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UNDERSTANDING OF TEACHERS ON PHASES OF THE MOON AND THE LUNAR ECLIPSE[i]

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Abstract:
Even though the educational researchers have developed and implemented various educational strategies to teach the concepts of the phases of the Moon and the formation of the lunar eclipse more effectively, many studies conducted by them in recent years reveal that the teachers still do not understand the causes and scientific processes related to the phases of the Moon phases and lunar eclipse. In addition, this situation shows that there are deep problems in teaching the subjects of Moon phases and lunar eclipse to students. Examining the main causes of learning difficulties in the phases of the Moon and lunar eclipse, this study is designed on the basis of development and implementation of a project supported by STRCT (The Scientific and Technological Research Council of Turkey) in order to discuss the possible solutions. A 5-day activity program including basic astronomy education was applied to science teachers by using the model developed within the scope of the project, and the changes in mental models of the teachers in the subjects of Moon phases and lunar eclipse were examined. This research was carried out with 29 teachers voluntarily participating in the project in the field of Science. In this study in which qualitative and quantitative data collection methods were applied together, as a result of the evaluation of the obtained data, it was observed that the project was very successful in understanding the phases of the Moon and the causes of the lunar eclipse. The obtained results were interpreted by comparing them with the literature.

Keywords: science teaching, astronomy education, formation of the phases of the Moon, the formation of the lunar eclipse, mental models

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Özet:
Son yıllarda eğitim araştırmacılarının yaptığı birçok araştırma, Ay'ın evreleri ve Ay tutulmasının oluşması kavramlarını daha etkili bir şekilde öğretmek için çeşitli eğitim stratejileri geliştirip uygulamalarına rağmen, öğretmenlerin Ay'ın evreleri ve Ay tutulmasının oluşma nedenlerini ve bilimsel süreçlerini hala kavrayamadıklarını ortaya koymaktadır. Bu durum, Ay'ın evreleri ve Ay tutulması konularının öğrencilere öğretilmesinde derin sorunlar yaşandığını göstermektedir. Bu çalışma, Ay'ın evreleri ve Ay tutulması konularındaki öğrenme zorluklarının temel nedenlerinin araştırılarak, olası çözümlerin tartışılması için TÜBİTAK (The Scientific and Technological Research Council of Turkey) tarafından desteklenen bir proje geliştirilmesi ve uygulanması üzerine kurgulanmıştır. Proje kapsamında geliştirilen model kullanılarak fen bilimleri öğretmenlerine temel astronomi eğitimi konularını da kapsayan 5 günlük bir etkinlik programı uygulanmış ve öğretmenlerin Ay'ın evreleri ve Ay tutulması konularındaki zihinsel modellerinin değişimleri incelenmiştir. Bu çalışma Fen Bilimleri alanında projeye gönüllü olarak katılan 29 öğretmen ile gerçekleştirilmiştir. Nitel ve nicel veri toplama yöntemlerinin bir arada kullanıldığı bu araştırmada, elde edilen verilerin değerlendirilmesi sonucu, Ay'ın evreleri ve Ay tutulmasının oluşum nedenlerinin kavranmasında oldukça başarılı olunduğu gözlenmiştir. Elde edilen sonuçlar literatürle karşılaştırılarak yorum yapılmıştır.

Anahtar kelimeler: fen eğitimi, astronomi eğitimi, Ay'ın evrelerinin oluşumu, Ay tutulmasının oluşumu, zihinsel modeller

1. Introduction

According to the examinations conducted in the scope of the study, as the importance of the basic astronomy subjects in the science curriculum of many countries in the world is increasing, the importance of research and education strategy practices in this field is also becoming widespread. When the literature in this field is examined, it is observed that the teaching and learning of the phases of the Moon and the lunar eclipse are among the most fundamental subjects of astronomy education (Bailey & Slater, 2003; COCESoE, 2015; Gregory, Luzader & Coyle, 1995; Sadler, 1992). The phases of the Moon and the lunar eclipse are among the concepts that have been at the center of human development in a historical process since the existence of human being. In addition to this, teaching the phases of the Moon and the lunar eclipse has an important place in modern science at present time since it brings many scientific disciplines together. The majority of studies carried out in the literature indicate that the phases of the Moon and the lunar eclipse, like other basic concepts of astronomy, are considered as excellent instruments to teach the essence of science (Sneider, 2011).

Recently, many studies have been conducted on the phases of the Moon and the lunar eclipse. Kavanagh et al. (2005) state that secondary school teachers encounter a great difficulty in teaching the phases of the Moon and the lunar eclipse. National Science Education Standards (National Research Council, 1996) mention that there are many

studies concluding that the middle school students have difficulty in explaining the phases of the Moon and the lunar eclipse. Besides, National Science Education Standards emphasize that all the students are expected to learn these concepts when they graduate from the eighth grade. This situation brings about the emergence of many questions:

- At what age level should the dynamic structure of the Earth-Moon-Solar system be learned?
- What are the most effective teaching methods to assist the students to acquire a mental model for the Earth-Moon-Solar system that is consistent with science?
- What kind of prior knowledge should the students have so as to learn this system effectively?

It is expressed in the book "Heavenly Errors" written by Neil Comins (2001) that the phases of the Moon and the lunar eclipse have a complex scientific process. In order to comprehend these concepts, it is emphasized that the synthesis of all this information (comprehending the rotation and entanglement motion system of the Moon and the Earth, understanding the movement of this system in the orbit of the Sun and the effects of the positions of these three celestial bodies on the formation of phases and eclipse, and discovering in the mind at what rate the illuminated face of the Moon at these locations can be observed from the Earth) should be able to form the three-dimensional image and relative movements of these three celestial bodies in the minds so as to understand the reason of the lunar phases and eclipse in a meaningful way. Similar to many other subjects in Earth and space science, understanding the phases of the Moon and the lunar eclipse requires knowledge of many scientific processes such as light physics and the solar system.

When the literature is examined, it is observed that many studies examining the basic concepts of astronomy have been conducted with different sample groups (Bretones, 2019; Bretones, Jafelice ve Horvath, 2016; Bisard ve diğ., 1994; Bryce ve Blown, 2006; Chen ve diğ., 2020; Fitzgerald ve diğ., 2014; Fraknoi, 2014; Gürbüz, 2015; Kalkan, 2018; Kalkan, Kalkan ve Ustabaş, 2007; Keçeci, 2012; Orbay ve Gökdere, 2006; Piaget, 1929; Sadler, 1992; Schoon, 1989; Targan, 1993; Trumper, 2003; Uçar ve Demircioğlu, 2011; Zeilik ve diğ., 1998). However, it has been determined in the literature that there are few studies on how the teachers perceive the concepts of Moon phases and lunar eclipse. These few studies conducted with the teachers demonstrate that the teachers also have similar misconceptions with the students (Kikas, 2004; Ojala, 1997).

