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Primary School Students' Ideas Concerning the Apparent Movement of the Moon

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Abstract

In the present study, primary school students' ideas concerning the apparent movement of the Moon are investigated. The research was carried out in five primary schools of Athens (Greece) with a sample of forty (40), fifth and sixth grade students. Semistructured interviews were used to gather scientific data and students had the opportunity to provide their answers either orally and/or as a drawing. The results revealed that students think that (a) apparent movement of the Moon takes place always at night and (b) simultaneous presence of the Sun and the Moon occurs mainly around sunset and sunrise. These ideas were found to be barriers for the construction of the scientific view concerning the relative positions of the Sun-Earth-Moon system, since three-quarters of the students have the idea that the Sun and the Moon are at opposite sides of the Earth.

1. INTRODUCTION

In the past three decades, many researchers examined children's and adults' ideas of basic astronomical events (see Bailey and Slater 2003). Some of these studies concerned lunar phenomena such as Moon phases (Parker and Heywood 1998, Trundle, Atwood, and Christopher, 2007), "dark" side of the Moon (Trumper 2001, Dove 2002), tides (Bisard *et al.* 1994, Taylor *et al.* 2003), and lunar eclipse (Barnett and Morran 2002, Bekiroglu 2007).

Focused on the apparent movement of the Moon, three studies were found, two referring to tertiary education (Mant and Summers 1993, Bekiroglu 2007) and one referring to primary school students (Sharp 1996), where the researchers examined this phenomenon, among others. Mant and Summers (1993) interviewed 20 primary school teachers in the United Kingdom and found that 80% of them thought that the Moon did appear to move through the sky although most of them had no idea of its path. The rest (20%), considered the Moon being always in a constant position in the Sky. Bekiroglu (2007) analyzed the written responses of 36 pre-service physics teachers, who had already obtained a bachelor degree in Physics. The main ideas revealed, concerning the apparent movement of the Moon were that (i) the Moon rises and sets at the same time everyday (36%), (ii) the Moon does not rise and set (33%), and (iii) we cannot see the Moon in the daytime (17%). Finally, Sharp (1996) interviewed 42 K–5 and K–6 students from south-west England and discovered that most of them (62%) seemed unaware of the Moon's apparent position or movement in the sky.

The present study is focused on primary school students' ideas concerning the apparent movement of the Moon but, unlike the aforementioned studies, it deals not only with the observational base of the phenomenon but mainly with its explanatory mechanisms. It is part of a broader research concerning the Sun-Earth-Moon system from an educational point of view and it is based on the "Model of Educational Reconstruction." In this model, the understanding of students' perspectives and the interpretation of the scientific content, are closely linked, aiming at designing new teaching and learning sequences (Duit *et al.* 2005).

2. APPARENT MOVEMENT OF THE MOON (THE SCIENTIFIC MODEL)

According to the scientific model, the Moon rises every day with an approximate 50 min delay. This delay is caused due to the simultaneous *spinning of the Earth once a day* and *the revolving of the Moon around the Earth within a synodical month*, both in the same direction (counterclockwise). If the Moon did not revolve around the Earth, moonrise would occur everyday at the same time. But since the Moon does revolve, the Earth "needs" more than 24 h to spin in order to "catch up" to the Moon's orbit. Due to the fact that the Earth spins counterclockwise, the Moon seems to rise from the East, crossing the sky and set in the West.

3. THE STUDY

3.1. Sample

The present study took place at five primary schools in different socioeconomic regions of Athens (Greece). Eight students (four from the fifth grade and four from the sixth grade) from each school were chosen at random. Half of the children were boys and half girls.

3.2. The Research Instrument

All students were interviewed individually by an interviewer. Each interview lasted approximately 30 min and was recorded using a digital voice recorder. The interviews were semistructured, which means that apart from the core questions (the following seven-item questionnaire) there were also follow up questions to clarify students' ideas, if necessary. Students' answers were expressed either orally and/or as a drawing. The analysis of the digital recorded interviews was done according to the "content analysis" method.

3.3. The Core Questions of the Interview

The core questions according to which the interview was structured were the following seven:

Q1. "Suppose that you are constantly watching the Sky for days. When does the Moon appear?"

