



Pre-service Primary Teachers' Ideas about Lunar Phases

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ABSTRACT

The purpose of this study was to explore pre-service primary teachers' ideas about how lunar phases occur. 154 third year primary student teachers were asked to explain "why the moon is seen in different shapes when we look at the sky at different times". They have given enough time to explain their answers in writing. Then, their responses were examined and categorized as scientific explanations and misconceptions. Results of the study showed that while the 54 % of the student teachers' ideas about the lunar phases are scientific, the remaining 46 % of them could be categorized as misconceptions. Some of the misconceptions detected from the student teachers' explanations of the causes of the moon phases are: earth's shadow on the moon, earth's rotation or varying distance between the earth and the moon. The study revealed similar results with the previous studies conducted in other cultures.

Keywords: Pre-Service Primary Teachers; Misconceptions; Moon Phases.

INTRODUCTION

Expertise in subject matter is one of the most important competencies pre-service teachers should gain during their preparation. Pre-service teachers' conceptions of the subjects that they will be teaching in their future classrooms should be scientifically acceptable so that they can teach them accurately. Subject matter knowledge affects teachers' way of teaching, planning, questioning, and constructing activities, facilitating student understanding and the like (Schulman, 1986; Osborne & Simon, 1996). For this reason, studies focusing on pre-service teachers' understanding of certain subjects are exceptionally important. This research aimed to explore pre-service teachers' conceptions about moon phases which is a topic covered in fifth grade science curriculum in Turkey.

Conceptualizing what causes moon phases requires a highly complex thinking. First of all, students should know the rotating and revolving motions of the moon and the earth and their relative positions to the sun while they move. Second, they should know that the moon is lit by the sun and we can see only the illuminated portion of the moon by the sun. And that this illuminated portion differs in shape as the position of the earth and the moon system changes relative to the Sun. To make a sound understanding of the cause of lunar phases, students should synthesize all these information, and be able to construct a three dimensional image of this trio and their relative motions in their minds.

Understanding of the lunar phases has been the subject of much research in the past. Black (2004) noted that “moon phases, an astronomical phenomenon involving movement of a half-lit body in space viewed from the unavoidable fixed position of Earth observers,” was one of the most difficult of the concepts for university students responding to an Earth science questionnaire (cited by Mulholland & Ginns, 2008). Various researches about students’ understanding of what causes the moon phases indicated that most primary and secondary students held misconceptions. For example, Stahly et al. (1999) investigated 21 third grade students’ conceptions about the lunar phases by employing qualitative research methods. They focused specifically on four students’ understandings in the group. They explored students’ understanding through their oral and written responses to interview questions, drawing and building 3 dimensional models during interview. Pre- instructional interviews revealed that students held very divergent ideas about the cause of the lunar phases as well as scientific conceptions. For example, some students believed that shape of the moon was related to the area of it which was not covered by clouds. Some believed that observer’s location on the earth determines the shape of the moon, and moon phases could be observed at any time no matter what relative positions of the moon, the earth and the sun.

Bisard et al. (1994) investigated middle school through university students’ understanding of some astronomical concepts. Their study showed that only 40 % of the students knew that the moon phases were due to the reflected sun light from the moon. Trumper (2001a) studied understanding of basic astronomical concepts of a wide range of students at high school and university level in Israel. The researcher concluded that from junior high school through university, students have particular misconceptions about the moon phases. Results of the study revealed that 19 % of junior high school students, % 27 of pre-service elementary school teachers, 16% of pre-service high school teachers and 25% of nonscience major university students believed that the cause of the moon phases is the shadow of earth falling on the moon. Trumper (2001b) conducted another study to investigate Israeli junior high school students’ understanding of some astronomical phenomena with a total of 448 seventh through eight grade students by using a questionnaire. The research showed that 19 % of the students believed that lunar phases occurs due to the Earth’s shadow obscuring portions of the moon and 25 % of the students believed that the Moon moves into the Sun’s shadow.