According to these studies, owing to the geocentric perspective of the Sun-Earth-Moon system (Black, 2005; Nussbaum, 1986), misperceptions about the relative sizes and distances of astronomical objects (Miller & Brewer, 2010) and mentally evaluating the Earth perspective as a reference make it difficult to understand the concepts of the phases of the Moon and the eclipse (Gazit et al., 2005). Therefore, this situation prevents the recognition of the three-dimensional nature of the mechanism behind the phenomenon. These difficulties cause the student groups with different ages and cultural backgrounds to generate very different alternative concepts about the phases of the Moon and the lunar eclipse (Roald & Mikalsen, 2001). The national and international studies (Brunsell & Marcks, 2005; Emrahoğlu & Öztürk, 2009; Orbay & Gökdere, 2006) reveal that the pre-

service science teachers have various misconceptions about the phases of the Moon and lunar eclipses. According to a similar study conducted by Kanlı (2014) with pre-service science teachers and physics teachers, it is determined that 42% of the pre-service science teachers state that the Moon moves towards the shadow of the Earth while the phases are forming and that 13% of them state that the Moon moves towards the shadow of the Sun. In the same study, it is also revealed that 33% of the physics teachers in service mention that the Moon moves towards the shadow of the Earth while the phases of the Moon are forming and that 7% of them mention that the Moon moves towards the shadow of the Sun.

Gobert and Clement (1999) emphasize the importance of using visual stimuli in the teaching and conceptual understanding of the concepts of the phases of the Moon and the eclipse. In order to understand these facts conceptually, it is necessary to explain the concepts scientifically. However, it is very challenging to scientifically interpret the concepts of science (Ayas, Çepni, Johnson & Turgut, 1997; Collette & Chiappetta, 1989). Therefore, the teachers and the students prefer the way of learning at the knowledge level, mostly as a cause-effect relationship, together with the phases of the Moon and the formation of the lunar eclipse. The STRCT project related to this by Kalkan (2018) show that some of the teachers explain the reason for the formation of the phases of the Moon with the movement of the Moon towards the shadow of the Earth. It is also determined that most of the teachers participating in the project could not explain why the lunar eclipse does not occur in every full moon phase. According to Sneider, Bar, and Kavanagh (2011), many university professors have the idea that the misunderstandings of the students are attributed to a lack of understanding of their teachers, resulting in poor teaching and learning.

It is foreseen that a physical model that will provide scientifically correct mental models for teachers and students about the phases of the Moon and the formation and causes of the lunar eclipse will be effective. Thus, a project supported by STRCT has been planned to examine the subject in detail. Depending on the position of the Moon, which is the main reason for the formation of the phases of the Moon with respect to the Earth and the Sun, the study was carried out taking into account the alignment of the Sun, Earth and Moon, which are the main causes of lunar eclipse, with this order and considering that the illuminated part of the Moon appears at different rates than the Earth. A physical model has been generated so as to teach these factors at comprehension level and higher cognitive domain levels. It is expected that understanding of the teachers on the phases of the Moon and the processes related to the lunar eclipse will be easier through this physical model.

2. Method

This research was carried out to determine the effectiveness of the model by developing a physical model to enable the phases of the Moon and the lunar eclipse to be comprehended. Besides, the mixed method (MM) was applied to include the opinions / thoughts of the teachers in the study. The basic assumption of MM is to provide a better

understanding of the obtained answers by using qualitative and quantitative research methods together (Creswell, 2013). One-sample quasi-experimental method was implemented in this study. Some measurements were applied to the sample group before and after the instruction (Sönmez & Alacapınar, 2013).

3. Population and Sample of the Research

The study group consists of 29 science teachers selected by using simple probability sampling and purposeful sampling methods together. The sample was determined, among 547 teachers who applied to the project voluntarily, as 22 female and 7 male teachers depending on the application rates by considering the provinces they work in, their professional experience periods, and their education levels.

4. Data Collection Instrument and Data Analysis

The data obtained in the study were examined through two different analyzes. These are listed as follows;

- Question by question item analysis in the analysis of multiple choice questions,
- Content analysis of the explanations of multiple choice questions,
- Content analysis of open-ended questionnaire (OEQ).

Measurements were applied 3 times as pre-teaching, post-teaching and persistency.

Initially, the teacher expressions and drawings belonging to OEQ were coded and divided into categories. The distribution of the categories developed for the questions used in the research is presented in Table 1 and Table 2.

It was repeated independently by another expert researcher other than the researcher in order to increase the reliability in the qualitative data analysis process, and the codes and categories used in the data analysis process were obtained. The consistent codes are labeled as "consensus", and the inconsistent codes as "dissensus". The following formula was applied to calculate the reliability of the obtained data (Miles et al., 2014). According to Şimşek and Yıldırım (2011), the rate of consensus being 70% means that the coding is reliable.

$$\frac{\text{Consensus}}{(\text{Consensus}+\text{Dissensus})}\ x\ 100$$ (Miles et al., 2014).

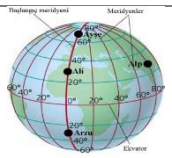
Regarding open-ended questions during independent analysis,

- This value was determined as 0,81 for the open-ended question asking the current misconceptions about the phases of the Moon, and 10 categories were created.
- This value was determined as 1,00 for the open-ended question asked to determine the misconceptions about lunar eclipse, and 6 categories were formed.

While examining the explanations made for the multiple choice questions, the reliability analysis of the four questions was conducted separately because it was determined that there are differences in the explanations made to all questions.

- 4 categories with a consensus percentage of 1,00 in the first question,
- 3 categories with a consensus percentage of 0,75 in the second question,
- 5 categories with a consensus percentage of 0,80 in the third question,
- 7 categories with a consensus percentage of 0,75 in the fourth question were formed. The categories created in the research are given in Table 1.

Table 1: Categories related to the formation of phases of the Moon

Questions	Method	Categories
How are the phases of the moon formed?	1. Open-ended question	1. Moon-Sunlight relationship 2. The rotation of the Moon 3. Rotation of the Moon around the Earth* 4. Rotation of the Moon around the Sun 5. Formations of shadow and light 6. Those explaining what the phases are 7. Sunlight reflection 8. The rotation of Earth 9. Other 10. Empty
a. As the Moon rises on the eastern horizon in the evening, it appears as in the figure (Full Moon). So, what is the new image of the Moon when it reaches approximately the highest point in the sky 6 hours later on the same day?	1. Multiple choice question	1. Only the position of the moon changes during the day. 2. The moon always remains in the same phase throughout the day. 3. The phases of the moon change over a period of one week. 4. Moon phases turn into the next phase in 6 hours.
b. Why?	Open-ended	
a. Which of the information about the rates of illumination of the moon by the sun in the phases given below is correct?	2. Multiple choice question	1. It illuminates at different rates in each phase. 2. Half of it always illuminates. 3. Other
b. Why?	Open-ended	
a. Ali, Ayşe, and Arzu live on the same longitude, and Ali and Alp live on the same latitude. Ali, Ayşe, Alp, and Arzu are watching the Moon at the same time. Accordingly, 	3. Multiple choice question	1. It changes depending on the rotation of the moon. 2. It depends on the hemisphere. 3. It depends on the longitude. 4. It depends on the latitude. 5. It does not depend on location.

which of the following choices is correct?	
b. Why?	Open-ended

*Scientifically correct

Table 2 provides the distribution of the categories formed to determine the misconceptions about lunar eclipse. A total of 6 different categories were generated. Two of these represent the "Other" and "Empty" categories.

