis.	17.5	16.1	12.6
	The seasons are caused by the sunlight falling on Earth.	15.0	19.5	10.6
	The seasons are caused by the movement of the sun.	5.0	6.4	6.3
	The sun goes around the world.	15.0	16.1	10.6
	Seasons occur thanks to the Earth's distance from the Sun changes.	17.5	16.1	12.8

Note. F: Freshman, S: Sophomore, J: Junior

The misconceptions of students from their responses to the other questions are summarized in Table 4. As seen in Table 4, students have many incorrect beliefs about astronomy concepts. Even some of the questions were left empty by large percentages of students and they said they had no idea.

Some of the students' responses are given below:

"I can understand object is a meteor if it fell to earth, because the meteors are always falling." (Student 18)

"Stars give light and floating, planets are lit up with the satellites." (Student 102)

"Light is larger than it receives from the Moon's star is brighter." (Student 52)

"Stars reflect the light of the heavenly bodies around them. They are appeared at the night because there is no night light." (Student 95)

"Moon consists of phases due to lengthiness or shortenings of the day and night." (Student 64)

"The Sun is a big star, but there are other bigger stars in the Universe. I don't understand why we see only the Sun." (Student 18)

"The sun is a planet, because there are objects revolving around it, such as satellite." (Student 46)

"Blackhole is the center of the universe, because one day everything is will be swallowed and all the scattered planets will gather in this center." (Student 61)

"Earth is the center of the universe, because it is the only area in which life in the universe." (Student 102)

"If the world were not come around its axis people could not walk without falling and assets, objects, creatures could not stand still." (Student 54)

Student responses obtained from the visual questions are presented as thematically in Table 5. Students are forced to interpret visuals. It is understood that students do not know the properties of certain celestial bodies. Some of the questions were left empty by large percentages of students and they said they had no idea.

Question 13 were distributed to the two halves of the students. We asked half of them: "Would you like to make a trip to Mars even though you are not likely to go back?" and also we asked other half of them: "Would you like to become one of the scientists who voyage to the Moon?"

Students' thoughts about discovering celestial bodies and interests of the other planets are investigated with these two questions. Students' responses have been summarized in Table 6.

Table 5. Percentages of students' interpretation about astronomical visuals

Category	Students' Interpretation	F(%)	S(%)	J(%)
Visual interpretation of the phases of the Moon	Full moon and new moon phases are written as inverse.	27.5	29.0	21.3
	The first quarter and last quarter of the Moon phases is written as inverse.	20.0	22.6	12.8
Recognition of basic astronomical figure	Stars are named as Galaxy.	17.5	16.1	17.2
	Moon is named as Planet.	12.5	12.9	12.8
	Sun is named as meteor.	2.5	6.4	4.2
	Stars are named as meteor.	2.5	6.4	4.2
Distinguishing between the lunar and solar eclipses	The solar eclipse is named as lunar eclipse	32.5	19.5	17.2
	The lunar eclipse is named as solar eclipse	22.5	22.6	17.2
	A lunar eclipse occurs when the Sun gets between the Moon and the Earth.	12.5	12.9	12.8
Classification of celestial bodies	Sun is classified as planet	27.5	29.0	21.3
	Moon is classified as planet	17.5	22.6	19.1
	Moon is classified as star	12.5	12.9	14.9
	Some of the planets are classified as stars.	12.5	16.1	8.5

Note. F: Freshman, S: Sophomore, J: Junior

Table 6. Percentages of students' interest to explore other celestial bodies

		Freshman(%)	Sophomore(%)	Junior(%)
Moon question	Students who want to go	50.0	48.4	51.1
	Students who don't want to go	45.0	51.6	42.6
Mars question	Students who want to go	2.5	6.4	4.2
	Students who don't want to go	97.5	93.6	95.8

Students' responses for Moon are almost the same percentages. Some of the examples are given below.

"Yes. Because I'm curious. I would like to investigate the Moon like astronauts. I would like to see how it is." (Student 11)

"I don't want. Because I don't know how this place is and what I will encounter." (Student 19)

As seen in Table 6 only one or two people from each grade level has want to go to Mars. Although they have interest, due to thought of staying there students stated that they did not prefer this trip. Some of the students' responses for this question are given below:

"No I do not. Because of the lack of facilities and thought of staying there are made me think. I would not dare to do so." (Student 99)

"I would like to live on Mars. If I knew that I didn't come back the Earth, chances of survival aroused curiosity in me." (Student 100)

In fact, some of the students wonder about living in different places. However, they do not really prefer the situation of staying there. Furthermore, misconceptions that students have also been identified in responses to these questions. For example, student 14 said that *"I want to go to the Moon. Because I wonder how I walk without gravity."* Some students have a thought that there is no gravity on the Moon.

When looking at findings obtained from both the paper-and-pencil questionnaire and the semi-structured interviews, it can be said that there are no different responses between the levels of students' grades. Although the knowledge of participants changes, what they notice do not change.