Q2. "Suppose that you are standing still, watching constantly the Moon for hours. Do you see it moving as time passes or not? Justify your answer."

Q3. "Suppose that you are constantly watching the Sky for days. When does the Moon disappear?"

In questions 4, 5, 6, and 7, students had to draw a circle representing the Earth and a spot on its perimeter representing the place they live in, for every question (as in Figure 1). For each question, students were free to choose any place on the Earth's perimeter to put the spot on. In the relative tables (Tables 5–8), each written statement represents the students' ideas as they appear in their drawings. Due to the fact that these drawings came from Greek students, the symbols representing the Sun and the Moon do not make sense to English readers. To make the meaning of these symbols clear we note that the letter "H" is the symbol for the Greek word "Ηλιος" (Helios) or "Sun" in English, while the Greek letter "Σ" is the symbol for the Greek word "Σελήνη" (Selene) or "Moon" in English.

Q4. "Imagine that on the spot (representing the place you live) it is midnight. Add on the picture the Sun and the Moon relative to the place you live in."

Q5. "Imagine that on the spot (representing the place you live) it is noon. Add on the picture the Sun and the Moon relative to the place you live in."

Q6. "Imagine that on the spot (representing the place you live) the Sun is about to set. Add on the picture the Sun and the Moon relative to the place you live in."

Q7. "Imagine that on the spot (representing the place you live) the Sun is about to rise. Add on the picture the Sun and the Moon relative to the place you live in."

Question 2 investigates the students' justifications whether apparent movement of the Moon is taking place or not, while questions 1 and 3 are focused on investigating their ideas of the time span of the phenomenon.

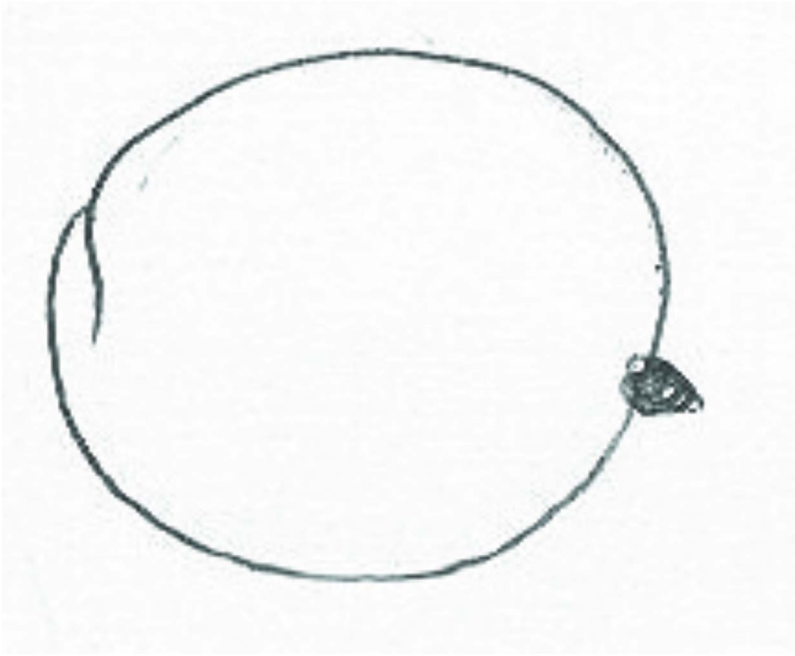


Figure 1. This figure is a student's drawing representing the Earth (circle) and the place he lives in (spot)

The remaining questions (4–7) examine how the students' ideas of the apparent movement of the Moon affect their ideas of the relative positions of the Sun, the Earth and the Moon, as a system.

Question 6 was given only to those students who replied in question 1 that the Moon may appear before Sunset. Similarly, question 7 was given only to those students who replied in question 2 that the Moon may disappear after Sunrise.

4. FINDINGS—DISCUSSION

In the following tables, the findings of the present study are presented as they emerged from the analysis of the digital recorded interviews.

4.1. Questions 1 and 3

The first finding from the data analysis of questions 1 and 3 is that all students consider the Moon to be always visible at night (unless clouds obstruct its view, according to their oral responses).