Barnett and Morran (2002) investigated the effect of project-based learning on fifth grade students’ understanding about the phases of the Moon and eclipses. Students’ answers to pre-instructional interviews showed that majority of fifth grade students explained moon phases in the same way they explain the lunar and solar eclipses. Using a multiple choice instrument, Schoon (1992) found that the eclipse explanation was selected by 48% of the participants. Two additional studies (Sadler, 1987; Bisard et al., 1994) found that 38% and 37% of the participants respectively agreed with the eclipse explanation.

Studies involving pre-service teachers also found that the eclipse notion was the most frequently given response for the cause of the lunar phase (Callison & Wright, 1993; Dai & Capie, 1990; Schoon, 1995). Collision and Wright (1993)’s study revealed that only % 6 of the subjects (76 pre-service elementary teachers) held scientific understanding of the moon phases before instruction. Schoon (1995) found that only % 18 of the subjects (122 elementary pre-service teachers) held scientific conceptions.

Suzuki (2003), who documented conversations that occurred during science classes for preservice teachers, also found that the ecliptic explanation was prevalent. She attributed this, in part, to the publicity given to the Moon during a lunar eclipse. Other difficulties in understanding Lunar phases, that are documented in research literature, are

inability to appreciate the scale of the Sun–Earth–Moon system (Fanetti, 2001), the struggle to develop mental models to explain Sun–Earth–Moon relationships due to the level of reasoning and spatial ability required (Callison & Wright, 1993), and inability to work from a perspective other than that of an observer on Earth (Suzuki, 2003).

Trundle, Atwood and Christopher (2002) investigated pre-service elementary teachers' understanding of moon phases. The researchers collected data from 78 pre-service elementary teachers through qualitative research methods such as classroom observations, document analysis and structured interviews before and after instruction. Instructional process included moon observations, group discussions about the moon observations and utilization of physical models. They found that before the instruction only about 10% of the students held scientific understanding of the lunar phases, whereas this rate increased up to 93.7% after the instruction. Before the instruction teachers mostly held eclipse (23%) and earth rotation on its axis (7.6%) misconceptions. Trundle, Atwood and Christopher (2007), using the same instructional approach replicated this study with 48 fourth-grade students. Pre-instructional interviews showed that these students have not reached the goals expressed in the U.S. Science Education Standards for lunar concepts. However, results of the study showed that the instructional approach followed in the study is effective for primary students as well as pre-service teachers in conceptualizing the cause of moon phases.

All studies cited here reported that majority of pre-service teachers held misconceptions about the moon phases. Only study reporting a different result is performed by Ogan-Bekiroglu (2007). The result of the study, which investigated 36 Turkish pre-service physics teachers' conceptions of the moon, moon phases and other lunar phenomena, showed that all but one pre-service teacher participated in the study held scientific conceptions. The researcher stated that the discrepancy between her findings and findings from other research studies investigating the same topic might be related to the subjects' major. Her subjects were majoring in physics education whereas other studies were conducted with pre-service elementary teachers.

Although several studies documenting pre-service teachers' understanding of the lunar phases exist, they were mostly done in the US. Seeing the situation in different cultures might help to make more confident generalizations. This study aimed to examine pre-service primary teachers' understanding of moon phases in Turkey.

Theoretical framework of this study based on the constructivist theory which proposes that learners construct knowledge in their minds by relating new information to preexisting mental structures. Students' pre-existing knowledge can influence their new learning's. Often, these student preconceptions are not congruent with scientifically accepted ones. Such ideas termed as "misconceptions" or "alternative conceptions" are resistant to change, primarily due to the complexity of students' mental structures. Not only must students address and change their particular alternate conceptions, but—since alternative conceptions are highly integrated with other conceptions—they may also need to restructure entire schemas.

