Journal of Education in Science, Environment and Health

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ISSN: 2149-214X

To cite this article:

Sagdic, A. & Sahin, E. (2023). The role of microteaching on pre-service primary school science teachers' conceptual understandings regarding phases of the moon. *Journal of Education in Science, Environment and Health (JESEH)*, *9*(1), 29-43. https://doi.org/10.55549/jeseh.1239054

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Journal of Education in Science, Environment and Health
Volume 9, Issue 1, 2023 https://doi.org/10.55549/jeseh.1239054

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Article Info

Article History

Published:
01 January 2023

Received:
08 January 2022

Accepted:
05 September 2022

Keywords

Conceptual change
Microteaching
Phases of the moon

Abstract

Microteaching is a significant way to prepare pre-service teachers to overcome specific challenges in a natural classroom environment. It is widely accepted that pre-service science teachers gain pedagogical benefits from microteaching activities. Furthermore, microteaching enhances the conceptual understanding of the presenter on the related teaching topics. This research intends to map two pre-service science teachers' conceptual understanding before and after engaging in microteaching on the concept of phases of the moon. The data were collected through pre and post-interviews and observations of microteaching. Activated knowledge elements during interviews and microteaching were determined and compared. The study's results provided evidence that microteaching is a fruitful way to improve pre-service science teachers' understanding of phases of the moon. Furthermore, it was detected that both the quality and quantity of pre-service science teachers' knowledge elements increased after their microteaching engagements

Introduction

Astronomy concepts have been regarded among the most significant agents in teaching the basics of science since it includes apprehensible laws (Schatzman, 1972) and themes, facts, and paradoxes that easily fascinate students (Lelliott & Rollnick, 2010). Therefore, teaching astronomy concepts (e.g., gravity, the night-day cycle, the seasons, and phases of the moon) has taken an important place in various levels of formal education and informal education, such as museums and planetariums. In astronomy education, moon-oriented research studies have focused on moon phases, eclipses, and tides since these were perceived as difficult to conceptualize. These difficulties emerged from the complex nature of the sun/moon/earth system (Gazit et al., 2005) and shortcomings in teacher education programs regarding astronomy (Hemenway, 2009). In addition to these barriers, an individual's lack of spatial abilities also hinders the development of a sophisticated understanding of moon-related issues (Black, 2005; Cole et al., 2015; Wilhelm, 2009). Moon-related topics require performing different types of spatial abilities. Geometric spatial ability is needed to visualize the dimensions of celestial bodies, and spatial projection ability is required to visualize celestial bodies considering the location of an observer (Wilhelm et al., 2013). Furthermore, spatial transformation ability is needed to understand the different appearances of celestial bodies from the earth and space perspectives (Plummer, 2014). Correspondingly, research studies reported that individuals with better performance on spatial ability tasks explained phases of the moon more accurately (Wellner, 1995). Despite the complexity of the topics regarding the moon, it requires teachers to have a solid understanding of the phases of the moon topic. Unsurprisingly, the studies showed that teachers' misconceptions limit their students' learning (Monk, 1994). In this aspect, pre-service teachers should acquire a sophisticated understanding to meet their future teaching responsibilities and competencies. However, an immense body of research (Kanli, 2014; Schoon, 1995; Trundle et al., 2002; Türk et al., 2017) reported deficiencies in pre-service teachers' conceptual understandings pertinent to phases of the moon topics.

Misconceptions of pre-service teachers hinder the development of a sound understanding of moon's phases topic (Schoon, 1995). Therefore, explicit attention has been paid to the literature to explore teaching methods and techniques to improve pre-service teachers' conceptual understandings regarding the phases of the moon. Student-centered activities following an inquiry-based teaching approach providing students with a wide range of learning opportunities, such as observation of the moon for an extended period, discussion on the pattern of the moon, modeling or explaining the sun/moon/earth system, are effective in improving pre-service science teachers' understandings (Abell et al., 2002; Düşkün & Ünal, 2020; Ogan-Bekiroglu, 2007; Trundle et al., 2002, 2006). Furthermore, studies showed that technology-enriched inquiry activities, such as examining the change in the moon's appearance via software and designing animations related to moon phases, also fostered pre-service teachers' understanding (Bell & Trundle, 2008; Nielsen & Hoban, 2015).

As indicated by the relevant literature in astronomy education, student-centered teaching approaches constructed on discussion, developing models, natural observations, and technological equipment usage stimulates pre-service teachers' conceptual understanding of moon-related topics. However, at this point, it should be noted that implementations based on these teaching techniques take extensive periods and needs expensive technical devices or software. For instance, the research of Abell et al. (2002) covered observation, keeping records, and group discussions lasting six weeks. Likewise, Ogan-Bekiroglu, (2007) researched pre-service teachers' understanding of lunar phenomena. Fourteen weeks were devoted to model teaching and learning activities in the research. On the other hand, creating digital teaching sources (Nielsen & Hoban, 2015) or using planetarium software (Bell & Trundle, 2008) is highly dependent on digital literacy. Pre-service teachers should be familiar with using required software or be taught how to use them. Therefore, using technology has become time-consuming activity. In addition, some planetariums are licensed software; consequently, they should be purchased. This situation might be an obstacle for teacher educators.

