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A cross-age study of junior high school students' conceptions of basic astronomy concepts

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Junior high school students' astronomy conceptions were analysed by means of a written questionnaire presented to them during the beginning of the first semester. The main findings were as follows: almost half of the students indicated that the cause of the day-night cycle is the Earth spinning on its axis; most students chose as their best account for changes in the Moon's phases the Moon moving around the Earth. Despite that, most students thought that the Moon must be in its Full phase for there to be a total solar eclipse; most students underestimated the distances in the Universe and overestimated the Earth's diameter. A great proportion of students indicated that the reason for the different seasons is the tilt of the Earth's axis relative to the plane of its orbit as it revolves around the Sun. But almost the same number of students chose the varying distance between Sun and Earth or between the Earth, Moon and Sun, as a reason for the seasons. Only a third of the students answered correctly that in Israel's latitude, north of the Tropic of Cancer, the Sun is never directly overhead at noon; most students chose the correct estimate of a month for the Moon revolving around the Earth and a year for the Moon going around the Sun; about a third of the students chose the correct answer that when it is noon in Haifa, it would be about sunset in Beijing (90° east of Haifa). Few students indicated that the fact that we always see the same side of the Moon from the Earth implies that the Moon rotates on its axis once a month.

Introduction

Education reformers' attention to the state of school science teaching has been influenced by the public's increasing preoccupation with the apparently falling standards of students' knowledge and understanding of science (Wallace and Louden, 1992). Such developments have appeared in reports from the USA (American Association for the Advancement of Science 1993, National Research Council 1996), Canada (Orpwood and Souque 1985), Australia (Department of Employment, Education and Training 1989), the UK (Secretary of State for Education and Science 1983) Italy (Borghi *et al.* 1991), and Israel (Tomorrow 98 1992).

The Israeli education system is undergoing a long period of changes as a result of the recommendations of the 'Tomorrow 98' Report (1992). Among the reforms proposed by the report are the revision of curricula, including the introduction of a new compulsory and interdisciplinary program called 'Science and Technology' for junior high schools (pupils aged 13 to 15). This programme

> has to emphasize the relationship between science and technology in our modern society, and to provide the learner with the basic knowledge and ways of thinking that characterize these fields in an interdisciplinary context. (1922: 31).

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According to these premises, a programme including seven different topics was written for the three years of junior high school (a total of 540 hours). One of the new topics included in the programme is 'The Earth and the Universe', whose core subject is astronomy.

The limited impact of the reforms made in science teaching over the past two decades in different parts of the world has been the subject of considerable interest. Various explanations have been proposed, such us a lack of time and money (Johns, 1984) and inadequate teaching pedagogy (Stronck, 1986). Wallace and Louden concluded that the reform of classrooms must be understood through the 'view of the central place of teacher's knowledge in teacher's work' (1992: 519). Several recent studies analysing the results of the reforms in science education in American schools have come to the following conclusions (Yager *et al*. 1996, Dana *et al*. 1997, Radford, 1998):

1. Instituting reform in science education requires teachers who are knowledgeable in science content, process, and inquiry pedagogy.
2. Most teachers do not teach reform-based science and need training to be able to do so.
3. Standards for both teaching and learning science must take into account recent research into constructivist theory and its implementation in the classroom.

Young pupils' conceptions of basic astronomy concepts

Understanding the solar system involves a number of related conceptual areas that are clearly of importance in relation to children's existing frameworks. They include an understanding of spatial aspects of the Earth, a conception of day and night, of seasonal change, etc. More than 20 years ago various workers began to examine these very intensively and they have produced a growing body of evidence that throws doubt on the assumption that adults and children are post-Copernican in their notions of planet Earth in space. The research shows that pupils frequently come to their lessons having constructed their own explanations for many of the easily observed astronomical events and that these children's notions are at variance with the accepted view. Early researchers concentrated on elementary school pupils' understanding of the Earth only as a cosmic body (Nussbaum and Novak 1976, Nussbaum 1979, Nussbaum and Sharoni-Dagan 1983, Sneider and Pulos 1983).

Nussbaum and Novak (1976) showed that second-grade (7 and 8 years old) American children's concept of planet Earth in space develops from a naive flat-Earth notion through a series of phases towards the accepted view. In a subsequent study with an Israeli sample (Nussbaum 1979), the characterization of those five notions was revised and refined and their prevalence at different age levels (from 9 to 13 years old students) was studied. Kramer (1977) branched off the original study to investigate junior high school students' conceptions of the 'structure of the universe'. He found that elements of various notions about the Earth still appear in the ninth-graders' more detailed notions about the universe.