METHODOLOGY

a) Sample

The subjects of this study were 154 pre-service primary school teachers. They were at their third year of study at the Faculty of Education. Pre-service classroom teachers take basic science classes such as physics, chemistry and biology in their second year at the faculty. However, curriculum content does not contain a part specifically focusing on how lunar phases occur and such astronomical concepts. All they know about the subject might be based on the knowledge they acquired in their elementary school years. The study was

conducted as a part of Science Teaching Methods course which is a third year course in Primary Education program. The course content include topics such as examination of primary science curriculum, science teaching methods, planning and evaluating science classes, students' misconceptions about specific science topics and methods of overcoming them. Furthermore, the pre-service teachers practice student teaching in numerous topics included in primary science content. This study is conducted prior to teaching of lunar phases.

b) Data Collection

This research is descriptive in nature. Qualitative research method was used to characterize participants' conceptions of lunar phases and their cause. Student teachers' written responses to an open ended question were utilized to realize this goal. Student teachers were asked to explain "why the moon is seen in different shapes at different times when we look at the sky". In order to make the question clearer for the student teachers the following explanation was made by the researcher: "You probably have noticed that the moon does not always look the same. Sometimes we have what we call a full moon, and at other times the moon is not full. The different appearances of the moon are called moon phases. What do you think causes the phases of the moon?" Student teachers were given enough time to explain their answers in writing as detailed as possible.

c) Data Analysis

The data analysis system used in this study was developed by Trundle and her colleagues (Trundle et al., 2002). By using the information obtained from previous research (Targan, 1988; Callison & Wright, 1993; Stahly et al., 1999) the researchers identified the criteria used to describe a scientific understanding and possible alternative conceptions that participants might have. This information was then used to develop a "partial framework" (Glaser & Strauss, 1967, p. 45). The partial framework and field notes, which included ideas about data analysis and coding, were used to design the coding sheet and the coding system. (Trundle et al., 2002). The coding sheet facilitated analysis and helped standardize coding among researchers. In the current study, these coding sheets and the coding system was used to analyze each student teacher's written explanation.

The codes key is shown in Table 1. It should be noted that the codes key was used to provide coding guidelines, but it was not allowed to restrict the coding process. New codes that emerged during analysis were added to the original coding system such as "varying distance", "geographical differences" and "clouds". However the number of student teachers whose responses under these categories were small so they were categorized as AltOthers.

Table 1. Codes key

| Code | Meaning of Code |
|-----------|---|
| SciOrb | Moon orbits earth. |
| SciHalf | Half of moon illuminated that half toward the sun. |
| SciSee | Part of the illuminated half we see determines phase. |
| SciEMS | Relative positions of earth, sun, and moon determine the part we see. |
| AltEcl | Dark part of moon in earth's shadow; phases caused by earth's shadow. |
| AltRot | Earth's rotation on axis causes phases. |
| AltOthers | Reason other than any of above given. Provide description and add to coding system. |

By using the above coding system student teachers conceptualizations were categorized according to following criteria (Table 2.).

Table 2. Types of conceptual understandings and criteria

| Categories of Conceptual Understandings | Criteria |
|---|--|
| Scientific | All 4 scientific critical elements included (SciOrb + SciHalf+SciSee +SciEMS) |
| Scientific Fragments | Included a subset but not all of the 4 scientific critical elements. |
| Scientific with Alternative | Included scientific elements plus an alternative conceptual understanding Sci(W)ecl (scientific conception with eclipse misconception) Sci(W)rot (scientific conception with earth's rotation misconception) |
| Alternative Conceptual Understandings (Misconceptions) | Included a subset or subsets of alternative conceptual understandings. AltRot (Earth's rotation) AltEcl (Eclipse) AltOthers |

FINDINGS

Results of the study revealed that majority of pre-service teachers explained the reason why the moon looks different at different times accurately. However, a considerable number of the teachers held misconceptions which were then categorized into specific misconceptions: Earths' shadow falling on the moon (eclipse explanation) and earth's rotation. There were other explanations which were not common as these two misconceptions. These are: clouds, varying amount of light from the sun, varying distance between the sun and earth, planets' shadow, and some other answers that cannot be categorized. Some students' explanations included both scientific conception and misconception. Some explanations included more than one misconception and some that cannot be categorized (See figure 1. for the proportions of students who held certain conceptions).