90% of them (categories 1, 3, 4, and 5 in Table 3) have the idea that the Moon is visible in the Sky from just a little before or after sunset to just a little before or after sunrise. The expression *a little* varies from some minutes to approximately one hour. However, in some cases (3 out of 40) the students extend the aforementioned time span even more stating that sometimes the Moon becomes visible from early in the afternoon and/or until late in the morning. Such views show an attempt to compromise an erroneous belief (the Moon is always visible at night) with everyday experience (the Moon can also be seen in the daytime) resulting in embodying the second into the first. This finding is also directly linked to the relevant theory of children's cognitive development according to which, views like the aforementioned ones are considered to be attempts to interpret scientific information within an existing framework theory that contains information contradictory to the scientific view (Vosniadou 1994). Furthermore, two students (category 6 in Table 3) give a vague picture of the phenomenon ("*I can see the Moon at night and sometimes at daytime"*) since they cannot specify its time span. Finally, there is one student who claims that the Moon appears and disappears only at night without providing any further information, and another one who claims that the Moon is always visible (categories 2 and 7 respectively in Table 3)

60% (N=24) of the students believe that the Moon can be seen in the daytime. The overwhelming majority of them (21 out of 24) claim that this is something that occurs only around Sunset and/or Sunrise. The opposite

view (the Moon cannot be seen in the daytime) is held by 40% of the sample. The corresponding percentages in the study of Bekiroglu (2007) for pre-service teachers are 72% (the Moon can be seen in the daytime) and 17% (the Moon cannot be seen in the daytime).

Table 3 shows the *time span* when the Moon is visible in the Sky, as a combining result of the students' answers in questions 1 and 3.

Table 1. Students' ideas in question 1

Q1. "Suppose that you are constantly watching the Sky for days. When does the Moon appear?"	***n***	**%**
1. "A little after Sunset"	24	60
2. "At night" (no further information provided)	1	2.5
3. "A little before Sunset"	7	17.5
4. "Sometimes a little after and sometimes a little before Sunset"	5	12.5
5. "I' am not sure. I can see the Moon at night and sometimes in daytime"	2	5
6. "The moon never disappears"	1	2.5

Table 2. Students' ideas in question 3

Q3. "Suppose that you are constantly watching the Sky for days. When does the Moon disappear?"	***n***	**%**
1. "A little before Sunrise"	17	42.5
2. "At night" (no further information provided)	1	2.5
3. "A little after Sunrise"	4	10
4. "Sometimes a little after and sometimes a little before Sunrise"	15	37.5
5. "I' am not sure. I can see the Moon at night and sometimes in daytime"	2	5
6. "The moon never disappears"	1	2.5

Table 3. Combining result of the students' answers in questions 1 and 3

Time span when the Moon is visible in the Sky	***n***	**%**
1. Appears a little after Sunset—Disappears a little before sunrise	15	37.5
2. "Only at night" (no further information provided)	1	2.5
3. Appears a little before Sunset—Disappears a little after sunrise	10	25
4. Appears a little after Sunset—Disappears a little after sunrise	9	22.5
5. Appears a little before Sunset—Disappears a little before sunrise	2	5
6. "I' am not sure. I can see the Moon at night and sometimes at daytime"	2	5
7. "Always"	1	2.5

4.2. Question 2

The data analysis in question 2 revealed that 77,5% of the students (categories 1–8 in Table 4) think that the Moon appears to move through the Sky while the rest (categories 9 and 10) hold the opposite view. These results are in contrast to those of Sharp's study (36 and 62%, respectively) and quite similar to those of Mant

and Summers' study (80 and 20%, respectively), even though Mant and Summers' study concerns pre service physics teachers while the present study and Sharp's, concerns primary school students.

Most of the students holding the idea that the Moon appears to move through the Sky, justify their answers on the basis of celestial movements of the Earth and the Moon (categories 1–6 in Table 4). According to the most popular explanations, Apparent Movement of the Moon is attributed either to the Earth's spinning (40%) or to the Moon's revolving around the Earth (12,5%).

Only two students (category 3 in Table 4) attribute the phenomenon to the simultaneous Earth' spinning and the Moon's revolving around the Earth. However, they believe that these simultaneous movements take place in opposite directions; otherwise the Moon would always be in front of a certain part of the Earth. It seems that they reproduce pieces of declarative knowledge without being able to form a coherent explanation.