4. Discussion and Conclusions

In this study we determined some conceptions held by future preservice elementary teachers in astronomy. The preservice science teachers have developed mainly alternative conceptions about astronomical basic concepts and have difficulties with basic definitions.

Trundle et al. [34] and Barnett & Morran [21] indicated that participants with varied levels of schooling and training from elementary school through in-service teachers have difficulties the cause of moon phases. Ogan-Bekiroglu [29] also found that pre-service physics teachers have misconceptions about Moon, Moon phases and other lunar phenomena. Barnett and Morran [21] pointed out the majority of students began the course with particular understandings of various aspects of the Earth-Moon-Sun system. Some studies indicated that many students was unaware that the universe was expanding [42,43].

The results obtained from the study also exhibit similarities with other research results. Trumper [2,26] conducted a study which investigates day-night cycle, moon phases, seasons, solar eclipse and center of the universe etc. conceptual understandings of high school students. Similar

misconceptions were encountered between high school students and preservice science teachers. Kanli [28] also found that the percentages of preservice and in-service teachers' achievement scores are very low on basic astronomy concepts about the reasons for seasons, the Sun's position, the Moon's phases, and the Moon's phase in a solar eclipse. These findings are in agreement with other previous studies in other counties [30,31,33,36,37,39,44,45]. Results of this study also have revealed that the percentages of preservice science teachers' responses are very inadequate on astronomy concepts and student's conceptual understandings are almost parallel in all grades. Indeed, we point out similar alternative conceptions shared by those preservice science teachers. In quantitative sense, our study covers to previous studies.

The results of this study show that preservice science teachers have lack of knowledge, scientific mistakes and misconceptions about astronomy concepts. These concepts are often abstract and require threedimensional thinking. This makes it difficult to learn and comprehend basic astronomy concepts properly [48].

Vosniadou[46] found that elementary school students did not make correct sequencing concepts such as Sun, Earth, Moon and Stars. Similar deficiencies were encountered with preservice science teachers. This study indicated that in the pre-service science teachers at all three levels have difficulties in sequencing some of the celestial bodies.

Visuals have an important place in astronomy education. There is a study that reports visualization has a positive impact on students' understanding [47]. Testa, Leccia and Puddu[25] investigated whether iconic features of astronomy images help students in understanding familiar phenomena such as the change of seasons, the solar eclipses and lunar phases. Researchers emphasized the importance of visuals and they reported that secondary school students have difficulties interpreting visuals of astronomy. In this study, it indicated that preservice science teachers have difficulties about interpreting visuals. Teachers play an important role in reducing the misconceptions of students in teaching of astronomy. Therefore, it can be said that if the future teachers have deficiencies about interpreting visuals, their students will have difficulties too.

Celestial bodies are impossible for students to touch and feel. Because of that study of astronomy may cause to misconceptions in people' minds. The best way to change the misconceptions is to determine the knowledge of the students in terms of basic astronomy concepts and to ensure an appropriate educational environment. Students' participation in explanation and discussion of these topics as well as experiments and observations is the most effective way of teaching [49].

Although people today have accessed easily to information about astronomy through media such as television, books, and the Internet, their students have lack of knowledge. They don't wonder about other celestial bodies and they have wrong beliefs on these concepts. For this reason, they should be encouraged to raise awareness

among students. It is the task of science education.

Astronomy teaching is considered difficult because of the large amount of facts and details it contains and because some of the concepts seem like abstracts [47]. Trumper[2] suggested that if these concepts are learned properly in the classroom, every effort must be made to help students to develop their conceptual understanding. Therefore, in order to achieve meaningful progress, learning to identify misconceptions of students is important.

Barnett and Morran [21] pointed out the need that instruction depends on students' pre-existing ideas and supports their reflection and discussion of their ideas. An understanding of knowledge of science teacher candidates in astronomy will be valuable to curriculum writers and preservice teacher training schools. It is critical that pay special attention to preservice teachers' training on astronomy concepts.

Based on the findings of this study, it might be recommended that before starting to teach any subject, it should first be determined whether students have preconceptions or misconceptions about the subject and teaching activities should proceed on the basis of this information (to eliminate existing misconceptions). In the light of these results, learning environment for the students is organized so as to understand the key concepts of astronomy. It can be suggested that concept maps, conceptual change text, analogies may be prepared. In order to develop students' imagination about astronomy, night-sky observations with telescope, videotaped films, computer simulations and many existing internet resources may be used. In curriculums, students should have activities, including prediction, observation and explanation to learn fundamental characteristics of celestial bodies.

The conclusions presented here carry implications for curriculum developers and teacher education. If it is considered that the educational system today is transitioning from traditional instruction to contemporary teaching methods, more rooms should be made for these modern methods in the organization of teaching and education efforts. It might be suggested that constructivist methods and techniques should be developed to shift these misconceptions in future studies.

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