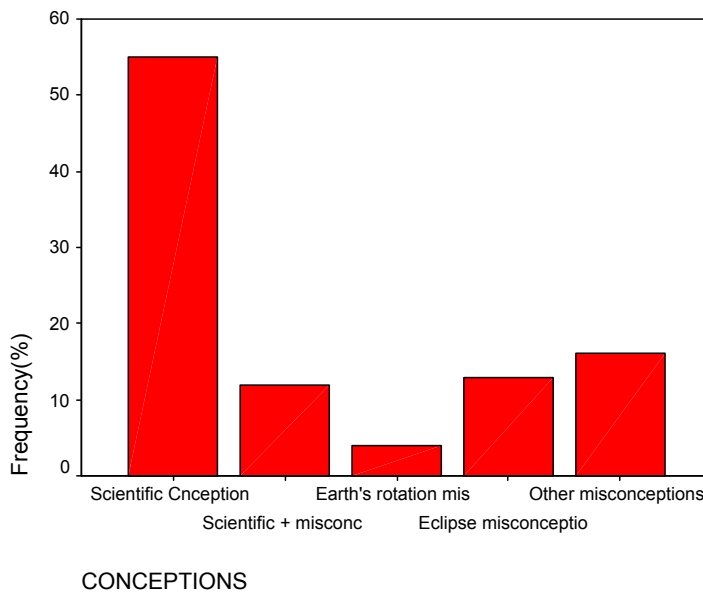


Figure 1. Frequency of student teachers by conception types

In the following sections the categories are described and specific examples of students written explanations are given for each category.

Scientific Conceptions

Explanations including the following phenomena are categorized as scientific conceptions: the moon's and the earth's motions relative to the sun; the illuminated parts of the moon is seen from the earth ; and illuminated portion differs in shape as the position of the earth and the moon system changes relative to the Sun categorized as scientific conceptions. Eighty four (% 54.5) of the 154 student teachers held scientific conceptions.

"We see the moon in different shapes due to the positions of the moon, the earth and the sun. Because the moon reflects the light which it receives from the sun, we see the parts of the moon which receives light from the sun." (Use different code for each student teacher and show it here, for instance, (ST 1).

"The moon gets its' light from the sun. Due to the motion of the moon around the earth, the angle of the sun light coming to the moon changes and different parts of the moon are lit, that's why we see different moon shapes at different times." (ST 5)

"The earth revolves around the sun. The moon revolves around the earth. As they revolve around each others, they come to different positions (relative to each other). Because the moon's different areas lit by the sun, when it is at these different positions it is seen in different shapes." (ST 47)

"It depends on the sun light becomes effective in some areas or not due to the revolution of the moon around the earth. The area lit by the sun is seen bright and the area that is not lit by the sun is seen dark." (Use different code for each student teacher and show it here, for instance, (ST 56).

"The moon revolves around the Earth. At the same period it rotates on its axis. That is why we always see its same face. However, sun lights fall on different parts of the moon. Depending on what parts getting light from the sun we can see different shapes of the moon." (ST 57)

Scientific conceptions with eclipse misconception

Explanations including scientific explanation with eclipse misconception which is the idea that the shadow of the earth falling on the moon determines the shape of the moon. Twenty one (% 13.6) of the 154 answers included the misconception of eclipse with the scientific explanation.