Children's concept of the relationship of the Earth and Sun, particularly their understanding of the notion of night and day and the relative sizes of these bodies, were examined by Klein (1982). Second-grade (7 and 8 years old) American children had many different ideas about the Earth and the Sun concepts as assessed in that study. Their answers and explanations ranged from possible examples of precausal thinking, whereby some children believed that the Sun 'hid' at night, to an understanding of the concept of night and day as caused by the Earth's rotation. The majority of children did not demonstrate an understanding of the 'Earth in space' perspective, the rotation of the Earth as the cause of night and day, or the reason for the difference in sunrise times in different geographical locations.

Jones *et al.* (1987) turned their attention to the solar system itself. They investigated elementary school Tasmanian (Australia) children's understanding of the Earth-Sun-Moon system in terms of shape, size and motion of these components. The pupils' spatial models fell into five distinct systems. The first three of these were egocentric Earth-centered models and the last two were Sun-centered models. Furthermore when the pupils did explain that the Earth was spinning, many had no idea of how many times it would spin in a year.

Baxter (1989) surveyed the understanding of basic astronomy concepts among English children in grades four to ten (from 9 to 16 years old students). He broadened his research by investigating pupils' conceptions of the phases of the Moon and the seasons. Most pupils held four alternative notions of the Moon's phases involving an object either obscuring part of the Moon or casting a shadow on its surface (e.g. clouds cover part of the Moon; the shadows of planets or the Sun falls on the Moon). There appeared to be some confusion between a lunar eclipse and the Moon's phases, as the most common notion in all age groups entailed the Earth's shadow being cast on the Moon. Very few pupils held a notion that explained the phases of the Moon in terms of a portion of the illuminated side of the Moon being visible from the Earth.

Young pupils' notions of the cause of the seasons involved near and familiar objects (e.g. cold planets take heat from the Sun; heavy winter clouds stop heat from the Sun; changes in plants cause the seasons). Older children appeared to replace these ideas with notions that involved the astral bodies moving their positions. At first this motion was 'up', 'down' or 'across', later being replaced by orbital motion (e.g. Sun moves to the other side of the Earth to give the summer). The most common notion placed the Sun farther away during the winter, a notion that may have its origins in children's experience of altering their distance from a heat source. Only few pupils explained seasons in terms of the Earth's axis being set at an angle to the Sun's axis.

Although the results of this survey showed a reduction in the more naive views as age increased, misconceptions persisted in many pupils up to 16 years of age, supporting the claim that children's naive concepts frequently pass on into adulthood. This has been confirmed by Durant *et al.* (1989), who quoted the results of two parallel public national surveys, carried out in Britain and in the USA, indicating that only 34% of Britons and 46% of Americans appeared to know that the Earth goes round the Sun once a year. A poll carried out in parallel in France (Acker and Pecker 1988) showed that about 33% of the public still believed that the Sun orbits the Earth.

Vosniadou and her colleagues conducted a series of experiments investigating children and adults' knowledge of observational astronomy. They involved preschool, elementary school, and high-school children, college undergraduates, and illiterate adults (Vosniadou 1987, 1989, 1991, Brewer *et al.* 1988). In addition to studies conducted in the USA, they collected data from children and adults in

India (Samarapungavan *et al*. 1996), Samoa (Brewer *et al*. 1988) and Greece (Vosniadou and Brewer 1990). These studies have provided us with specific information on children's and adults' knowledge of the size, shape, movement, temperature, composition, and location of the Earth, Sun, Moon, and stars, and their explanations of phenomena such as the day-night cycle, the seasons, the phases of the Moon, and the eclipses of the Sun and the Moon. They showed that the majority of children have well defined mental models (Vosniadou, 1992, Vosniadou and Brewer, 1992, 1994). They differentiated three types of models: (a) initial models that are derived from and are consistent with the observations of everyday life, (b) synthetic models that are the attempts to integrate scientific and everyday information, and (c) scientific models that agree with the accepted scientific view.

