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Full Length Research Paper

On pre-service science teachers' preexisting knowledge levels about basic astronomy concepts

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A curriculum to train teacher candidates is a very important factor in developing teacher candidates' conceptual understanding of scientific concepts. Teacher candidates have a dramatic impact on students' ability to understand and construct new knowledge of the concepts. The purpose of this study was to determine the preconceptions and misconceptions of teacher candidates about basic astronomy concepts. This was measured by administrating the validated diagnostic questions from the latest version of the Astronomy Diagnostic Test 2.0 - 113 teacher candidates in the School of Education in Amasya University, Turkey. The findings indicated that teacher candidates held a series of misconceptions on several basic astronomy concepts. Common misconceptions were identified and a constructivist-inquiry approach to teaching basic astronomy concepts in the astronomy curriculum for pre-service teachers was proposed.

Key words: Astronomy concepts, science teachers, teacher training.

INTRODUCTION

Astronomy, the oldest and most popular science field, has developed satellite technologies. Astronomy takes an important place in science education because it has a relation with earth, space, and nature. Another important astronomy feature is that it comprises mathematics, physics, chemistry, and biology. In other words, it includes all science disciplines. For these reasons, it is not appropriate to consider education without astronomy. Because of its relation with several fields and high students' interest, astronomy education has been begun to be offered in elementary and high school levels in order to promote students interest in science courses in developed and developing countries since the beginning of 1970 (Bailey and Slater, 2003; Trumper, 2006).

Nowadays, science and technology teachers have important responsibility to teach astronomy and promote students interest and understanding of astronomy. If astronomy is not taught properly, astrology, fortune reading, and horoscope might be included in astronomy teaching, therefore leading people to have misunderstandings of astronomy. It is vital to rewrite and reconstruct curricula based on the results of studies on science and technology education which examine pre-service teachers' knowledge level and their misconceptions (Sadler, 1992; Trumper, 2003, 2006).

This study was conducted in the context of first year pre-service science and technology teacher education in Turkey. A curriculum to train teacher candidates is a very important factor to develop teacher candidates' conceptual understanding of scientific concepts because they have a dramatic impact on students' ability to understand and construct new knowledge of scientific concepts. This, more research is needed to determine the most effective methods of preparing future science teachers. However, very little work has been done even though it is still seen by many as one of the highest and most urgent priorities of the field (Bailey and Slater, 2003).

At this point, the Turkish astronomy curriculum will be summarized briefly. The Turkish school system is divided into two parts, called primary schools (K-8) and secondary schools (9 - 12). Since the curriculum is centralized, all over the schools throughout the country must follow the same one and use the same educational materials. Recently, the Turkish education system has made

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changes under the European Union Standards, and some reforms have been implemented in all educational fields, including science and technology. Astronomy is an important component of the new science and technology curriculum throughout the different education levels. The main objectives in the present curriculum include describing changes over time and the objects and motions of the sky, day and night, seasons, the relationship between earth, moon, and sun; and our planet's shape and size; and gravity, solar system, stars, and galaxies (Korkmaz, 2009). Astronomy topics have appeared in school science curricula at all levels while the numbers of high schools that offer astronomy as a separate course have decreased. Unfortunately, since few teachers have taken astronomy courses in high school or university, astronomy concepts are often not taught effectively. Thus, students are disadvantaged because they have no chance to learn one of the most fundamental and unifying of science subjects (Aslan et al., 2008). To eliminate this defect, Turkish education policy makers included an astronomy course, as a compulsory requirement for pre-service science teachers' training programs from academic year 2006 - 2007 onward (Korkmaz, 2009).

The purpose of this study was to characterize pre-service science teachers' preexisting knowledge level of basic astronomy concepts. Specifically, the study attempted to answer the following question:

What misconceptions about the basic astronomical concepts do the first-year pre-service science teacher candidates possess?

An understanding of the current baseline of teacher candidates' content knowledge in astronomy will be valuable to curriculum writers of professional pre-service teacher training programs. This study confines itself to investigating the content knowledge of teacher candidates in the School of Education at Amasya University, Turkey. The sampling-by-convenience procedure used during this study may limit the generalizability of the study to a national population.