"It is due to the moon's revolution around the earth. Because the moon reflects the light coming from the sun, when the earth comes between the moon and the sun in different positions, it blocks the sun light, and we can't see that part of the moon blocked by the earth." (ST 36)

It is related to the position of the earth. That is, the positions of the moon, sun, and the earth's relative to each other changes the shape of the moon seen from

the earth. The reason is for that the shadow of the earth falling on the moon. (ST 67)

This occurs as a result of the path the earth and the moon follow around the sun. When the earth come between the sun and the moon, it occurs because of the earth's revolving around the sun. When the earth fully blocks the moon that is when the moon does not see the sun, moon becomes fully dark and we cannot see it at all. This shape changes as the earth revolves. (ST 116)

The moon always revolves around the sun. During the revolution the moon reflects the light it receives from the sun to the earth. When the earth comes between the moon and the sun, the sun's light cannot be fully reflected to the earth. For this reason the moon is seen in different shapes (ST 123)

The earth revolves around the sun. The moon also revolves around the sun together with the earth. These revolutions occur on particular orbits. During these revolutions the moon sometimes comes between the earth and the sun, sometimes stays behind the earth's sun facing side. During these occurrences the parts lit by the sun becomes bright and the parts that the earth's shadow falls becomes dark. The moon's shapes occur this way. (ST 137)

The part of the moon that receives light from the sun is seen bright. The parts that the earth's shadow falls cannot be seen. Sometimes it can be seen as full moon because all parts of it can receive light from the sun. (ST 151)

Scientific conception with Earth's rotation misconception

Earth's rotation misconception is the idea that the cause of the moon phases is the rotation of the earth on its axis. Two (%1.3) of 154 answers included earth rotation misconception with the scientific explanation.

It is related to the earth's position. The moon, which is the satellite of the earth, locates at different positions and different viewpoints. The earth's rotating on its axis and revolving around the sun causes the different shapes of the moon. (ST 12)

Because of the earth's rotating on its axis and the revolving around the sun, some parts of the moon do not receive lights from the sun. (ST 132)

Eclipse misconception

The explanations indicating that the cause of the reason is earth's shadow fall on the moon is the cause of the moon phases. 20 (% 13) of the 154 pre-service teachers indicated eclipse explanation.

The earth is one of the planets that revolve around the sun. The reason that we see the moon in different shapes is the earth's coming between the earth and the sun. (ST 21)

The moon is seen in different shapes because the earth's shadow falls on the moon in different shapes. (ST 35)

Due to the earth's motion, the earth comes in the way of the moon blocking its different parts. That's why we see different shapes of the moon. (ST 56)

The earth's shadow falls on the moon. Depending on what position it falls, the moon's shape seen from the earth changes. (ST 71)

The earth's shadow falls on the moon. If the shadow falls on the half of it, it becomes half moon. If no shadow on the moon, it becomes full moon. If it falls on a part bigger than the half, it becomes crescent. (ST 72)

The earth comes in the way between the moon and the sun and this event occurs in different shapes at different times. For this reason, some times a part of the moon is seen dark, sometimes all dark and sometimes all bright. (ST 86)

Earth's Rotation Misconception

Six (% 3.9) of 154 pre-service teachers indicated earth rotation explanation only.

The moon is seen in different shapes because of the earth's rotation. Weather conditions have an effect too. (ST 79)

Because of the earth's rotation on its axis and the revolution around the moon we see the different shapes of the moon. (ST 83)

The earth's rotation on its axis causes the different shapes of the moon. (ST 84)

It is related to the earth's motion. Changes occur as a result of the earth's rotation on its axis and revolving around the sun. The moon's position relative to the earth changes as the earth rotates around its axis. As a result of this, the phases of the moon occur such as crescent, half moon, and full moon. (ST 97)

Other misconceptions

The pre-service teachers held some other misconceptions that are not so common. These are: clouds, varying distance between earth and moon, varying amount of light.