Table 2: Categories for the occurrence of lunar eclipses

Questions	Method	Categories
How does a lunar eclipse occur?	2. Open-ended question	1. Sun-Moon-Earth sequence* 2. Incasing the Moon 3. Formation of shadow 4. Being at the same plane* 5. Other 6. Empty
a. In order for a person on Earth to observe the lunar eclipse, at which of the following phases must the Moon be?	4. Multiple choice question	1. The moon being in the full moon phase 2. The moon being in the new moon phase 3. The moon being in the first quarter moon phase 4. The moon being in the darkness 5. Seeing the dark side of the moon 6. The Moon completely incasing the Sun 7. The Sun, Earth, and Moon being at the same direction
b. Why?	Open-ended	

* Scientifically correct

According to Şimşek and Yıldırım (2011), it can be mentioned that the classification is reliable if a combination percentage of at least 70% is achieved.

The statements were supported with the original statements of the teachers in the presentation of the obtained results. The teachers are numbered as T1, T2,…, and T29 so as to ensure that the direct quotations are included.

5. Development of the Physical Model

5.1. Development Stages of the Moon Phases Model

a. Half of the 10 cm white foam ball used in explaining the phases is used as black.
b. Rotation of the Moon around the Earth was made by one of the participants in a manner compatible with the orbital motion of the Moon.

c. A representative Earth (with a radius of 40 cm) was placed in the middle of the model, and the participants were placed around this representative Earth in groups.
d. In the model, the differences were illustrated by showing the phases from a distance of 135 cm, then from a distance of 12 meters by taking the Earth model with a diameter of 26 cm as a reference.
e. Size and distance ratios for the Earth-Moon model are given in table 17.

5.2. Development Stages of the Lunar Eclipse Model

Three factors to be considered in the models of lunar eclipse were determined.

a. It was determined for a 40 cm Earth model that the distance between the Earth and the Moon should be 7 meters and that the Moon model should be 10 cm.
b. Based on the difference between the orbits, the Moon model was orbited in an orbit approximately 1 meter above and below by taking the orbit of the Earth around the Sun as a reference.
c. The descent and ascent node points (the intersection of two orbits) are mentioned during this rotation.
d. It was stated that if these nodes occur while in the new moon phase, there will be a solar eclipse and that if it occurs during the full moon phase, the lunar eclipse occurs.
e. It was shown on the model that the different versions of eclipses such as total eclipses, partial eclipses, or annular eclipses can be experienced depending on the distance of celestial bodies.

5.3. Practice Stages of Experimental Study and Physical Model

The chart of the processes carried out in the time interval from pre-teaching to obtaining persistency data in the study is presented in Figure 1. Pilot studies of the physical model, which is the subject of the research, were carried out with the teachers who participated in another STRCT project in 2018-2019, and missing or uncertain points were identified in this way. The final form of the model was generated at the end of the revision process. The teaching activities suitable for the physical model were prepared, and the teaching process was recorded. All the practices and teaching activities of the model were performed by the researcher.

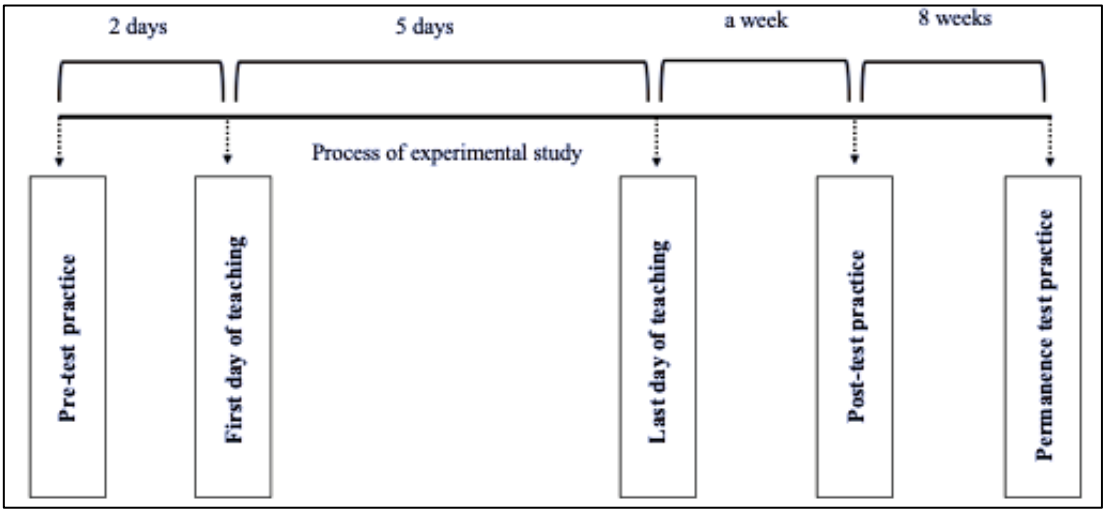


Figure 1: Experimental Study Process

6. Findings

The findings of the study are explained under two subsections. These can be listed as follows;

- Findings on the questions about the formation of the phases of the Moon,
- Findings on the questions about the occurrence of lunar eclipse.

6.1. Analysis of the questions and the explanations to the multiple choice questions in OEQ

While analyzing the content, the categories of the answers given by the teachers were initially developed (Table 2). The multiple choice questions and the answers to open-ended questions were interpreted together. The frequencies of the answers given to the multiple choice questions and the explanations made with the marked options are presented in table 5, table 8, table 11, and table 15 in comparison. The explanations to the multiple choice questions and the categories and findings of the explanations made to open-ended questions are shown in table 4, table 7, table 10, table 12, table 14, and table 16. Within the framework of the research, the teachers were expected to make a scientific explanation about how the phases of the Moon are formed.

The scope of scientific explanation expected from the teachers is as follows;

> *"The light reflected by the Moon, which receives the light from the Sun, is seen by an observer looking from the Earth at varying rates depending on the different positioning of the Moon due to its rotation around the Earth."*

Besides, the scientific explanation of Lunar Eclipse, which is the second concept discussed within the scope of the research, is as follows;

> *"At the intersection of the orbits on which the Earth and the Moon are located, it is the event which the Moon is temporarily invisible in all regions of the Earth where night is*

experienced and which occurs as a result of the alignment of the Sun, Earth and Moon with this sequence."

Analyzes related to both scientific concepts are examined under separate headings.

6.1.1. Findings related to the questions about the formation of the phases of the Moon

Within the framework of the research, a scientific explanation to the question "Why did you give this answer?" was expected from the teachers.

6.1.1.1. Analysis of the first question

Table 3: Frequency table for the first question

1	**As the Moon rises on the eastern horizon in the evening,, it appears as in the figure (Full Moon). So, what is the new image of the Moon when it reaches approximately the highest point in the sky 6 hours later on the same day?**	**Pre-test**		**Post-test**		**Persistency**	
		f	**%**	**f**	**%**	**f**	**%**
A	Full moon	22	75,8	26	89,6	28	96,5
B	Waxing gibbous	4	13,8	1	3,5	0	0
C	First quarter	1	3,5	2	6,9	0	0
D	Crescent	0	0	0	0	0	0
E	New moon	0	0	0	0	0	0
Empty		2	6,9	0	0	1	3,5

The correct answer to the first question is the option a. According to Table 3, it was seen that 22 teachers marked the correct option in the pre-test, and while 2 teachers could not answer at all, only 5 teachers marked the wrong options b and c. Whereas 26 teachers marked the correct option in the post-test, 28 teachers marked the correct option in the persistency test.