METHODOLOGY

As is well known, a standard diagnostic test can be a powerful tool to assess students' conceptual understanding of concepts, as has been proven for undergraduate physics instruction over the last two decade (Redish and Steinberg, 1999). The Astronomy Diagnostic Test 2.0 (ADT), the most commonly used diagnostic to date in introductory astronomy courses, has 21 multiple-choice content questions covering a wide range of astronomy topics and is aimed at the introductory-level courses typically taught to non-science majors at colleges and universities (Hufnagel et al., 2000; Hufnagel, 2002; Zeilik, 2003). The ADT questions can be retrieved from http://solar.physics.montana.edu/aae/adt/ADTv2.0.PDF. The ADT questions can also be found in Appendix A. The ADT was used to determine the preexisting knowledge level of pre-service science teachers' about basic astronomy concepts. Two experienced lecturers and two experts in the physics education field judged the content validity of the translated new version of ADT 2.0. After making some minor changes as suggested by the experts, the test was deemed valid. The test reliability was measured by calculating the Cronbach's alpha coefficient getting an estimate of 0.51. Afterwards, the ADT was given to participating science teacher candidates during the beginning of the first semester of 2008.

Although the ADT has 33 questions, we only used the 21 multiple-choice content questions covering a wide range of astronomy topics. The remaining questions are related to demographic questions. Demographic data regarding gender and ethnicities were not necessarily required for the purpose of the study; therefore we did not use this part of the survey. The results were obtained from only the 21 multiple-choice content questions.

RESULTS AND DISCUSSION

In the current study, the ADT was completed by 113 future science teacher candidates in school of education in Amasya University, Turkey. The overall correct response rate was 34.2%. In Table 1, answers to individual test items on ADT were summarized.

The ADT assessed the astronomy knowledge of undergraduate students in introductory college astronomy courses. Items on the ADT measure discreet astronomy topics and contain distractors that can be used to identify alternate conceptions. Therefore, analysis of individual test items is more useful than looking at a composite score. As can be seen in Table 2, items on the ADT can be divided into four distinct conceptual categories (Brunsell and Marcks, 2005). Also in this table, taking into account % correct responses to individual items on the ADT given by Table 1, the general comments are summarized briefly.

Meanwhile, the ADT sample yielded an average value of 32.4% for the pre-course test (Deming, 2002). In this regard, the overall correct response rate (34.2%) in this study was slightly higher than the average pretest score given by Deming, 2002 for introductory college astronomy. However, the mean score in the current study was less than the mean score of non-science majors taking advanced astronomy undergraduate courses (66% in Hufnagel, 2002).

The general comments given in Table 2 are supported by the results of national and international research (Jones et al., 1987; Baxter, 1989; Kikas, 1999; Zeilik et al., 1999; Trumper, 2000; Kalkan and Kiroglu, 2007; Bayraktar, 2009; Kucukozer, 2007; Kucukozer, 2008). Although the subjects were science students, they had almost the same average as non-science students on the test. Therefore, this can be considered as a failure.

According to the results of the research, there are important differences between pre-service science teachers' conceptions of some basic astronomy concepts and the experts' views of these concepts. By utilizing these concepts properly in the classroom, we can astronomy concepts. The first step in reducing misconceptions that students hold is to determine students' preexisting ideas about astronomy concepts.

This step in instruction can obviously elicit students' views because it might be views because it might be

Table 1. Responses to individual test Items on ADT.

Item	The percentage distribution of options				
	% A	% B	% C	% D	% E
1. Position of The Sun in The Sky and Shadows	55	10	2	3	30
2. Eclipse and Moon Phase	44	20	3	4	29
3. Earth / Moon Scale	2	20	37	25	16
4. Gravity	28	69	3		
5. Electromagnetic Radiation	56	23	21		
6. Gravity and "*Weightlessness*" in Orbit	3	21	4	6	66
7. Seasons and Earth's Orbit	40	8	28	24	
8. Origin of Sun's Energy	32	50	4	14	
9. Change in The Position of The Sun in The Sky over Time	44	14	42		
10. Position of The Sun and Constellations in The Sky	7	7	23	14	49
11. Earth / Moon / Space Shuttle Scale	46	14	31	9	
12. Earth / Solar System / Stars Scale	12	28	25	20	15
13. Object Arrangement By Distance	17	5	27	24	27
14. Gravity	19	6	11	27	37
15. Light and Inverse Square Relationship	11	13	10	56	10
16. Location of The Center of The Universe	7	11	12	5	65
17. Star Color And Temperature	22	18	26	17	17
18. Moon Phases	20	21	3	25	31
19. Moon Phases and Moon Motion in The Sky	16	38	33	13	
20. Angular Distance	5	12	13	38	32
21. Cause of Global Warming	53	5	42		

the focus of learning activities, such as discussions of science misconceptions between students and interactive-engagement group work (Wubbels, 1992; Laws, 1997).