The present research was devoted to suggesting another plausible way to enhance pre-service teachers' understanding of the moon's phases concepts. Therefore, the current research focuses on a microteaching environment designed for a science teacher education program. It has been advocated that microteaching is an effective and widely preferred way of preparing pre-service teachers for a classroom environment (Copeland, 1977; He & Yan, 2011; Simbo, 1989). Microteaching provides future teachers with some opportunities to engage in specific teaching techniques, re-organize class activities for their later practice, and practice in a short time and not a crowded audience (Fiorella & Mayer, 2014; Peterson, 1973). Besides its pedagogical contribution reported by an immense body of research (e.g., Boz & Belge-Can, 2020; Durdu & Dag, 2017; Fernández, 2010; Önal, 2019; Subramaniam, 2006), microteaching contributed to student teachers' conceptual understandings in their academic field (Annis, 1983; Fiorella & Mayer, 2014; Roscoe & Chi, 2008; Topping, 1996). As pointed out by Bargh and Schul (1980) and more recently by Fiorella and Mayer (2014), prior to instruction, selecting and organizing teaching material for learners improves the conceptual understanding of the instructor in the intended teaching area. Two factors improve the conceptual understanding of the instructor while presenting the subject matter. Firstly, verbalizing and restating subject matter contributes to instructors' conceptualizations and richer understanding (Bargh & Schul, 1980; Coleman et al., 1997). Secondly, teaching others facilitates social interactions with others. Asking or answering questions, correcting errors, and giving feedback enhance cognitive awareness and conceptual understanding (Bargh & Schul, 1980; Coleman et al., 1997).

The current research contributes to research on pre-service science teachers in two critical ways. Firstly, this research suggests a plausible way to improve pre-service science teachers' understanding of phases of the moon concept. The phases of the moon concept are one of the challenging topics for pre-service science teachers. Researchers on this issue suggested implementing time-consuming and technology-integrated activities for pre-service science teachers. However, implementing these suggested ways is not feasible in many circumstances; therefore, different alternative methods are needed to improve pre-service science teachers' conceptual understanding. Secondly, microteaching is generally perceived as a way to enhance pre-service teachers' pedagogical skills, and its contribution to conceptual understanding is usually neglected. Thus, this research extends previous research about the effectiveness of micro-teaching in enhancing the conceptual understanding of pre-service science teachers. In addition, the potential contribution of micro-teaching to conceptual understanding highly depends on the characteristics of the subject matter. Therefore, it is recommended to test microteaching with different domains and complex topics (Fiorella & Mayer, 2013). The present study explores potential changes in conceptual understandings regarding phases of the moon, considering both the role of micro-teaching and the challenges of teaching phases of the moon.

In this aspect, the following research questions guided this research:

1. What is the conceptual understanding of pre-service primary school science teachers regarding phases of the moon?
2. How do pre-service primary school science teachers' conceptual understanding change through microteaching?

The Perspective of the Current Study on Conceptual Change and Lunar Phases

Concepts are mental units of internal representations (Carey, 2000) and are constituted by different knowledge elements organized differently (diSessa, 1993; Vosniadou & Skopeliti, 2014). Changing concepts is a fundamental way of learning since students' preconceptions or misconceptions about the physical world should evolve to expert understanding. The classical view of conceptual change promotes the idea that intuitive concepts have a coherent structure and are replaced with scientific ones via the cognitive conflict method (Posner et al., 1982). However, more recent studies criticized the classical view and suggested knowledge in pieces perspective. According to this perspective, knowledge consists of multiple fragmented knowledge elements rather than a coherent structure. Individuals absorb new knowledge elements, add them to their existing internal representation, and re-organize them (diSessa, 1993; Vosniadou, 2012). The present research followed the paradigm of knowledge in pieces perspective. In the scope of the current research, engaging pre-service science teachers with microteaching involving preparation, teaching, and interaction ensured an opportunity to re-organize their knowledge elements on phases of the moon concepts.

Conceptual understanding can be tracked by the knowledge analysis method. Describing knowledge elements and their changes is an indispensable part of this method. Accordingly, knowledge elements are bits of a knowledge system, and individuals explain a natural phenomenon by activating and organizing them in a context (diSessa et al., 2004). An activated group of knowledge elements is supposed to fit together to solve a problem, respond to a question, or make sensemaking (Hammer et al., 2005). According to Parnafes (2012), four knowledge categories, propositions, mental images, mental models, and general schemas, are functional to capture conceptual dynamics. Propositions refer to statements that are considered entirely accurate. Individuals acquire propositions and, consequently, personal experience or learning. For instance, students may learn from their textbooks that the moon is the earth's satellite, or they stress that the moon's shape changes gradually depending on their daily moon observations. General schemas are explanations of the working mechanism of things (Parnafes, 2012). For instance, a student may stress that the distance between the moon and the earth determines the moon's shape. Therefore, it is plausible to consider that this student activated a general schema of distance to explain phases of the moon. The mental model corresponds to the dynamic and runnable mental structure created dealing with an issue or responding to a question (Vosniadou & Brewer, 1992). Explanations and demonstrations pertaining to the moon's orbit around the earth can be given as an example of a mental model. The final category is mental images, which refer to static images and snapshots of a concept. For example, students' drawings of different appearances of the moon can be categorized as mental images.

The sun, the earth, and the moon are related to the occurrence of lunar phases. Four mechanisms among these celestial bodies should be noticed to understand why we observe different moon phases (Parnafes, 2012; Trundle et al., 2002, 2007). As seen in Figure 1, while orbiting around the earth, half of the moon is illuminated by the sun. In addition, it should be considered that we only see half of the moon from the earth. Finally, individuals should visualize the lightened side of the moon seen from the earth to determine lunar phases. A total number of four general schemas are necessary to explain this phenomenon. These knowledge elements were entitled "orbit," "illumination," "half," and "apparent." Due to the mechanism explained above, eight different basic moon shapes have appeared from the earth. These different appearances and their names are shown in Figure 1.