These studies showed that there are a limited number of mental models of the Earth, the Sun, the Moon and the stars that individuals construct. For example, in the case of the Earth, they showed that many elementary-school children hold one of six mental models. Some think that the Earth is shaped like a rectangle. Others think that the Earth is circular but flat like a disc. A few children think that there are two earths: a flat one in which people live, and a round one that is up in the sky. Others believe that the Earth is a hollow sphere and that people live on flat ground inside it. Finally, some children think that the Earth is flattened at the top and bottom where people live.

A number of different mental models of the day/night cycle have also been identified. Some elementary-school children believe that the Sun's moving down to the ground and hiding behind the mountains causes the change from day to night. Others think that clouds move in front of the Sun and block its light. Some children who have a hollow sphere mental model believe that the day/night cycle is caused by the Sun's moving from the sky, which is located inside the hollow sphere, to outer space, which is located outside the hollow sphere. Children who think that the Earth rotates in an up/down direction and that the Moon and Sun are fixed at opposite sides of the Earth hold one interesting model. They believe that the Moon is fixed in some place of the sky where it is always night; as the Earth rotates in an up/down direction our part of the Earth eventually comes to face the Moon in the night sky.

High-school students' conceptions of basic astronomy concepts

High-school students' conceptions of astronomy concepts have been much less investigated than those of elementary school students. Lightman and Sadler (1993) found that students in grades eight up to twelve (from 13 to 18 years old) shared some of the conceptions held by elementary school children. Though more than 60% of the students held the accepted scientific concept about the day-night cycle, less than 40% knew the correct characteristics of the Moon's revolution. Furthermore, less than 30% of the students had a correct conception about three different subjects: the reason for the change in the Moon's phases, the Sun overhead at noon and an estimation of the Earth's diameter, and only 10% knew the reason for the seasonal changes.

Bisard *et al*. (1994) carried out an interdisciplinary study whose purpose was to investigate and assess suspected science misconceptions held by groups of students ranging from middle school through university. The results of this study showed a correct response rate that steadily increases from middle school (35%) to introductory college students (46%). As expected, students in advanced college classes achieved the highest correct response rate (55%). The correct response rate was slightly lower for science majors in teacher-education classes and was much lower for general education majors. The correct response rate for this latter group was approximately equivalent to middle-school students. This suggests that future general elementary teachers have about as many misconceptions concerning the topics covered in this survey, as do typical middle-school students. Regarding the astronomical topics separately, their findings were as follows:

1. A large number of students answered the questions dealing with the causes of the seasons correctly. This was found surprising as several studies suggested that misconceptions are much more widespread.
2. Students generally performed quite poorly when asked about the Sun's position in the sky at specific times of the day and year.
3. A little less than 40% of all students correctly responded that the different phases of the Moon are caused by reflected sunlight. Consistent with other studies, nearly 60% of students believed that the Earth was some way involved in producing lunar phases, either through the Earth's shadow obscuring portions of the Moon or by sunlight reflecting off the Earth and clouds.

Since there is very little information in literature about junior high-school students' astronomy conceptions, I decided to investigate them in order to: (a) compare their performance with that of elementary school students, (b) widen the range of conceptions investigated, and (c) analyse the most widespread misconceptions. In the following sections I present the result of a cross-age study analysing junior high-school students' conceptions of basic astronomy concepts.

A cross-age study

Participants in the present study were drawn from two rural regional schools in Israel that had not yet began to implement any of the Tomorrow 98 (1992) reforms and had not had any formal astronomy instruction. All the students studying in these schools participated in the study, and I analysed the responses of those who answered at least 75% of the questions presented to them, namely 448 students (154 students aged 13 in grade seven, 152 students aged 14 in grade eight, and 142 students aged 15 in grade nine). The sample included 244 girls and 204 boys.

In junior high school in Israel the Physics topics are compulsory for all students. In seventh grade the topic taught is the Particulate State of Matter; in eighth grade there are two main topics taught: (a) Heat and Temperature and (b) Basic electric circuits. In ninth grade there are also two main topics: (a) Mass, Force and Weight and (b) Transformation and Conservation of Energy.