Students who claim that the Moon does not appear to move through the sky, are almost equally divided into those who don't justify their answers and those who claim that the Moon is an unmoving planet. (category 10 and 9 respectively in Table 4)

Table 4. Students' ideas in question 2

Q2. "Suppose that you are standing still, watching constantly the Moon for hours. Do you see it moving as time passes or not? Justify your answer."	***n***	**%**
1. Yes. Because the Earth spins	16	40
2. Yes. Because the Moon revolves around the Earth	5	12.5
3. Yes. Because the Earth spins and the Moon revolves around the Earth, in opposite directions	2	5
4. Yes. Because the Earth spins and revolves around the Sun	2	5
5. Yes. Because the Earth revolves around the unmoving Sun and Moon	2	5
6. Yes. Because the Moon revolves around the Sun	1	2.5
7. Yes. I do not know why	2	5
8. Yes. (Incoherent)	1	2.5
9. No. Because the Moon is an unmoving planet	4	10
10. No. I do not know why	5	12.5

4.3. Questions 4 to 7

In question 4, 39 out of the 40 students, drew the Moon in front of the place where it is midnight (categories 1, 2 and 3 in Table 5). On the contrary, at noon (question 5), 38 out of the 40 students placed the Moon: on the other side of the Earth, far away from the Earth or somewhere hidden (categories 1, 2, and 3 in Table 6. Regarding the period of Sunset and Sunrise (questions 6 and 7 respectively), the vast majority of the students who answered these questions, placed the Moon and the Sun at opposite sides of the Earth in order for both to be visible (category 1 in Tables 7 and 8). It has to be clarified again that question 6 was provided only to those 12 students who replied in question 1 that the Moon may appear before Sunset (categories 3 and 4 in Table 1). Similarly, question 7 was provided only to those 19 students who replied in question 2 that the Moon may disappear after sunrise (categories 3 and 4 in Table 2). The aforementioned results are in accordance with students' expressed ideas in questions 1 and 2 [*(a) the everlasting visibility of the Moon at night and (b) the Sun's and Moon's simultaneous presence only around sunset and sunrise].*

Regarding the relative positions of the Sun, the Earth and the Moon, the main finding from the previously mentioned results is that more than three quarters of the students of the sample, place the Sun and the Moon always at opposite sides of the Earth (category 1 in questions 4, 5, 6, and 7). Previous studies on students' conceptions about the relative movements of the Sun-Earth-Moon system (Jones *et al.* 1987, Osborne *et al.* 1994, Sharp 1996, Taylor *et al.* 2003) have shown that whenever students place the Sun and the Moon at opposite sides of the Earth they do it on a basis of geocentric views of the Sun-Earth-Moon system.

Table 5. Students' ideas and drawings to question 4

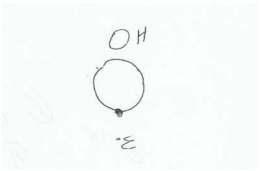
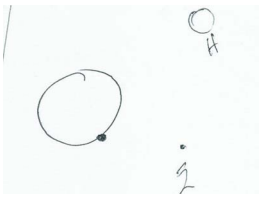
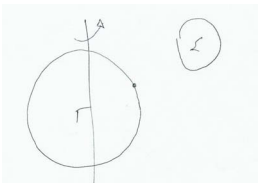
Q4. "Imagine that on the spot (representing the place you live) it is midnight. Add on the picture the Sun and the Moon relative to the place you live in." **Categorization of the Responses**	**Typical Examples of Students' Drawings**	***n***	***%***
1. The Sun and the Moon are at opposite sides of the Earth		32	80
2. The Moon is in front of the spot and the Sun is far away		4	10
3. The Moon is in front of the spot and the Sun is nowhere (hidden, don't know)		3	7.5
4. Fragmented		1	2.5