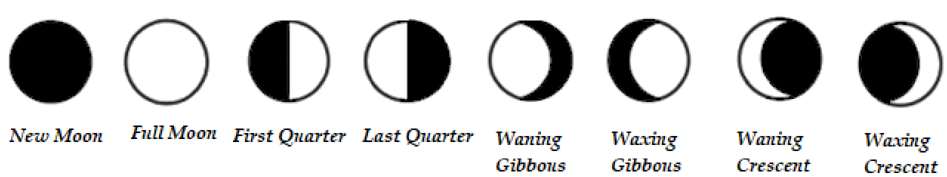

Figure 1. Name and appearance of the lunar phases

It is documented that lunar phases concept is confused with the eclipses concept, not only for children but also for adults. Since both phenomena occur due to the movement of the sun/earth/moon system, individuals cannot differentiate lunar phases from eclipses. A solar eclipse occurs as a result of the occultation of the sun by the moon, and lunar eclipses occur while the moon moves into the earth's shadow cone (Moore, 2000). Lunar eclipses and full moons occur when the earth is located between the moon and the sun, and solar eclipse and the new moon occur when the moon is located between the sun and the earth. Since the moon's orbit is tilted by 5.2 degrees, the shadow of the earth and the moon fall above or below. Therefore, eclipses do not occur once a month. Another problem detected by the previous studies (e.g., Ogan-Bekiroglu, 2007) is related to the moon's appearance in the daytime. The individual considers that the moon can be observed only at night. However, since its brightness is enough, it is visible when the moon is high enough in the sky. In addition, it is noted that (Parker & Heywood, 1998) awareness of the nature of light, including its rectilinear propagation and reflection from a spherical surface, is crucial to understanding lunar phases.

Research Methodology

Research Design

This research was designed concerning a qualitative case study. Each participant corresponded to the cases of the research. Conceptual understanding related to moon-related topics is complex since different pre-service teachers activate different knowledge elements. These knowledge elements interact with each other and constitute a unique conceptual structure for individuals. Therefore, this research was conducted to provide an in-depth explanation of pre-service science teachers' conceptual understanding.

Participants

Participants of the research were two senior female students in the field of primary school science education. Participants (Eva and Arya as pseudo names) had almost similar experiences in the field of astronomy. They pursued an introductory astronomy course lasting one term in their second year of the undergraduate teacher education program. They have not participated in a training program dealing with astronomy issues provided in out-of-school learning environments. Their knowledge of astronomy stemmed from popular media and undergraduate astronomy courses.

Research Context

Data of the present research were collected at an undergraduate course requiring teaching experience while providing student teachers some opportunities to reflect upon teaching. In the context of the course, pre-service teachers obtained experience in different teaching primary school science topics in a real classroom environment and the faculty class as a microteaching activity. This research was designed to examine the role of pre-service science teachers' microteaching, including teaching, preparation, and social interaction, on the development of conceptual understandings concerning phases of the moon. In this regard, two pre-service science teachers were assigned to teach their classmates phases of the moon topic. After one week of preparation, two pre-service science teachers gave their classmates thirty minutes of instruction. Although eleven pre-service science teachers were pursuing this undergraduate course, the current study examined two pre-service science teachers' instructions on phases of the moon. Since the other micro-teaching activities should be related to physics, chemistry, and biology issues, they were not involved in the current study.

Data Collection Tools

Interviews. Pre-service science teachers were interviewed to map their conceptual understanding before and after microteaching. Both interviews included six main questions based on previous research (Nielsen & Hoban, 2015; Stahly et al., 1999; Trundle et al., 2002) to reveal a conceptual understanding of the moon's phases. Furthermore, each participant was directed to two questions to determine their interest in astronomy in the pre-interview and the sources they utilized for preparation for instruction.

Interviews were designed as semi-structured, requiring further questions to articulate participants' ideas. The pre-service science teachers were interviewed before and after one week of their instructions. Spheres and drawings were utilized to enrich their verbal explanation during the interview, similar to previous research (Barnett & Morran, 2002; Stahly et al., 1999; Trundle et al., 2002). To explain the phenomenon, participants responded to the question one more time with their illustrations and spheres. Each interview lasting approximately 30 minutes, was video and audio recorded and then transcribed. Interview questions are presented following table.

Table 1. Interview questions

Interview questions
What are the moon’s phases?
Can you draw the appearance of the moon for each phase?
What are the names of these phases?
What causes the moon to have different appearances?
Can you draw the mechanism of each phase?
Can you demonstrate how the different phases occur with three-dimensional models?

Observation of Microteaching. Both pre-service teachers’ microteaching activities included the names, sequences, and causes of phases of the moon. They preferred student-centered teaching methods enriched by questioning, three-dimensional models, and worksheets. A total of nine pre-service teachers acted in the primary school students' role, and the researchers were in the classroom during their instruction. Pre-service science teachers taught in a technology classroom, including a smartboard and computer. Both researchers and classmates provided feedback at the end of the microteaching activity regarding the only pedagogical aspect of the instruction. Feedback regarding the subject matter was given after completing the research to prevent manipulation of participants’ conceptual understanding before the second interview. Microteaching activities were videotaped and transcribed. Researchers focused on pre-service science teachers’ verbal explanations, conversations with their classmates, and feedback on classroom activities while analyzing recorded video data.

Data Analysis. The theoretical construct of knowledge in pieces perspective and framework developed by Parnafes (2012) were utilized to describe and compare pre-service science teachers’ conceptual understandings before and after microteaching. Inferences were generated from pre-service science teachers’ explanations, drawings, and model demonstrations. In other words, to generate inferences, pre-service science teachers’ arguments were analyzed as a whole. Therefore, a holistic perspective was followed instead of coding data. As noted before, four general schemas are necessary to produce a scientific explanation of lunar phases. In addition to them, pre-service teachers activated different general schemas. A complete list of the detected general schemas and their descriptions are tabulated in Table 2.

Table 2. Activated general schemas

Shemas	Descriptions
Orbit	The moon orbit around the earth
Illumination	The sun illuminates the moon
Half	An observer from the earth always sees half of the moon
Apparent	The entire illuminated half of the Moon does not always point toward the earth.
Angle	The angle of light received from the moon determines phases.
Blocking	An object can block light from the sun.
Reflection	Different parts of the moon reflect light on the earth to a different extents.
Face	Only the same side of the moon is visible from the earth

Findings

In this section, the findings of the present research were documented concerning two identified cases. Pre-interview, observation of microteaching, and post-interview were presented, respectively.