Table 4: Categories and findings for the first question related to the formation of the phases of the Moon

Level	**Category**	**Explanation of category**	**Practice**	**f**
Knowledge	Only position of the moon changes during the day.	Explanations about the change of its position, not explaining the situation that will occur in the phase of the Moon	Before practice	2
			After practice	0
			Persistency practice	3
	The moon always stays in the same phase throughout the day.	Explanations that the phase where the moon is formed will not change on the same day	Before practice	10
			After practice	11
			Persistency practice	13
	The phases of the moon change. over a period of one week.	Explanations that the phases of the moon will change in a week or 7 days or that there are	Before practice	7
			After practice	13
			Persistency practice	7

	four main phases in total, and these phases are completed within 30 days.		
The phases of the Moon turn into the next phase in 6 hours.	Explanations that the moon will turn into the other phase in the same night as it makes the motion of rotating around the Earth	Before practice	2
		After practice	1
		Persistency practice	1

When the explanations made in the first question in which the formation of the phases of the moon and the duration of the phases are measured were examined, common categories were created for all the answers given to the pre-test, post-test, and persistency tests. The answers given to the question are divided into 4 categories.

Table 5: The correct / wrong markings for the first question and the correlation of the explanations to this question

	Pre-test	**Total**	**Post-test**	**Total**	**Persistency test**	**Total**
Those who selected the correct option and made a scientifically correct explanation	17	22	24	26	20	28
Those who selected the correct option and made scientifically wrong / incomplete explanations	3		0		8	
Those who selected the correct option but did not explain	2		2		0	
Those who selected the wrong option and made a scientifically correct explanation	0	5	0	3	0	0
Those who selected the wrong option and made a scientific wrong explanation	3		1		0	
Those who selected the wrong option and did not explain	2		2		0	
Those who did not select any option	2	2	0	0	1	1

According to the results of the analysis in Table 5,

a. In the pretest, 17 teachers gave the correct answer and gave parallel answers with the correct explanation "The phase of the moon does not change during the day.". It was determined that there were 3 teachers who made the wrong explanation despite selecting the correct option.
b. When the post-test data were examined, 24 out of 26 teachers who selected the correct option made statements parallel to the scientifically accepted comment that *"Moon phases do not change during the day, and the phases of the Moon change within a week"*. Also, there were two teachers who could not make any explanation despite selecting the correct option.

c. When the data of the persistency test were examined, 20 out of 28 teachers who selected the correct option made explanations that could be considered scientifically correct. 1 teacher did not answer the question.

6.1.1.2. Analysis of the second question

Table 6: Frequency table for the second question

2	Which of the information about the rates of illumination of the moon by the sun in the phases given below is correct?			Pre-test		Post-test		Persistency	
				f	%	f	%	f	%
	First quarter	New moon	Crescent						
A	%25	%0	%10	2	6,9	0	0	0	0
B	%50	%0	%15	12	41,3	4	13,8	5	17,2
C	%50	%50	%50	11	37,9	25	86,2	24	82,7
D	%75	%100	%25	2	6,9	0	0	0	0
E	%25	%0	%25	0	0	0	0	0	0
Empty				2	6,9	0	0	0	0

When Table 6 is examined, the rate of selecting b and c options in the pre-test was high. While 11 teachers selected the correct option, c, option b was the strongest distractor. In addition, 2 teachers could not answer this question at all. Whereas 25 teachers selected the correct option in the post-test, 24 teachers selected the correct option in the persistency test.

Table 7: Categories and findings for the second question related to the formation of the phases of the Moon

Level	Category	Explanation of category	Practice	f
Comprehension	It illuminates in different rates in each phase	Explanations made in the direction that the different rates of the moon in different phases are illuminated	Before practice	8
			After practice	1
			Persistency practice	2
	Half of it illuminates all the time	Explanations that half of the moon is always illuminated but seen in different rates when viewed from the Earth	Before practice	11
			After practice	20
			Persistency practice	19
	Other	Explanations about what the phases of the Moon are	Before practice	5
			After practice	1
			Persistency practice	3

When the Table 7 containing the explanations to the questions is examined, it is observed that there are those who selected the correct answer c option in the pre-test, post-test, and persistency test and who made parallel explanations to the correct explanation "50% of the Moon is always illuminated by the Sun. However, due to the different positions of the Sun, Earth and Moon within a month, different rates of the part illuminated from the Earth can be observed." However, it is also observed that these explanations are at different frequencies in each test. It is also determined that there is a significant increase in the post-test.

Table 8: The correct / wrong markings for the second question and the correlation of the explanations to this question

	Pre-test	Total	Post-test	Total	Persistency test	Total
Those who selected the correct option and made a scientifically correct explanation	11	11	21	25	19	24
Those who selected the correct option and made scientifically wrong / incomplete explanations	0		1		3	
Those who selected the correct option but did not explain	0		2		2	
Those who selected the wrong option and made a scientifically correct explanation	0	16	0	4	0	5
Those who selected the wrong option and made a scientific wrong explanation	12		2		3	
Those who selected the wrong option and did not explain	4		2		2	
Those who did not select any option	2	2	0		0	0

According to the results of the analyzes in Table 8,

a. 11 teachers selected the correct option in the pretest, and all 11 teachers gave scientifically correct explanations.
b. When the post-test data were examined, it was determined that 25 teachers selected the correct option and that 21 teachers made a scientifically correct explanation.
c. It was determined in the persistency test that 24 teachers selected the correct option and that 19 of these teachers made explanations that could be considered as scientifically correct. Although 3 teachers selected the correct option, it was observed that they scientifically made the wrong explanation.

6.1.1.3 Analysis of the third question

Table 9: Frequency table for the third question

3	**Ali, Ayşe, and Arzu live on the same longitude, and Ali and Alp live on the same latitude. Ali, Ayşe, Alp, and Arzu are watching the Moon at the same time. Accordingly, which of the following choices is correct?**	Pre-test		Post-test		Persistency	
		f	%	f	%	f	%
A	Ali and Ayşe see the Moon in the same phase, and Alp sees it at different phase.	10	34,5	1	3,5	4	13,8
B	Ali and Alp see the Moon in the same phase, and Ayşe sees it at different phase.	0	0	2	6,9	1	6,9
C	Ali, Ayşe Alp, and Arzu see the Moon in the same phase.	17	58,6	26	89,7	24	82,7
D	Ali, Ayşe, and Arzu, see it at different phase.	2	6,9	0	0	0	0
E	Arzu cannot observe the phases of the Moon from her location.	0	0	0	0	0	0
Empty		0	0	0	0	0	0

When Table 9 is examined, it was concluded that whereas 17 teachers selected the correct option c in the pre-test, 10 teachers selected option a, which is a strong distractor. It was also determined that 26 teachers in the post-test and 24 teachers in the persistency test selected the correct option c.