Clouds cause the different shapes of the moon. (clouds)(ST 66)

It depends on the light the moon receives from the moon. When it receives the most amount of light it is seen as full moon. (Differing amount of light) (ST 74)

The moon cannot always receive the same light from the earth. It receives different amount of light at different dates and it repeats this between certain dates (Differing amount of light). (ST 93)

Because the moon is the satellite of the earth it always revolves around the sun. As this revolution is going on different angles occurs. The distance between the earth and the sun also affects the shape of the moon (varying distance). (ST 148)

The moon revolves around the earth. It is seen from the world's different parts in different angles and different shapes. If it is at the nearest point to earth, seen as full moon, and if it is at the farthest place it is seen as crescent. Some times it cannot be seen at all (varying distance). (ST 149)

The reason is that as the moon rotating on its axis and revolving around the sun the light coming from the sun reach to the moon differently. Different shapes of the moon occur because as the light coming from the sun travels through the earth some planets come in the way and block the light (planets). (ST 151)

We cannot see the moon if the moon is at the opposite side related to our position. We can see the moon clearer depending on its distance from us (varying distance). (ST 154)

Explanations including more than one misconception

Four of the explanations included more than one of the above mentioned misconceptions.

The reason for this is the rotation of the earth on its axis (Earth rotation). Some times the moon comes between sun and the earth. Some times the earth comes between the sun and the moon (eclipse). These events results in different shapes of the moon seen from the earth. (ST 17)

The moon seen in different shapes in different counties on the world because of their geographical positions, the sun and the earths' motion and the weather conditions are also effective (ST 19)

The Earth's rotation on its axis, the moon's motion, geographical differences. The reason for different shapes of the moon is the motions of the earth (earth's rotation). Not seeing the moon at all might be because of the clouds (clouds). (ST 47)

CONCLUSIONS and IMPLICATIONS

The results of the study showed that nearly % 45 of the student teachers held specific misconceptions about the lunar phases. The most common misconceptions are the ideas that: earth's shadow (eclipse) on the moon causes the lunar phases (% 26.6), earth rotation causes the lunar phases (% 5.2). There are other misconceptions detected in this study which possessed by very few students as well. The misconceptions detected by the present study are similar to other studies related to the same topic. For example, Schoon (1995) found that % 62.3 of elementary pre-service teachers held eclipse (earth's shadow on the moon) as their conceptual understanding, while only % 18 held scientific

conceptions of what causes moon phases. Kallery and Psillos (2001) investigated pre-school teachers' conceptions about the moon phases. Their study also revealed that about % 60 of their subjects' conceptions are not scientific and the most commonly held misconception about the moon phases is that the earth's shadow on the moon causes the moon phases. Similar results were reported by other researchers exploring pre-service teachers' conceptions about the same topic (Dai & Capie, 1990; Trundle et al., 2002).

This research tried to reveal student-teachers' conceptions about the cause of the moon phases. To some extent this goal has been achieved. However, the instrument used to examine their conceptions has its limitations. Had the researcher have a chance to make one-on-one interviews with the student teachers, the exact reason behind their difficulties conceptualizing the cause of moon phases could have been explicit. Nevertheless, this research shed light on an important issue in the sense that misconceptions or conceptions of a certain phenomena are independent of culture in a large extent since it has showed that the misconceptions about moon phases are similar worldwide. Of course there are minor differences in the proportions of students' holding certain misconceptions. This might be due to the differences in previous instruction received about the phenomena and the spatial ability levels of the investigated samples. The researcher believes that majority of students would have "eclipse" or "earth's rotation" misconceptions if they had not received any instruction specifically designed for the investigated astronomical phenomena. It is very reasonable for persons to conceptualize the moon phases similar to eclipse phenomena if they had no idea about the sizes of the astronomical objects, type of their motions, tilt of their orbits, and the distances between them. It is also not an easy task to visualize which parts of the moon could be seen for an observer on the earth even the students have all these required information at hand. However, this same task might not be so difficult for student teachers who are at high spatial ability level. Studies investigating the effect of spatial ability level on conceptualization of the moon phases should be conducted to see if this hypothesis is verified.

In summary, the current study detected that pre-service teachers' conceptions about the moon phases are not at the desired level. If all pre-service teachers were to teach at primary school in the near future, not only some of them but all of them should gain accurate understanding of the concepts which they will be teaching in their future classrooms. Their knowledge about specific topics in science should be assessed and if they have misconceptions, they should be solved before they start to teach in schools.

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