Case 1

Pre-interview. The results showed that Eva had embryonic ideas about different appearances and causes of the moon phases. Initially, s/he tried to explain why we observe the moon with its various shapes. S/he said, “I think it is related to the relative location of the moon to the earth. I am not sure”. Accordingly, Eva attributed the different phases of the moon to its orbit around the earth. Namely, s/he activated the general schema of "orbit" to explain the moon's phases. Eva could not explain why and how the orbital position leads to different moon appearances due to her superficial understanding. On the other hand, s/he stressed that the shape of the crescent moon changes after days and then becomes a full moon. S/he drew the name and sequence of each phase, as seen in Figure 2.

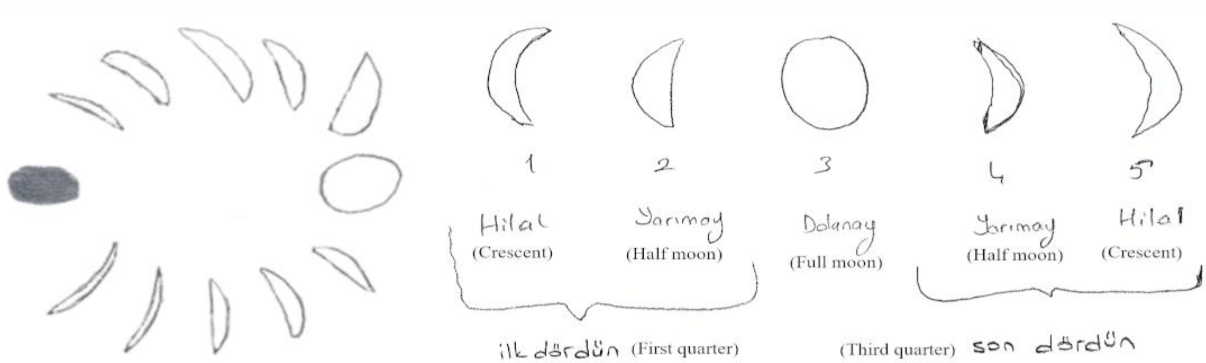

Figure 2. Eva's perspective on the appearance of the moon's phases

Figure 2 shows that s/he was aware of the certain shapes of the moon. The diagram included waxing and waning crescent, first and last quarter, full moon, and new moon. However, waxing and waning gibbous did not exist in these diagrams. Terminological problems also appeared. S/he did not differentiate crescent moons as waxing and waning. In addition, s/he is entitled to the first and last quarter as a half-moon. According to her perspective, the first quarter and last quarter corresponded to crescents and half-moons. Her explanations were based on her limited past observation and terminological similarities among the terms. S/he entitled the first quarter as half-moon and the half-moon and waxing crescent as the first quarter.

Eva was asked to explain different moon phases via the researcher's sun/moon/earth models. S/he did not show specific lunar phases while organizing the positions of the sun/earth/moon models. However, s/he inserted new explanations for the moon's phases. S/he articulated:

> The moon does not have anything. It is just the reflected light of the sun. It should reflect all sunlight to be a full moon. If the moon is right in front of the sun, it may be a solar or lunar eclipse. But I could not memorize what exactly they were.

While explaining the previous utterance, Eva located the moon model between the earth and the sun, corresponding to the new moon phase. In other words, Eva stressed that the moon reflects sunlight from the sun to be a full moon while demonstrating a position where there was any received sunlight to the half of the moon seen from the earth. This situation showed that Eva activated the "reflection" general schema. However, s/he could not visualize how reflection occurs from the moon to earth in three-dimensional nature. Afterward, s/he located the moon behind the earth relative to the sun to show crescent moons. S/he stressed that it is somewhere here but not at an invisible point while pulling over the moon from the line of the earth/sun. S/he noted that the moon could reach the sunlight to its edge in this way. It was revealed that Eva harbors "blocking" general schema. Therefore, s/he avoided locating the moon in line with the earth due to possible inhibition of sunlight by the earth. In other words, s/he considered that the moon could not be seen when it was behind the earth relative to the sun.

From the scientific explanation of the phases of the moon and knowledge in pieces perspective, we can claim that Eva did not have a solid understanding of the moon's phases. It was revealed that the general schemas of "orbit," "blocking," and "reflection" were activated while responding to the interview questions about phases of the moon. S/he tried to explain the phases of the moon concepts via activating these knowledge elements. However, both "blocking" and "reflection" general schemas were not related to the scientific explanation of phases of the moon. Furthermore, Eva's model demonstration showed that s/he could not visualize the spatial characteristics of the sun/earth/moon. S/he stated that the moon reflects the sunlight between the sun and the earth; therefore, we observe the full moon. However, this position corresponds to the new moon since half of the moon we observe is not illuminated by the sun. Eva's mental model regarding phases of the moon and activated knowledge elements is summarized in Figure 3.

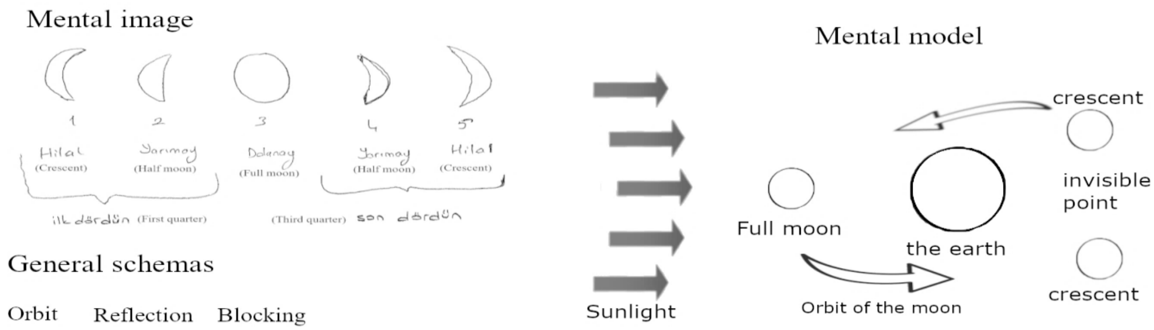

Figure 3. Summary of mental elements activated by Eva

Observation of microteaching and post-interview. The instruction of Eva commenced with introducing different appearances of the moon. S/he stressed:

> Eva: I do not know whether you are interested in moon phases. I have tried to observe the moon for a long time. Now, we are observing the moon with its crescent phases. However, it was different last week. Is there anybody who observes different lunar phases?
> Student 1: Sometimes, it is enormous.
> Student 2: We sometimes could not see the moon.
> Eva: We can start our activities (distributing activity sheets). Could you read the first question?