Table 10: Categories and findings for the third question related to the formation of the phases of the Moon

Level	Category	Explanation of category	Practice	f
Comprehension	It changes depending on the rotation of the Moon.	Explanations that we see the light parts of the moon differently because the Earth rotates around the Moon.	Before practice	1
			After practice	0
			Persistency practice	0
	It depends on the hemisphere.	Observers in different hemispheres see different phases, however, observers in the same hemisphere see the same phases.	Before practice	2
			After practice	1
			Persistency practice	0
	It depends on the longitude.	Observers at different longitudes see different phases, however, observers at the same longitude see the same phases.	Before practice	5
			After practice	1
			Persistency practice	3
	It depends on the latitude.	Observers at different latitudes see different phases, however, observers at the same latitude see the same phases.	Before practice	5
			After practice	0
			Persistency practice	1
	It does not depend on the location.	The phases of the moon look the same everywhere on Earth. Location does not cause the phases to look different.	Before practice	10
			After practice	20
			Persistency practice	23

The teachers were asked to explain their answers to the third question. In the third question addressed to the teachers, the expected answer from the teachers is "The Moon appears in the same phase wherever it can be observed from wherever the Earth is observed". The main reason for this is that the distance between the Moon and the Earth is undeniably long. None of the teachers who selected the correct option and gave the correct answer in the pretest did not mention the distance between the Earth and the Moon. However, these explanations were frequently encountered in the last test.

According to the results of the analyzes in Table 11,

a. As a result of examining the pre-test data, it was understood that 9 teachers selected the correct option c and that they made explanations that can be accepted as correct.
b. When the post-test data were examined, 26 teachers selected the correct option, and 21 of these teachers made explanations that could be considered scientifically correct.
c. In the persistency test, 24 teachers selected the correct option, and 20 of these teachers were able to make correct explanations. 1 teacher could not make a scientifically correct explanation although he/she selected the correct option.

Table 11: The correct / wrong markings for the third question and the correlation of the explanations to this question

	Pre-test	Total	Post-test	Total	Persistency test	Total
Those who selected the correct option and made a scientifically correct explanation	9	17	21	26	20	24
Those who selected the correct option and made scientifically wrong / incomplete explanations	3		4		1	
Those who selected the correct option but did not explain	5		1		3	
Those who selected the wrong option and made a scientifically correct explanation	0	12	0	3	0	5
Those who selected the wrong option and made a scientific wrong explanation	12		2		3	
Those who selected the wrong option and did not explain	0		1		2	
Those who did not select any option	0	0	0	0	0	0

6.1.1.4. Analysis of the data of the open-ended question related to the formation of the phases of the Moon

The analysis of the data of the question *"How are the phases of the moon formed? Please explain."* is presented in Table 12.

Scientific explanation of the open-ended problem to explain how the phases of the Moon are formed is that *"The light reflected by the Moon, which receives the light from the Sun, is seen by an observer looking over the Earth in varying degrees of light depending on the different positioning of the Moon as it rotates around the Earth"*. Based on this explanation, among the answers given by the teachers, such explanations as *"The rotation of the Moon around the Earth"* and *"Seeing the light reflected by the Moon from the Sun at different rates on the Earth"* were sought. 72.4% of the teachers stated that "The Moon rotates around the Earth" in the pre-test. While this rate reached 89.7% in the post-test, it was determined as 79.3% in the persistency practice, and both values were higher than the rates reached in the pre-test. The most-sought explanation in the answers given by the teachers is *"seeing the light reflected by the Moon from the Sun at different rates on the Earth"*. Whereas the rate of teachers who made such an explanation before the practice was 24.1%, it was determined after the practice that this rate increased to 79.3% and that there was a big increase. In addition, it was observed that the rate of this case in the persistency practice was 48.3%, which is much higher than the pre-test.

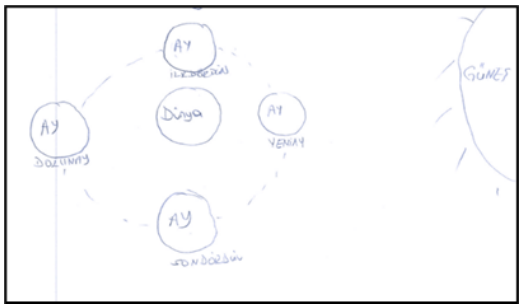
Table 12: Categories and findings of the open-ended question related to the formation of the phases of the Moon

Level	Category	Explanation of category	Pre-test		Post-test		Persistency	
			f	%	f	%	f	%
Synthesis	Moon-Sunlight relation	The reflection of the rays of the Sun on the Moon at different angles, the change of the Moon's receiving side of the Sun due to the motion of the rotation, the inability of the Moon to receive the rays from the Sun fully, the change of the solar part of the Moon, change in the state of sun rays illuminating the surface of the Moon	8	27,5	1	3,4	5	17,2
	Moon rotating / not rotating	The rotation of the moon around its axis	3	10,3	2	6,9	3	10,3
	Rotation of the Moon around the Earth*	Rotation of the Moon around the Earth	21	72,4	26	89,7	23	79,3
	Rotation of the Moon around the Sun	Rotation of the Moon together with the Earth around the Sun or rotation of the Moon around the Sun	6	20,6	1	3,4	2	6,9
	Shadow and light formations	Change in the angle of falling of the sun rays at certain intervals, the appearance of the rays reflected by the Moon from the Sun at different angles from the Earth, the observers on Earth seeing the light reflected by the Moon in different ways	7	24,1	1	3,4	0	0
	Those who explain what the phases are	An explanation of what the four main and four interval phases are (here is not how the phases are formed, but what the phases are.)	6	20,6	4	13,8	7	24,1
	Sunlight reflection*	Changes in the rate of reflection of sunlight to the Earth, changes in the falling angle of sun rays at regular intervals, the rays reflected by the Moon from the Sun appear at different angles from the Earth, observers on the Earth see the light reflected by the Moon in different ways, Appearance of the bright part of the Moon from the Earth in different ratios	7	24,1	23	79,3	14	48,3
	Rotation of the Earth	Rotation of the Earth around its own axis	2	6,9	1	3,4	1	3,4
	Other	Rotation of the Earth around the Sun, the speed of the rotation of the Moon and the Earth, and similar explanations	4	13,8	2	6,9	0	0
	Empty	Those who were not answered	0	0	0	0	1	3,4

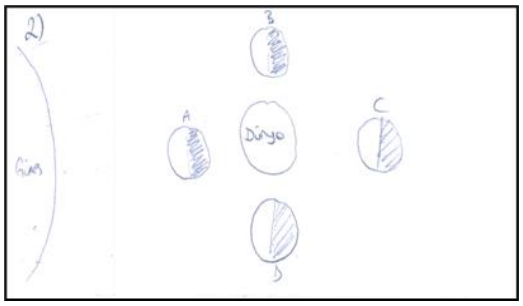
*Scientifically correct

In addition to these, one of the most mistaken phenomenon of teachers in the pre-test is “The Moon rotates around the Sun". If the Earth did not rotate around the Sun, the Moon would not be around the Sun. Under these conditions, the phases would still occur. After this event was shown to the teachers through the models, it was observed that this rate dropped from 20.6% to 3.4%.