The astronomy conceptions of the students were analysed by means of a written questionnaire presented to them during the beginning of the first semester, that was about six months after a partial solar eclipse was observed in Israel. The questionnaire contained 16 questions taken from three different sources: Zeilik *et al.* (1998), Lightman and Sadler (1993), and Bisard *et al.* (1994). Five experts in physics education research and three experienced lecturers in 'Introduction to Astronomy' courses judged the content validity of the questionnaire. After making some minor changes as suggested by the judges, the test (given in the Appendix) was deemed valid. The reliability of the test was measured by calculating the Kuder-Richardson 20 coefficient getting an estimate of 0.49, a relatively high score considering the fact that different questions in the test were related to different astronomy concepts and understandings, as may be seen in the question-by-question analysis in the following section.

The overall correct response rate was 36.4%, increasing somewhat through the three years, from 33.6% in grade seven to 39.2% in grade nine. However, a statistically significant difference was found only when comparing the results of the seventh and ninth grade students ($t = 1.97$, p-value $= 0.05$). Boys scored significantly better (38.7%) than girls (34.6%) [$t = 3.08$, p-value $= 0.002$]. Students that have studied previously some out-of-school astronomy course (20% of the whole sample), performed significantly better (43.5% success) than their colleagues [$t = 4.23$, p-value $= 0.0001$].

Question-by-question analysis

Question 1 (day-night cycle)

Almost half of the students answered correctly, indicating that the cause of the day-night cycle is the Earth spinning on its axis. Thirty-six percent of the students pointed out that the cause of the day-night cycle is that the Earth moves around the Sun, and another 11% indicated that *the Sun's movement around the Earth* is the correct answer. This is a poor performance compared to the result reported by Lightman and Sadler (1993) with senior high-school students (65% success).

Question 2 (Moon phases)

Most students (52%) answered correctly, choosing their best account for change in the Moon's phases as the Moon moving around the Earth. This is a better result than that obtained by Lightman and Sadler (1993) and by Bisard *et al.* (1994) with introductory and advanced college students (40%). However, I found a considerable number of students who misunderstood the role of the Earth and the Sun in the cause of change in the Moon's phases. Nineteen percent of the students believed that the Earth is involved in producing lunar phases through the Earth's shadow obscuring portions of the Moon and 25% believed that the Moon moves into the Sun's shadow. For a considerable number of students there appeared to be some confusion between a lunar eclipse and the Moon's phases.

Questions 3, 5 and 16 (dimensions and distances)

This was one of the weakest areas of students' knowledge. Only 20% of the students answered correctly when asked to give an estimate of the distance between the Sun and the Earth, and 18% appraised correctly the distance between the Sun and a close star. In both cases they underestimated the distances in Universe. By contrast, a great majority of the students overestimated the Earth's diameter (91%), while only 8% answered it correctly. These results may indicate some consistent geocentric bias in students' awareness of Earth's dimension compared with the distances in Universe.

Questions 6, 14 and 15 (seasons)

The largest proportion of students (46%) answered question 14 correctly, indicating that the reason for the different seasons we experience every year is the tilt of the Earth's axis relative to the plane of its orbit as it revolves around the Sun. Almost the same number of students (45%) chose the varying distance between Sun and Earth or between the Earth, Moon and Sun, as a reason for the seasons changes.

Only 36% of the students chose in question 6 the same argument as in question 14 as the main reason why it is hotter in the summer than in the winter, and only 20% answered both questions correctly.

Question 15 served to verify the consistency of responses to questions 6 and 14. If one incorrectly believes that Earth-Sun distance causes seasons, it follows that both hemispheres would experience the same season at the same time. Australia's longest day would, therefore, correspond to that of the Northern Hemisphere. Only 28% of students correctly selected December as the time of year a Southern Hemisphere location receives the longest period of daylight and only 6% of the students answered the three questions correctly.

Question 4 (Sun overhead at noon)

Only 32% of the students answered correctly that in Israel's latitude, north of the Tropic of Cancer, the Sun is never directly overhead at noon. Almost the same number of students (35%) believed that it is directly overhead every day. Maybe this arises from the widespread everyday meaning of noon ('the middle of the day'). This result is almost the same to that reported by Lightman and Sadler with senior high-school students.

Question 7 (relative distances of spatial objects from Earth)

Only 36% of the students answered this question correctly, positioning the Moon as the closest object to and the stars as the farthest objects from Earth, with planet Pluto between them. Thirty-eight percent of the students put Pluto behind the stars, and another 13% put the stars as the closest objects to Earth. This result shows that many students were guided in their answers by their seeing the stars at every night, not realizing they may be larger or brighter, but farther away.