As seen in the utterance above, Eva explained that the moon had different appearances. Initially, s/he asked the students to draw different shapes of the moon. After drawing each phase, Eva confirmed their appropriateness. It was revealed that students appropriately presented the figure of eight moon phases. Compared with responses in the pre-interview, s/he enhanced mental images of the appearance of lunar phases. Although s/he did not mention the waning and waxing gibbous moon in the pre-interview, these two moon phases took place under Eva's instruction.

After the drawing activity, s/he provided computers with a simulation program and asked students to observe the moon's phases via this software. After the students' examination, Eva directed questions to understand students' ideas on lunar phases. S/he said:

> Eva: We all see the different phases of the moon and draw them on the board. Why did we observe these different shapes of the moon?
> Student 1: The moon revolves around the earth.
> Eva: You say we observe phases since it revolves around the earth. Are there any explanations? Is there anything you want to add to this explanation?
> Student 2: While revolving, the part of the moon that receives sunlight changes. Therefore, we observe the phases of the moon.
> Eva: Is there anybody who explained it better? Look at the board (showing simulation). You can observe how the sunlight comes and the movement of the moon. While changing the position of the moon, phases also change. Why does this happen?
> Student 3: It is also related to our viewpoint. I mean that extent of the moon that we observe from our location determines moon phases. We observe the side closest to us divided by a green line (Eva changed the moon's position to the new moon). The part of the moon that is closest to us is dark. Therefore, it is the new moon.
> Eva: Yes, that is right. Since the moon's light could not reach, we observed the new moon. Here (full moon position), the part of the moon that we see receives all the sunlight. Do you understand?

The utterance above showed that Eva and Eva's classmates appropriately pointed out the factors behind the moon's phases. Eva's classmates explained, and Eva confirmed that the moon orbits around the earth (orbit), half of the moon was observed from the earth (half), half of the moon is illuminated by the sun (illumination), and illuminated part of the moon we observe from the earth (apparent) refers to the phases.

Post-interview conducted with Eva also showed that s/he changed her ideas from the pre-interview. S/he again explained the appropriate names of each different phase and their sequences. Her explanation regarding the moon's phases is shown in the following utterance.

> The location of the moon is essential. I want to explain it by showing these two examples (full moon-new moon). Considering these objects like the moon/earth/sun, the side of the moon we see receives sunlight; therefore, we see the moon as a full moon. On the other hand, the side of the moon illuminated by the sun is here, but we cannot see this part. The part we see does not receive sunlight; therefore, we cannot see the moon. The moon is the satellite of the earth and orbits around the earth. Depending on its different positions, we see it with its different shapes. It reflects the sunlight received from the sun, and we see.

As seen in the excerpt above, Eva appropriately explained the new moon and full moon phases. S/he considered the moon's orbit around the earth and illuminated part of the moon. Then, s/he considered the part of the moon we see from the earth to predict the moon's phases. After Eva discussed different moon appearances, s/he asked students to entitle the appearance of different phases. Students were appropriately entitled to eight different phases of the moon. Figure 4 presents the summary of Eva's activated mental elements.

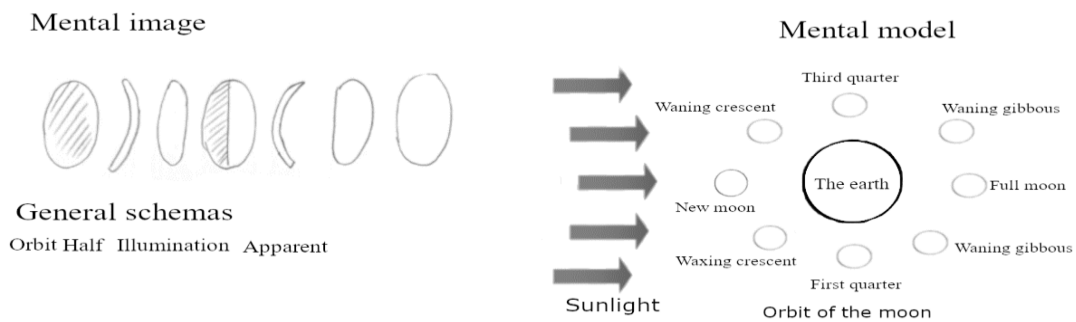

Figure 4. Summary of Eva's conceptual understanding

As shown pre-interview segment, s/he activated "orbit," "reflection," and "blocking" general schemas while explaining phases of the moon. Comparing Eva's instruction and post-interview with her pre-interview, it was revealed that s/he deactivated "reflection" and "blocking" general schemas and activated "half," "illumination," and "apparent" general schemas. In addition, s/he appropriately explained the reasons behind the moon's phases via her mental model.

Case 2

Pre-interview. Analysis of Arya's explanation and drawings showed that s/he also has a superficial understanding of lunar phases. Explanation of Arya regarding phases of the moon covered several related and unrelated knowledge elements with moon phases. S/he activated the general schema of "illumination" and "half" in her explanation. S/he articulated,

> Sunlight illuminates the moon. The moon reflects the sunlight to us from the part we see. We also see the same face of the moon. Because of the different angles of sunlight (received from the moon), we observe the moon with its different phases.