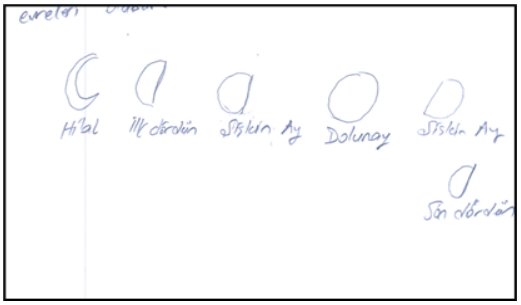
As can be understood from the answers given by the participants, there are some misconceptions related to the formation of the phases of the Moon in the mental models of the teachers. Some examples of drawings by the teachers are as follows;

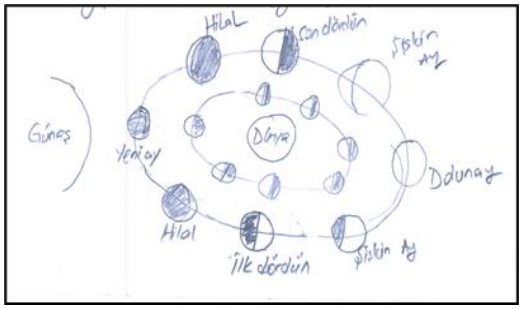


(T3, before practice)



(T3, after practice)





The part that is difficult to understand widely in this question is the part of understanding how much of the Moon actually is illuminated and how much of it is visible from Earth. It was determined that most of the teachers did not know how much of the moon was illuminated before the practice and therefore could not reflect this situation in their drawings. After the practice, it was concluded that the teachers made a double circulation drawing in order to explain the phases of the Moon. One of these drawings is used to express that half of the Moon is always illuminated, and the other is used to express the way this illuminated part appears from the Earth.

6.1.2. Findings related to the questions asking the misconceptions about lunar eclipse

The categories of the answers of teachers to the questions asked about the formation of the lunar eclipse were developed. Explanations for these categories are given in table 14.

Within the framework of the research, teachers were expected to make scientific explanations about how the phases of the Moon are formed.

6.1.2.1. Analysis of the fourth question

Table 13: Frequency table for the fourth question

4	According to the figure on the left, in which of the following phases should the Moon be in order for a person on Earth to observe the lunar eclipse?	Pre-test		Post-test		Persistency	
		f	%	f	%	f	%
A	Full moon	24	82,7	29	100	28	96,5
B	New moon	4	13,8	0	0	1	3,5
C	First quarter	1	3,5	0	0	0	0
D	Last quarter	0	0	0	0	0	0
E	Crescent	0	0	0	0	0	0
Empty		0	0	0	0	0	0

When the table 13 containing the data for the fourth question was examined, 24 teachers in the pre-test, all of the teachers in the post-test, and 28 teachers in the persistency test selected the correct option a.

Table 14: Categories and findings for the fourth question related to the formation of the lunar eclipse

Level	Category	Explanation of category		Practice	f
Knowledge	Full moon phase of the Moon	Those who explain how the eclipse occurs in the full moon phase of the moon or the phase when the moon appears to be bright		Before practice	5
				After practice	8
				Persistency practice	14
	New moon phase of the Moon	Those who explain how the eclipse occurs in the new moon phase of the moon		Before practice	2
				After practice	0
				Persistency practice	0
	First quarter phase of the Moon	Those who explain how the eclipse occurs in the first quarter of the moon		Before practice	1
				After practice	0
				Persistency practice	0
	The Moon in darkness	Those who explain the eclipse as the moon remaining in the darkness		Before practice	5
				After practice	0
				Persistency practice	0
	Appearance of the dark side of the Moon	Those who explain the eclipse as the dark side of the Moon visible from the Earth or the side of the Moon facing the Earth remaining in the dark		Before practice	2
				After practice	6
				Persistency practice	8
	Inability of the Moon to fully receive sunlight	The shadow of the Earth falling on the Moon	Those who explain the eclipse as the shadow of the Earth falling on the moon	Before practice	3
				After practice	1
				Persistency practice	4
		Earth entering between the Moon and the Sun	Those who explain that the Earth enter between the Moon and the Sun while incasing all the sun rays	Before practice	4
				After practice	6
				Persistency practice	7

	Earth blocking the sun rays	Those who explain it as the Earth blocks all the sun rays while preventing the sun rays from reaching the Moon	Before practice	4
			After practice	0
			Persistency practice	1
The Sun, Earth, and Moon are in the same direction	Those who explain that three celestial bodies must come in the same direction for the eclipse to occur		Before practice	0
			After practice	13
			Persistency practice	9

When the fourth question, which is the other question at the level of knowledge, was examined, 82.7% of the teachers selected the correct option, a. In order for a lunar eclipse to occur, the Moon must first be in the full moon phase. In addition, three celestial bodies must be in the same direction. When the given answers were examined, it was observed that most of the teachers stated that the Moon should be in the full moon phase. However, it was seen that they have difficulty in explaining how it is in this phase, which is the brightest cycle of the Moon. It was understood that none of the teachers mentioned that the three celestial bodies should be aligned.

Table 15: Correlation of correct / wrong markings in the fourth multiple-choice question and the explanations for this question

	Pre-test	**Total**	**Post-test**	**Total**	**Persistency test**	**Total**
Those who selected the correct option and made a scientifically correct explanation	13		27		26	
Those who selected the correct option and made scientifically wrong / incomplete explanations	2	24	0	29	0	28
Those who selected the correct option but did not explain	9		2		2	
Those who selected the wrong option and made a scientifically correct explanation	0		0		0	
Those who selected the wrong option and made a scientific wrong explanation	4	5	0	0	0	1
Those who selected the wrong option and did not explain	1		0		1	
Those who did not select any option	0	0	0	0	0	0

According to the table in which the answers given by the teachers to the 4th question and their explanations are compared;

a. In the pre-test practice, none of the teachers mentioned that three celestial bodies must come in the same direction. In the pre-test, 13 teachers both selected the correct option, option b, and gave parallel explanations with the explanations of "The lunar eclipse occurs when the moon is in the full moon phase, and the bright face of the Moon faces towards the Earth in the full moon phase", which is partially correct.

b. When the post-test data were examined, it was seen that the explanation that three celestial bodies must come in the same direction was included in the answers of thirteen teachers. It was also determined that 27 teachers made scientifically correct explanations in the post-test practice in which all the teachers selected the correct option.
c. When the data of the persistency test was examined, it was observed that 28 teachers selected the correct option and that 26 of them made explanations that could be considered scientifically correct. 2 teachers did not make any explanation. 9 of the teachers who made a scientifically correct explanation also mentioned on the explanation of the alignment of three celestial bodies. 2 teachers did not explain by selecting the wrong option.

6.1.2.2. Data analysis of open-ended question

The analysis of the data belonging to the question of *"How does a lunar eclipse occur? Please explain."* is shown in Table 16.