Based on a constructivist approach, experiences, knowledge, language, and instructional strategies and thinking strategies can be considered parts of progress of cognitive reconstruction. In this progress, students are always active participants and pioneers. In this context, educational strategies play a critical role in the constructing of new knowledge process. Constructivism can be efficiently used in astronomy teaching. Observations, representative-symbolic language, instructional strategies are concerned in astronomy teaching (Trumper, 2001a, b).

The constructivist pedagogical approach provides opportunity for teacher candidates to construct concepts in astronomy from observations and direct experiences. They should be given the opportunity to rediscover concepts and relationships from the above mentioned strategies so that their misconceptions can be overcome (Pasachoff and Percy, 2005). The approach can also be employed to enhance the teaching and learning astronomy in order that the curricula based on constructivist approach engage teacher candidates in challenging and constructing their own knowledge and understanding of astronomy concepts. In other words, through this approach they can begin to construct a logical and coherent understanding of astronomy concepts (Trumper, 2000).

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APPENDIX A

"**Introductory Astronomy Survey**"

[http://solar.physics.montana.edu/aae/adt/ADTv2.0.PDF]

Q1. As seen from your current location, when will an upright flagpole cast no shadow because the Sun is directly above the flagpole?

A. Every day at noon.
B. Only on the first day of summer.
C. Only on the first day of winter.
D. On both the first days of spring and fall.

Table 2. The conceptual categories of ADT.

Categories (Brunsell and Marcks, 2005).	Questions	General Comments
The Scale category includes five questions relating to size and distance of objects in the universe	3, 11, 12, 13, 20	The students do not have a strong conceptual understanding of the scale of either the Solar System or the Universe. Most students do not have an accurate knowledge of the relative distance between the Earth and the Moon, and many of the students have a disproportionate view of the scale of the Solar System compared with the distances between observable stars.
The Motion category includes seven questions relating to planetary motion, the Moon's phases, seasons, and other phenomena which relate to motion	1, 2, 7, 9, 10, 18, 19	There is significant misconception of the motions of the Earth and Moon. Most of the students are not able to comprehend the concepts of rotation and revolution to positions of the Earth, Moon, Sun, and other stars, and to observation.
The Gravity category includes three questions relating specifically to gravity	4, 6, 14	The students have at least a basic understanding of the concept of gravity and are not able to connect their understanding of gravity to orbital motion. However, the students do not know Newton's Law of Universal Gravitation clearly. Furthermore, the students are not able to connect their understanding of gravity to orbital motion and also the misconception that there is no gravity in space is prevalent.
The General category includes six questions, containing physical science concepts related to astronomy and other astronomical concepts which are not described by the other categories	5, 8, 15, 16, 17, 21	The students do not have an understanding of light and the electromagnetic spectrum and lack of basic astronomy concepts understanding.

E. Never from your current location.

Q2. When the Moon appears to completely cover the Sun (an eclipse), the Moon must be at which phase?

A. Full B. New C. First quarter D. Last quarter E. At no particular phase.

Q3. Imagine that you are building a scale model of the Earth and the Moon. You are going to use a 12-inch basketball to represent the Earth and a 3-inch tennis ball to represent the Moon. To maintain the proper distance scale, about how far from the surface of the basketball should the tennis ball be placed?

A. 4 inches (1/3 foot) B. 6 inches (1/2 foot) C. 36 inches (3 feet) D. 30 feet E. 300 feet

Q4. You have two balls of equal size and smoothness, and you can ignore air resistance. One is heavy, the other much lighter. You hold one in each hand at the same height above the ground. You release them at the same time. What will happen?

A. The heavier one will hit the ground first.
B. They will hit the ground at the same time.
C. The lighter one will hit the ground first.

Q5. How does the speed of radio waves compare to the speed of visible light?

A. Radio waves are much slower.
B. They both travel at the same speed.
C. Radio waves are much faster.

Q6. Astronauts inside the Space Shuttle float around as it orbits the Earth because

A. there is no gravity in space.
B. they are falling in the same way as the Space Shuttle.
C. they are above the Earth's atmosphere.
D. there is less gravity inside the Space Shuttle.
E. more than one of the above.

Q7. Imagine that the Earth's orbit were changed to be a perfect circle about the Sun so that the distance to the Sun never changed. How would this affect the seasons?