As seen in the excerpt above, Arya also considered that the angle of sunlight reflected by the moon is associated with moon phases; we observe only one face of the moon (face), and the moon reflects sunlight (reflection). In other words, Arya activated only the "illumination" general schema, which is necessary to explain phases of the moon considering the excerpt above. Other activated general schemas such as "face," "angle," and "reflection" are not directly associated with lunar phases. According to normative scientific explanation, we observe only one side of the moon. This situation is related to the fact that the moon's spin and orbit around the earth take the same time. Although Arya considered this fact, there is no direct relationship between the appearance of the same face of the moon and lunar phases. In addition, the angle and amount of the reflected light are not the factors that determine phases of the moon.

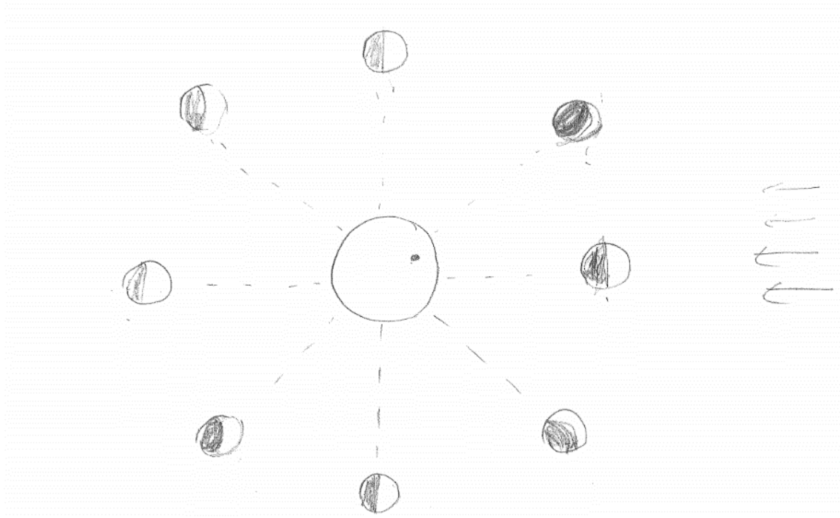

Figure 5. Arya's perspective on the appearance of the moon phases

In addition to the explanation above, Arya drew Figure 5, which indicates her mental image. On the one hand, s/he showed different appearances of the moon while orbiting. Therefore, it was revealed that s/he activated the “orbit” general schema. Figure 5 also showed that Arya was aware of each phase's appropriate sequence and name. On the other hand, s/he confused the space-based and earth-based appearance of the moon. According to a space-based demonstration, half of all moons closest to the sun must be illuminated, while the other half is dark. Since an observer observes the phenomenon from the top of the sun/moon/earth system, s/he only observes that half of the moon is illuminated by the sun. The moon's appearance from the earth is generally demonstrated separately, as seen in figure 8. However, considering Figure 5, some of the moon shapes have greater illuminated parts while some have less, which is the moon's appearance from the earth, not space. In other words, although Arya drew a space-based demonstration of the moon's phases, s/he inserted the earth-based appearance of lunar phases in her demonstration. The shape of the gibbous moons, which resemble a thick crescent moon, is another problem in Arya’s drawing. Figure 6 shows a summary of Arya’s understanding of the lunar phases.

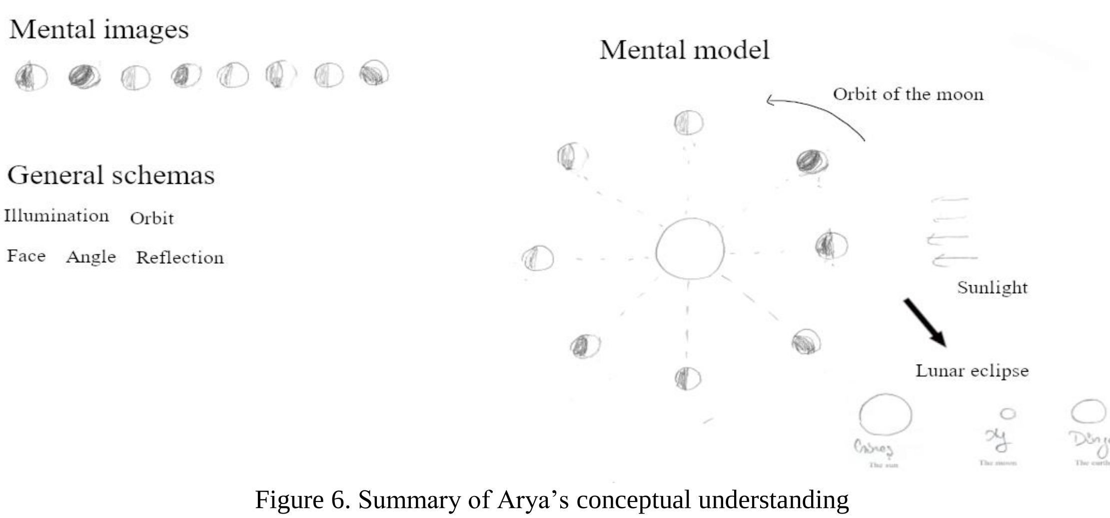

Figure 6. Summary of Arya’s conceptual understanding

Observation of microteaching and post-interview. Arya explained that the moon revolves around the earth at the beginning of instruction. S/he designed role-playing activity with three students acting as the moon, the earth, and the sun. The students performed as the moon held a half-black ball. Arya stressed that the black part of the moon corresponded to half of the moon, which does not receive sunlight. The student acted as the moon revolved around the earth and spun the ball in her hands. The student acting as the earth explained what s/he observed and drew them on the board. At the end of the activity, the student drew eight different appearances of the moon. Arya noticed the shape of the waning gibbous moons was not appropriate. S/he corrected it, as seen in Figure 7.


Figure 7. Change of appearance of the waning gibbous moon

As shown in Figure 7, the student drew waning gibbous moons as it was a concave appearance (on the left side). Arya realized this mistake and changed the appearance of gibbous moons from concave to convex, which is seen on the right of Figure 7. This situation showed that Arya has appropriate mental images of the moon's phases. Therefore, s/he realized students' mistakes and corrected them.