Table 16: Categories and findings for the open-ended question on the occurrence of lunar eclipse

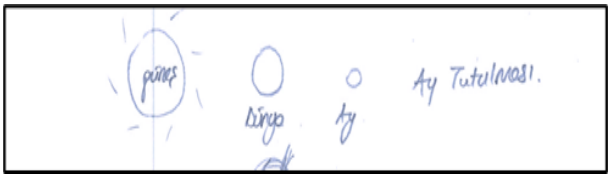
			Pre-test		Post-test		Persistency	
Level	**Category**	**Explanation of category**	**f**	**%**	**f**	**%**	**f**	**%**
Synthesis	Sun-Moon-Earth sequence*	The Moon entering between the Sun and the Earth, the Earth entering between the Moon and the Sun, the Moon being in the new moon / full moon phase, the Moon being behind the Earth, inability of the Moon (due to the intervention of the Earth) to reflect the rays received from the Sun	20	68,9	27	93,1	24	82,7
	Incasing of the Moon	The Moon cannot be seen from the Earth, the Moon cannot reflect the rays received from the Sun (due to the intervention of the Earth), an observer on the Earth cannot observe the Moon	6	20,7	4	13,8	1	3,5
	Formation of shadow	The shadow of the Earth falls on the Moon as a result of the shadow of the Moon falling on the Earth	7	24,1	3	10,3	14	13,8
	Being on the same plane*	Sun, Earth, and Moon coming to the same plane; Moon, Earth, and Sun in the same direction; Sun, Earth, and Moon orbits being in the same direction	6	20,7	18	62	16	55,1
	Other	Partial or complete incasing of the Sun with the entry of a celestial body between the Earth and the Sun, full or partial incasing of the Moon with the entry of a celestial body between the Earth and the Moon, lunar eclipse, the Moon appearing red	2	6,8	1	3,5	1	3,5
	Empty	Those who were not answered	5	17,2	2	6,8	3	10,3

*Scientifically correct

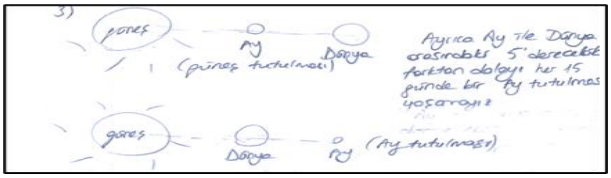
When Table 16 is examined, the obtained data are as follows;

It was determined that 68.9% of the teachers had the idea that the Sun, Earth, and Moon should be arranged in a certain order before the teaching process. This situation is expected. However, this value increased to 93.1% at the end of the teaching process. In addition, it was observed that there was a relatively high concentration in the phenomenon of "these three celestial bodies coming in the same direction". However, it is necessary to discuss the explanation of the reason for the occurrence of "Lunar Eclipse" as "the incasing of the moon" or "shadow formation". Partial or complete incasing of the Moon is not a result/cause of the lunar eclipse, or "shadow formation" is a result and is not the main cause of the eclipse. It is observed that there is an increase in the scientific truths, which are "the realization of the alignment of the Sun, Earth, and Moon" and "the coincidence of the orbits of these three celestial bodies on the same plane" (due to the angle difference of 5%), which is the main reason for the lunar eclipse during the teaching process. Moreover, the value of celestial bodies coming to the same plane/same direction increased from 20.7% to 62%, and this value was fixed at 55.1% in persistency.

Some statements regarding the answers given by the teachers are as follows;



(T2, before practice)



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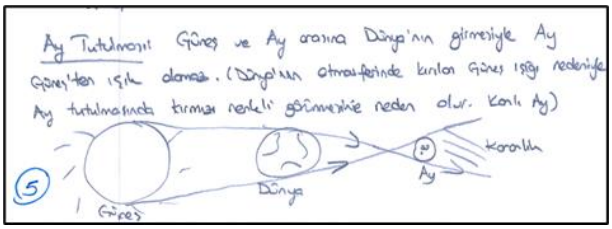
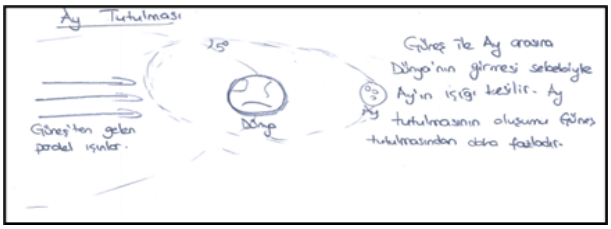


(T5, before practice)



(T5, after practice)

As can be understood from the drawings, whereas the teachers mostly believed that the sequence of three celestial bodies was sufficient for eclipses before the teaching, the opinion that these three celestial bodies should also be in the same direction was added after the teaching. The main subject to be examined here is to determine the effect of models used in developing the mental models of teachers in teaching the effects of the location of these celestial bodies in the universe, their distances, and sizes on eclipses. In this respect, based on the explanations made by the teachers, it was understood that most of them did not have the idea that these celestial bodies must be in the same direction, but it was concluded from the explanations they made later that this idea developed. In addition, it was seen that the explanations of the teachers about the effect of distance and size on eclipses, which were indirectly emphasized in the narration process with models, were included.

7. Conclusion and Interpretation

After the teaching through the developed models, it was concluded that the success levels of teachers related to the concepts of the Moon phases and lunar eclipse were increased. This result is consistent with the view by Snieder, Bar, and Kavanagh (2011) that the visualization will effectively teach astronomical concepts and make the process less complicated. It can be stated that the models developed within the scope of the research are successful in teaching new concepts to teachers and correcting the information they know wrong. However, the study indicated that there is a significant lack of knowledge and misconception among teachers. When the research findings are examined, it is observed that the number of teachers who gave correct answers to the whole test has a significant difference between the pre-test and the post-test. According to Snieder, Bar, and Kavanagh (2011), the mental effort in understanding a scientific explanation can help the teachers combine the position and motion of celestial bodies in space, and once the teachers understand the concept, they can have a unifying structure to synthesize other important ideas in earth and space sciences.

When the effects of the subjects that were taught through the models developed within the scope of the research on the persistency were examined, it was obtained that the questions answered correctly were high. The fact that there is no significant decrease in the level of success in the post-test shows that the developed models provide the least comprehension levels according to the Cognitive domain levels (CDL). It is useful to examine the explanations of the teachers to the multiple-choice questions they answered in order to comment on the level they have reached according to the CDL. The explanations made by the teachers demonstrate that there is a significant increase in the number of the teachers who make scientifically correct explanations.

The first question of the research is to test the information regarding the rotation time of the Moon around the Earth. Although it appears at the level of knowledge, it is a question that measures the level of comprehension because what is really curious in this question is to measure the correspondence of teacher explanations with the scientifically correct information. The obtained data showed that a considerable amount of the teachers selected the correct option in the pre-test. Moreover, this number increased at a certain rate in the post-test, but the correct answer rate was quite high before the practice. When the explanations made to the answers by the teachers were examined, the number of the teachers who gave scientifically correct answers in the pre-test decreased. The teachers know the correct answer of the question, but they have difficulty in explaining their answers. This situation indicated that the teachers had an idea at the level of knowledge about the formation of the phases of the Moon, and therefore had difficulty in comprehending and explaining it at a higher level. When the explanations made to the answers given in the post-test were examined, it was concluded that there was an increase in the rate of making scientifically correct explanation.