A. We would no longer experience a difference between the seasons.

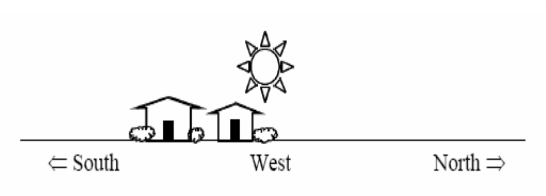
B. We would still experience seasons, but the difference would be much LESS noticeable.
C. We would still experience seasons, but the difference would be much MORE noticeable.
D. We would continue to experience seasons in the same way we do now.

Q8. Where does the Sun's energy come from?

A. The combining of light elements into heavier elements
B. The breaking apart of heavy elements into lighter ones
C. The glow from molten rocks
D. Heat left over from the Big Bang

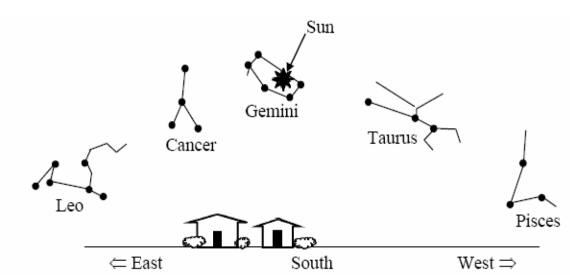
Q9. On about September 22, the Sun sets directly to the west as shown on the diagram below. Where would the Sun appear to set two weeks later?

A. Farther south B. In the same place C. Farther North



Q10. If you could see stars during the day, this is what the sky would look like at noon on a given day. The Sun is near the stars of the constellation Gemini. Near which constellation would you expect the Sun to be located at sunset?

A. Leo B. Cancer C. Gemini D. Taurus E. Pisces



Q11. Compared to the distance to the Moon, how far away is the Space Shuttle (when in space) from the Earth?

A. Very close to the Earth
B. About half way to the Moon
C. Very close to the Moon
D. About twice as far as the Moon

Q12. As viewed from our location, the stars of the Big Dipper can be connected with imaginary lines to form the shape of a pot with a curved handle. To where would you have to travel to first observe a considerable change in the shape formed by these stars?

A. Across the country B. A distant star C. Europe D. Moon. E. Pluto

Q13. Which of the following lists is correctly arranged in order of closest-to-most-distant from the Earth?

A. Stars, Moon, Sun, Pluto
B. Sun, Moon, Pluto, Stars
C. Moon, Sun, Pluto, Stars
D. Moon, Sun, Stars, Pluto
E. Moon, Pluto, Sun, Stars

Q14. Which of the following would make you weigh half as much as you do right now?

A. Take away half of the Earth's atmosphere
B. Double the distance between the Sun and the Earth.
C. Make the Earth spin half as fast.
D. Take away half of the Earth's mass.
E. More than one of the above

Q15. A person is reading a newspaper while standing 5 feet away from a table that has on it an unshaded 100-watt light bulb. Imagine that the table were moved to a distance of 10 feet. How many light bulbs in total would have to be placed on the table to light up the newspaper to the same amount of brightness as before?

A. One bulb. B. Two bulbs. C. Three bulbs. D. Four bulbs. E. More than four bulbs.

Q16. According to modern ideas and observations, what can be said about the location of the center of the Universe?

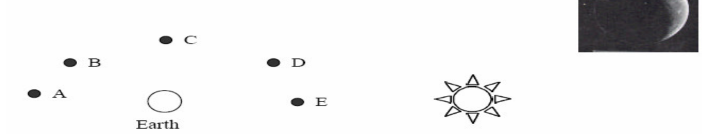
A. The Earth is at the center.
B. The Sun is at the center.
C. The Milky Way Galaxy is at the center.
D. An unknown, distant galaxy is at the center.
E. The Universe does not have a center.

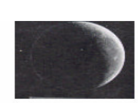
Q17. The hottest stars are what color?

A. Blue B. Orange C. Red D. White E. Yellow

Q18. The diagram below shows the Earth and Sun as well as five different possible positions for the Moon. Which position of the Moon would cause it to appear like the picture at right when viewed from Earth?

A. A B. B C. C D. D E. E





Q19. You observe a full Moon rising in the east. How will it appear in six hours?

A.

B.

C.

D.

Q20. With your arm held straight, your thumb is just wide enough to cover up the Sun. If you were on Saturn, which is 10 times farther from the Sun than the Earth is, what object could you use to just cover up the Sun?

A. Your wrist B. Your thumb C. A pencil D. A strand of spaghetti E. A hair

Q21. Global warming is thought to be caused by the

A. Destruction of the ozone layer. B. Trapping of heat by nitrogen. C. Addition of carbon dioxide.

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