After this activity, Arya demonstrated a video including the change in the moon's phases while the moon orbits around the earth. After the video, Arya explained why we observed the moon phases, as shown in the excerpt below.

> As seen from the video, suppose that sunlight comes from this side (illumination), and the moon revolves around the earth (orbit). While the moon revolves, only half of it receives sunlight (half). The shape of the half that we always observe changes (apparent). In other words, the illuminated portion of the half that we see changes since the moon's orbit around the earth.

Arya enhanced her understanding of the moon's phases compared to the pre-interview. "Orbit," "half," "illumination," and "apparent" general schemas were activated. S/he deactivated the "face," "angle," and "reflection" general schemas while explaining the phases of the moon. Dialogs between Arya and her classmates also indicated that Arya improved her understanding of the moon's phases.

> Arya: Who can tell me why we observe lunar phases?
> Student 1: The moon spins and orbits around the earth. Considering the moon, the earth, and the sun, it changes depending on sunlight. It also orbits around the earth. It prevents.
> Arya: Is there someone else? You should have understood the issue after my explanation.
> Student 2: We observe only one face of the moon. We observe the moon's phases since sunlight arrives and the moon orbits.
> Arya: That is right. If the moon did not orbit around the earth, we would not observe the moon's phases. Your friend's explanation (student 1) reminds me of a critical aspect of the issue. Your friend said that the earth prevents the moon. What do you think about that? Might different appearances of the moon may be related to the shadow of the moon?
> Student 3: It is related to the moon's position in the earth's orbit.
> Arya: Absolutely; the moon's position determines the moon's phases. The invisible part of the moon is not because of the moon's shadow.

Utterance above showed that both Arya and her classmate focused on the moon's orbit around the earth and the moon's illumination as a reason for the moon's phases. One student emphasized the moon's phases occur due to the prevention of the moon by the earth. S/he explained that the shadow of the moon was not a reason for the phases of the moon. This situation showed that Arya differentiated eclipse concepts from lunar phases.

Arya explained the names and sequences of the moon phases and why we observe these different appearances while utilizing the same video. Then, s/he finalized her micro-teaching instruction with a worksheet, including an activity regarding the puzzling change of moon phases. As seen in Figure 8, s/he designed this activity considering different perspectives. In other words, s/he differentiated the space-based appearance of the moon from its earth-based appearance. Compared to the pre-interview, her understanding improved concerning spatial characteristics of celestial bodies.

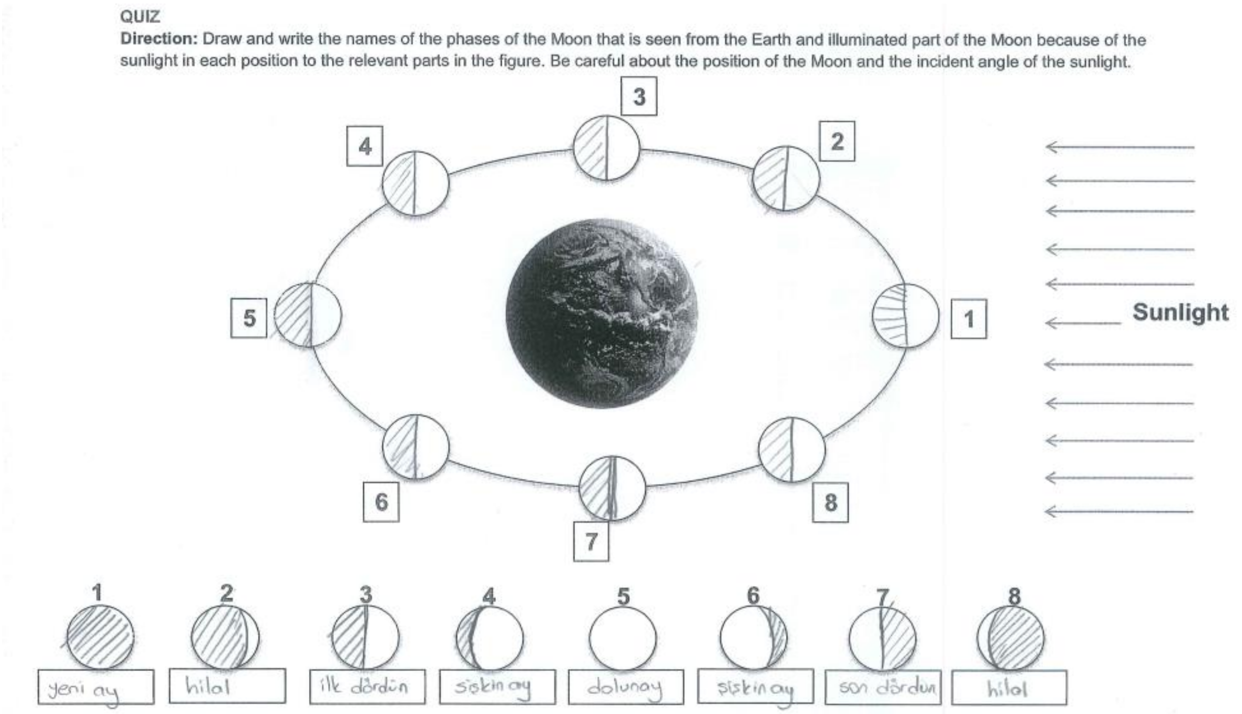

Figure 8. Sample activity sheet

In the second interview, Arya also responded to the interview questions confidently. S/he accurately indicated which part of the moon is illuminated and which is seen from the earth. Arya's drawing and explanations are summarized in Figure 9.