In the second question of the study, it was purposed to measure comprehension and higher level cognitive domains. Comprehension of the teachers about the formation levels of the phases of the Moon and the rate of their appearance from the Earth were

examined in the content of the question. It was examined to what extent they have the knowledge that 50% of the moon is always illuminated by the Sun, but that this part of the Moon is sometimes invisible, partially visible, or completely visible from the Earth. This question clearly revealed the cognitive domain levels of the teachers. The answers and explanations by the teachers show that the majority of teachers do not know or cannot imagine that the Moon is always illuminated on one side. The teachers who have an idea about the formation of the phases of the Moon at the level of knowledge based on memorization were determined within the scope of this question. According to the pre-test data, more than half of the teachers could not construct the formation of the phases of the Moon and the results of the movements of the Sun, Earth, and Moon relative to each other. It is observed in the data of the post-test and persistency tests that the developed models are very effective in this acquisition. The fact that scientifically correct answers are in the majority in the post-test and later in the persistency test indicates that this model is successful and serves its purpose.

Another one of the most important questions of the research is the third question. This question is an important question that measures the analysis and evaluation cognitive skills of the teachers. In line with the obtained data, it was concluded that most of the teachers did not select the correct option before the practice, and among the teachers who selected the correct option, there were those who could not explain scientifically. Some of the teachers stated that the seen phase will change according to the hemisphere, latitude, or longitude. One of the most successful achievements of the model developed within the scope of the research and describing the phases of the Moon is to show that the Moon is seen at the same phase from all over the Earth. The effect of the "distance between the Earth and the Moon" that the teachers overlook is clearly shown in this model. Therefore, through the developed model, the answers to the post-test and persistency tests after the teaching and the explanations indicated that the teaching was successful and effective.

The fourth question on the concept of lunar eclipse is the question that the teachers mostly selected the correct answers in the pre-test. However, the fourth question is a question formed at the knowledge level. When the same question was asked to the teachers as an open-ended question in the analysis domain, it was determined that the teachers were not as successful as the fourth question. Most of the teachers increasingly selected the correct option for the question "at which phase the eclipses occur" in the pre-test, post-test, and persistency test, but in an amount that would not make any difference. Therefore, the interpretation of this question was conducted according to the data obtained from open-ended questions.

The concept that has difficulty in reaching the upper levels of the CDL is "how the phases of the Moon are formed". Understanding and analyzing the formation of the phases of the Moon is a mentally difficult skill. The explanations to the question of how the phases of the Moon are formed before the teaching developed within the scope of the research led to the following results;

1) Ignoring the distance between the Earth and the Moon, the teachers try to understand and explain the phases.

2) In order to interpret and evaluate the formation of the phases of the Moon and its appearance form the Earth in different coordinates, it is initially very important to be able to comprehend the real size and distance. The study conducted with the teachers showed that the teachers had stereotyped knowledge before the activities carried out in the research process, that they did not have sufficient knowledge about the formation of the phases, and that they mostly knew what the phases were.
3) The teachers know that the formation of phases occurs when the Moon rotates around the Earth.
4) A significant number of the teachers who had scientifically wrong information were determined within the research.
5) It was observed that there were teachers in the sample group who did not know that the new moon phase occurred during the daytime.
6) Although the teachers stated that the phases were formed by the Moon rotating around the Sun together with the Earth, it was determined that they could not explain what kind of celestial event it came about.
7) The teachers mostly made an explanation that the phases were formed as a result of the illumination of the Moon at different rates.
8) The study indicated that almost half of the teachers did not know before teaching that half of the Moon was always bright. Therefore, it can be stated that this lack of information is the basis of their failure to answer the phases scientifically.
9) In addition, they do not know that the phases appearing in different coordinates are the same because they do not consider the concept of distance at all.

Before the teaching within the scope of the research, the explanations to the question of how the lunar eclipse occur led to the following results;

1) It was observed that teachers have general knowledge about the alignment of the Sun, Earth, and Moon in order for a lunar eclipse to occur.
2) However, it was determined that they could not express their opinion on the overlap of the Earth and Moon rotations (linear positioning of the Sun, Earth, and Moon) for the lunar eclipse to occur.
3) In the study, it was understood that the teachers do not know or ignore the difference of approximately 5° between the orbit of the Moon around the Earth and the orbit of the Earth around the Sun. This angle difference has an important place in the formation of the lunar eclipse. The angle difference between the two orbits was emphasized through the models developed in the research process, and the descent and ascent nodes formed as a result of their effects were mentioned. It is tried to be understood that if the full moon phase is experienced in the regions where the nodes are the moment these descent and ascent nodes occur, there will be a lunar eclipse.

The most overlooked concepts such as the phases of the Moon and the distance, size, angle difference between the orbits, the descent and ascent node, the direction of the celestial bodies in the formation of the lunar eclipse were emphasized in the activities carried out through the models developed within the scope of the research. Therefore, by

focusing on the effects of these concepts, it was ensured that there was a change in the mental models of the teachers. The feedback received from the teachers after the activities carried out through the models developed within the scope of the research show that they have scientifically learned the formation of the phases of the Moon and how the lunar eclipse occurs and that this information is permanently understood (table 12 and table 14). In the explanations made by the teachers according to Table 7 and Table 10, it was determined that the information that the phases were formed due to the rotation of the Moon around the Earth and the Sun and that the Moon, whose half is illuminated, appears from the Earth at different rates is acquired in the analysis domain. Also, it was comprehended at the same domain by the teachers that the information that the same phase appears from all over the world as a result of the distance between the Moon and the Earth.

The data obtained as a result of the research showed that the teachers were able to explain the formation of the phases of the Moon based on scientific foundations. Considering the answers to all questions asked about the formation of the phases of the Moon, when the data in table 4, table 7, table 10, and table 12 were examined, it was observed that the information accepted as scientifically correct in the mental models of the teachers was ensured to be permanently changed.

Understanding the phases of the Moon effectively is also very important in learning the lunar eclipse. Therefore, among the indirect results of learning the formation of the phases in a complete and clear way is also a correct understanding of the lunar eclipse. When the data obtained as a result of the research in table 14 and table 16 were examined, it was determined that the effect of the 5° angle difference between the orbit of the Earth around the Sun and the orbit of the Moon around the Earth, which is one of the important factors in the formation of a lunar eclipse, the meaning of the expression of linear positioning of three celestial bodies, is learnt permanently. For this reason, in order to both learn concepts scientifically and to complete the mental processes successfully, attention was paid to the necessity of addressing both concepts together and teaching them by paying attention to their correlational structures. However, it was concluded that the permanent learning of scientifically correct information was realized as a result of these processes.

About the Authors

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Appendix

Table 17: Actual and approximate values for the Earth and Moon in the model

	Actual Diameter	Proportioned Diameter	Actual distance between Earth and Moon (approximately)	Proportioned distance between Earth and Moon
Earth	12700km	40cm	384400km	12m
Moon	3474km	10cm		