Questions 8 and 9 (Moon's revolution)

Most students chose the correct estimate of a month for the Moon revolving around the Earth (58%) and a year for the Moon going around the Sun (52%). Forty-two percent of the students answered the two questions correctly. Some of the students claimed that the Moon only revolves around the Earth and not around the Sun, without understanding the meaning of a relative movement. This is a better result than that reported by Lightman and Sadler (1993) with senior high-school students.

Question 10 (*time zones*)

The largest proportion of students (35%) chose the correct answer, namely that when it is noon in Haifa it will be about sunset in Beijing (90° east of Haifa). Another 37% of the students thought that this longitude difference would result in a greater difference in time between the two cities, but in the right direction. This is a similar result to that reported by Lightman and Sadler (1993).

Question 11 (*solar eclipse*)

Only 18% of the students answered correctly that in order to have a total solar eclipse, the Moon must be in its New phase (unseen from the Earth). The answer chosen by the great majority of the students (74%) was the Moon must be in its Full phase in order to get a total solar eclipse. This is a discouraging result, considering that more than half of the students correctly answered question 2 concerning the reasons for the change in Moon's phases. The partial solar eclipse that was observed in Israel about six months before the questionnaire was presented to the students may have influenced students' responses.

Question 12 (*Moon's rotation*)

Only 25% of the students got the right answer, indicating that the fact that we always see the same side of the Moon from the Earth implies that the Moon rotates on its axis once a month. Zeilik *et al*. (1998) reported a much poorer result among university students (10% success). The answer chosen by the largest proportion of students (54%) was that the Moon does not rotate on its axis.

Question 13 (*centre of Universe*)

Most students (56%) correctly answered that according to current theories the Universe does not have a centre in space. Twenty- four percent chose the Sun, and 11% the Milky Way Galaxy to be at the centre of the Universe.

Discussion and educational implications

The research outlined above has shown that there is a serious discrepancy between junior high school students' conceptions of some basic astronomy concepts and the corresponding accepted scientific view. If these concepts are to be used properly in the classroom, every effort must be made to help students develop their understanding.

From the constructivist perspective, humans in general are seen as subjects who actively construct understanding from experiences using their already existing frameworks (Wubbels 1992). People continuously build their personal theories; accordingly, students enter science education with knowledge and attitudes that are deeply rooted in experience. They act as strong frameworks to interpret things that happen in classrooms and they help people to interact with their environment.

That is, students do have some ideas about most physics concepts in the syllabuses, though some of these ideas may well differ from the accepted ones.

If courses are to succeed, they need to take account of these prior ideas. As Millar (1988) argues:

> For each topic, a starting point is to elicit (students') current ideas and understandings about the topic. On the basis of this, they can be directed to carefully chosen readings and practical activities, designed specifically to challenge or deepen existing ideas. (1998: 51)

The key aspects of constructivism that should influence the materials for developing student teachers' understanding, can be expressed as the need:

a. to have knowledge of students' existing understanding in the targeted conceptual areas and to use this as a starting point for the design of appropriate teaching materials;
b. for students to become aware of their own views and uncertainties;
c. for students to be confronted, afterwards, with the currently accepted concepts;
d. to provide experiences that will help students to change their views and conceptions, and accept the scientific view;

However, it has already been observed that conceptual change is:

> only rarely a sharp exchange of one set of meanings for another, and is more often an accretion of information and instances that the learner uses to sort out contexts in which it is profitable to use one form of explanation or another (Fensham *et al.* 1994: 6).

Moreover, conceptual change involves the learner recognizing his/her existing ideas and then deciding whether or not to reconstruct them (Gunstone and Northfield 1992). This description clearly places the direct responsibility for conceptual change with the learner. Obviously, major demands are made of the teacher to provide contexts wherein the learner is more likely to undertake these weighty tasks. This links with metacognition, whose importance may be illustrated by negative cases where the context provided by the teacher cannot have any impact on conceptual change because of existing ideas and beliefs about learning held by the learners (Gunstone 1994).