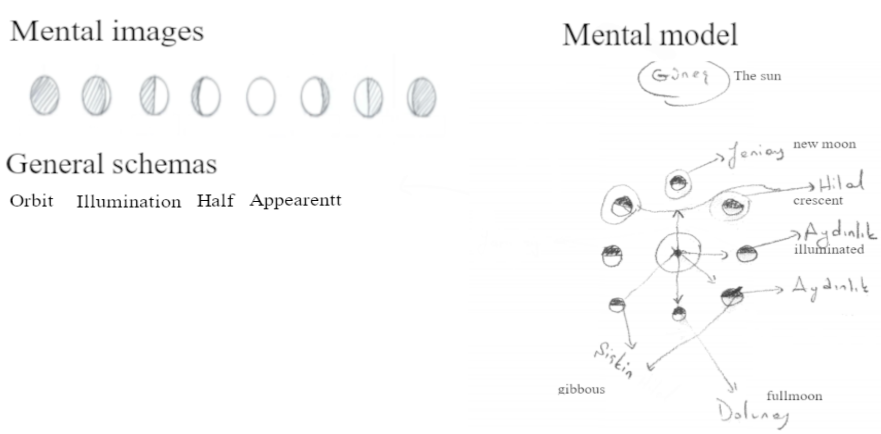

Figure 9. Summary of Arya's conceptual understanding

Discussion

This research attempted to examine pre-service primary school science teachers' conceptual understandings regarding phases of the moon. It was also intended to demonstrate the reflections of microteaching on their conceptual understandings. It was revealed that pre-service science teachers possessed different and superficial understandings concerning phases of the moon. After engaging in a microteaching process, pre-service science teachers improved their understanding. They activated all necessary general schemas for normative scientific understanding of lunar phases. In addition, the detected general schemas and mental images appropriately described lunar phases. At this point, it was found that engaging with microteaching activities improves pre-service science teachers' understanding of lunar phases. The quality and quantity of knowledge elements activated by pre-service science teachers increase after microteaching. Studies on conceptual change (diSessa, 1993; Vosniadou, 2012) stated that individuals re-organize their conceptual understanding due to daily life experiences. It was plausible to conclude that engaging with microteaching ensure learning opportunity for pre-service teachers. Therefore, they reached a more sophisticated understanding of lunar phases by activating necessary general schemas and deactivating unnecessary general schemas.

The current research findings were consistent with previous studies (e.g., Abell et al., 2002; Bell & Trundle, 2008), which showed pre-service teachers improved their understanding after engaging in inquiry-based activities. However, this research reported that pre-service science teachers could improve their understanding without different approaches requiring long periods and the ability to use technological devices. Specifically, pre-service science teachers stimulated their conceptual understanding with their preparation to teach and microteaching practices. These results were not surprising since pre-service science teachers whose age was approximately twenty years old had more life experience and awareness of their knowledge compared with preschool, primary school, and high school students. Motivating or engaging pre-service science teachers in microteaching may improve their conceptual understanding.

Previous research studies pointed out that teaching to others contains preparation, instruction, and interaction segments (Bargh & Schul, 1980) and could be a significant agent in developing conceptual understandings of various topics (Fiorella & Mayer, 2013, 2014). Pre-service science teachers engaged in microteaching activities in the current research also included preparation, instruction, and social interaction. Pre-service teachers who participated in the present research searched about teaching methods, materials, books, and videos to improve the quality of their presentations. Then, they instructed phases of the moon topic and verbalized related concepts. Instruction to their classmates contained social interaction, such as asking questions, responding to questions, or giving examples. Thus, improving the conceptual understanding of pre-service science teachers may be related to all three steps: social interaction, instruction, and preparation. However, this study did not design to examine the potential contribution of different steps of microteaching. Therefore, it was impossible to determine which part of microteaching was more effective in enhancing pre-service science teachers' understanding of phases of the moon concept in the context of the current study. On the other hand, the present study was conducted with two pre-service science teachers with almost the same level of experience in astronomy issues. The role of micro-teaching in the conceptual change of pre-service science teachers who had different experiences could not be observed in the context of the current research. It was recommended for future research to examine and compare the contribution of different microteaching steps to the development of conceptual understanding of a great number of pre-service science teachers. In this way, teacher educators may design their microteaching activities more effectively considering the potential contributions of these steps.

The present research also indicated that the pre-service teachers were not equipped with substantial observational knowledge of the sky. For instance, pre-service science teachers could not show different appearances of the moon during a month at pre-interview. The lack of observational knowledge of science teachers was documented in the previous research. For instance, Mant and Summers (1993) showed that teachers could not explain the apparent daily movement of the moon and other celestial bodies. This problem was generally attributed to the lack of experience in sky observation (Mant & Summers, 1993). It was revealed that pre-service science teachers' experience in sky observation was indispensable to properly understanding astronomy topics. Thus, pre-service science teachers should be motivated to observe the moon and other celestial bodies.

Previous studies reported that teaching others contributed to conceptual understanding. Since the contribution highly depended on the characteristic of subject matter knowledge, research about the effectiveness of microteaching on different domains was suggested (e.g., Fiorella & Mayer, 2013). According to the current research, it was revealed that pre-service science teachers improved their understanding of the concept of the lunar phase after engaging in microteaching. To be more specific, pre-service science teachers appropriately explained the name and sequence of lunar phases and the rationale behind the different appearances of the moon. As aforementioned, different spatial abilities, such as spatial transformation, spatial projection, and geometric spatial ability, were required to understand the moon's phases. Compared with the pre-interviews, pre-service science teachers had better performance with respect to their spatial ability. To cite an example, they demonstrated the moon's appearance from the earth and space to their classmates. In addition, Arya corrected her classmates' drawings of the gibbous moon from concave shape to convex. These situations showed that pre-service science teachers utilized the necessary spatial abilities to teach phases of the moon. Therefore, it was plausible to consider that the pre-service science teachers also enhanced their spatial abilities during the microteaching process.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors

Acknowledgments

Ethical approval. All procedures performed in studies involving human participants were in accordance with the ethical standards of the national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.
Data availability. Data generated or analyzed in the current research is available from the authors on request.
Conflict of interest. The authors declare that they have no conflict of interest.

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