Table 6. Students' ideas and drawings to question 5

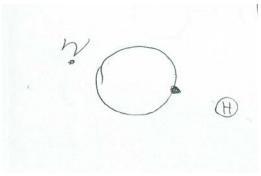
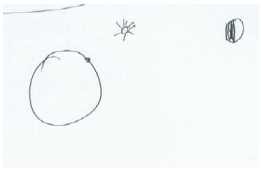
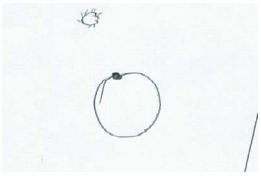
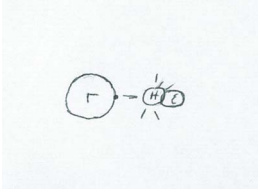
Q5. "Imagine that on the spot (representing the place you live) is noon. Add on the picture the Sun and the Moon relative to the place you live in." **Categorization of the Responses**	**Typical Examples of Students Drawings**	***n***	***%***
1. The Sun and the Moon are at opposite sides of Earth		30	75
2. The Sun is in front of the spot and the Moon is far away		5	12.5
3. The Sun is in front of the spot and the Moon is nowhere (hidden, don't know)		3	7.5
4. The Sun is in front of the spot and the Moon is hidden by the Sun		2	5

Table 7. Students' ideas and drawings to question 6

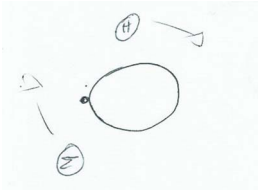
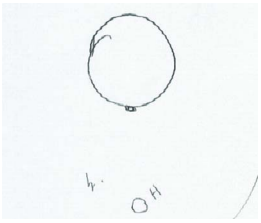
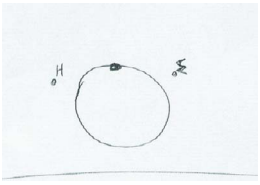
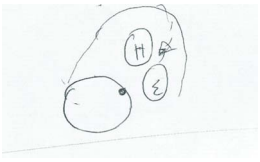
Q6. "Imagine that on the spot (representing the place you live) the Sun is about to set. Add on the picture the Sun and the Moon relative to the place you live in."		***n***	**%**
Categorization of the responses	**Typical Examples of Students Drawings**		
1. The Sun and the Moon are at opposite sides of the Earth		11	91.6
2. The Sun is close to the Moon		1	8.4

Table 8. Students' ideas and drawings to question 7

Q7. "Imagine that on the spot (representing the place you live) the Sun is about to rise. Add on the picture the Sun and the Moon relative to the place you live in."		***n***	**%**
Categorization of the Responses	**Typical Examples of Students' Drawings**		
1. The Sun and the Moon are at opposite sides of the Earth		15	79
2. The Sun is close to the Moon		2	10.5
3. I don't know		2	10.5

5. CONCLUSIONS

The present study is part of a broader research on the "Educational Reconstruction" of the Sun-Earth-Moon system. According to this Educational framework, students' explanations are not regarded as barriers to learning but as points to start from as well as mental instruments to work with in further learning (Duit and Treagust 2003). Consequently, addressing students' ideas of the apparent movement of the Moon is regarded as a means of looking for learning pathways where everyday experience of students would be consistent to the scientific view of the Sun-Earth-Moon system's relative movements.

The present study illustrates that the majority of the students of the sample regard the apparent movement of the Moon as a taking place phenomenon, which is not tied to human centered or teleological notions but caused by celestial movements of the Earth or the Moon.

However, their idea of the Moon being always visible at night leads to the adoption of a 24hour periodicity of the phenomenon which seems to act as a constraint for the construction of the scientific heliocentric view of the Sun-Earth-Moon system.

Furthermore, the aforementioned idea of the Moon being always visible at night, seems to interfere also with the acquisition of the scientific view for the day and night cycle, since, as research shows (Vosniadou and Brewer 1994), many primary school students hold the idea that the Day and Night Cycle, is causally related to the appearance and disappearance of both the Sun and the Moon, while in the usual presentation of the scientific explanation the role of the Moon cannot be clarified.

Bearing in mind all the above, we underline the necessity of teaching the Apparent Movement of the Moon as an integral part of a teaching and learning sequence for the Sun-Earth-Moon system. The direct observational knowledge and experience that the Moon rises every day with an approximate 50 min delay, could be the 'enabling concept' for the acquisition of the scientific view that the Moon is not always visible at night and consequently for the clarification of either why the Moon is not causally implicated in the day and night cycle or of why the Sun and the Moon are not always at opposite sides of the Earth.

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