For example, a conceptually centered astronomy course with actively engaged students might be planned (Bisard and Zeilik 1998). Key astronomical concepts may be organized into goal clusters: motions, distances, light and scientific models. Teaching strategies and assessment instruments may be developed to engage the students more actively with connected concepts and to assess the effects of such instruction upon the students' conceptual learning. For instance, after verbal instruction regarding the connection about different concepts, concept maps may be used as organizers for each major set of concepts. Students may be organized into teams either randomly or in dedicated groups, following a format of accepted cooperative learning strategies. Some of the possible activities, including a process of prediction, observation, discussion and conclusions, are:

a. Follow-up after the position of the sun in heavens from sunrise to sunset, by means of a transparent half-sphere shaped dome.
b. Follow up after the exact position and time of sunset for a period of several months.

c. Measurement of the Sun diameter by means of a pierced aluminum sheet and a common white sheet at a fixed known distance (using triangle similarity).
d. Construction of a model including a bright lamp (Sun), a tennis ball (Earth) and a ping-pong ball (Moon) in order to simulate the day-night cycle, the lunar phases and the relative motions between Sun, Earth and Moon.

Furthermore, night-sky observations, videotaped films, computerized simulations and the many existing Internet resources may be used following the same instruction principles stated above.

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Appendix 1: questionnaire—the Earth and the Universe

1. What causes night and day?
A. The Earth spins on its axis.√
B. The Earth moves around the Sun.
C. Clouds block out the Sun's light.
D. The Earth moves into and out of the Sun's shadow.
E. The Sun goes around the Earth.

2. The diagrams here show how the Moon appeared one night, and then how it appeared a few nights later. What do you think best describes the reason for the change in the Moon's appearance?

3. If you used a basketball to represent the Sun, about how far away would you put a scale model of the Earth?
A. 30 cm or less. B. 1.5 meters. C. 3 meters. D. 7.5 meters. E. 30 meters.

4. As seen from your home, when is the Sun directly overhead at noon (so that no shadows are cast)?
A. Every day.
B. On the day of the summer solstice.
C. On the day of the winter solstice.
D. At both of the equinoxes (spring and fall).
E. Never from the latitude of your home. √

5. Give the best estimate of the Earth's diameter from among the following numbers:
A. 1,500 km. B. 15,000 km.√ C. 150,000 km. D. 1,500,000 km. E. 15,000,000 km.

6. The main reason that it is hotter in the summer than the winter is that
A. The Earth is closer to the Sun in summer.
B. The Earth is farther from the Sun in summer.
C. The Earth's rotational axis flips back and forth as the Earth moves around the Sun.
D. The Earth's axis points to the same direction relative to the stars, which is tilted relative to the plane of its orbit. √
E. The Sun gives off more energy in the summer than in the winter.

7. Which of the following lists shows a sequence of objects that are closest to the Earth to those that are farthest away?
A. Moon — Stars — Pluto. B. Pluto — Moon — Stars.
C. Stars — Moon — Pluto. D. Stars — Pluto — Moon.
E. Moon — Pluto — Stars. √

Choose your best estimates of the times for the events listed. Choices may be used more than once.

8. The Moon to go around the Earth: A. Hour. B. Day. C. Week. D. Month.√ E. Year.

9. The Moon to go around the Sun: A. Hour. B. Day. C. Week. D. Month. E. Year.√

10. Beijing is 90° east of Haifa. If it is noon in Haifa, in Beijing it would be about:
A. Sunrise. B. Sunset. (C. Noon. D. Midnight. E. Noon the next day.

11. In order to have a total Solar eclipse, the Moon must be at what phase?
A. Full. B. New. √ C. First quarter. D. Last quarter.

12. When you observe the Moon from the Earth, you always see the same side. This observation implies that the Moon.
A. Does not rotate on its axis. B. Rotates on its axis once a day. C. Rotates on its axis once a month. √

13. According to modern ideas and observations, which of the following statements is correct?
A. The Earth is at the center of the Universe.
B. The Sun is at the center of the Universe.
C. The Milky Way Galaxy is at the center of the Universe.
D. The Universe does not have a center in space. √

14. The different seasons that we experience every year are due to:
A. The varying distance between the Sun and the Earth.
B. The varying distances between the Earth, Moon and Sun.
C. The tilt of the Earth's axis as it revolves around the Sun. √
D. Varying degrees of atmospheric pollution which dilute the Sun's rays.

15. When is the longest daylight period in Australia?
A. March. B. June. C. September. D. December. √

16. Two grapes would make a good scale model of the Sun and a close star, if separated by
A. 0.5 meter. B. 1 meter. C. 100 meters. D. 1.5 kilometer. E. 150 kilometers. √