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Kindergartners' Mental Models of the Day and Night Cycle: Implications for Instructional Practices in Early Childhood Classrooms

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Abstract

This study aims to examine kindergarten children's mental models of the day and night cycle and provide implications for pedagogical practices targeting space science concepts in early childhood classrooms. A total of 46 kindergartners participated in the study, their age ranging from 60 to 75 months, including 22 boys and 24 girls. Semi-structured interviews involving three tasks (verbal explanations, model manipulation, and model labeling) were conducted to collect the study data and children were individually interviewed. The data were analyzed using the model identification methodology. The results demonstrated that more than half of the children had naïve mental models of the day and night cycle with the distance model being the most common naïve model held by the children. A total of eight children held synthetic models of the day and night cycle while only six children held a scientific model of the day and night cycle. The findings of this study suggest that children possess limitations in verbally providing causal explanations. The use of models during the interviews helped children in expressing their ideas in a more competent manner, thereby overcoming their limitations in producing verbal explanations. Implications for pedagogical practices to support learning of the day and night cycle in early childhood classrooms are provided.

Keywords: Day and night cycle • Mental models • Kindergartners • Early childhood education

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Children, even at early ages, construct explanations for how the natural world works based on their daily observations of nature and the information they are exposed in their culture. The day and night cycle is one of the regularities that is easily observable by young children. Children, as young as two years old, begin to notice the differences and similarities between activities that are typically associated with day and night and celestial objects in the day and night skies (Trundle, Saçkes, Smith, & Miller, 2012). Based on these early observations and experience with day and night skies, children construct causal explanations about what makes day and night. Children's explanations or mental models of natural phenomena, however, are mostly contrary to scientific explanations and have potential to impede children's learning of scientific concepts in later grades (Trundle & Saçkes, 2012).

To date, a large body of literature dealing with young children's conceptual understandings of the day and night cycle has been generated (Saçkes, 2015). Nevertheless, such studies with young children are very few in Turkish literature on early childhood science education (Doğru & Şeker, 2012; Küçüközer & Bostan, 2010). Limited studies with Turkish kindergartners, however, are solely based on either children's verbal explanations or drawings, which are ineffective in identifying children's causal explanations due to young children's limitations in language and ability in representing 3D phenomena in two-dimensions. Moreover, studies suggest that while children in different cultures may share some common intuitive and synthetic mental models of the day and night cycle, they also have some unique models (Diakidoy, Vosniadou & Hawks, 1997; Samarapungavan, Vosniadou & Brewer, 1996). Similarly, compared with their peers in different cultures, young Turkish children might have similar and/or unique conceptions of the day and night cycle. Therefore, studies documenting the content of the young Turkish children's minds are required because it has profound implications for curriculum planning and the design of pedagogical techniques appropriate for young children.

The findings of the earliest study conducted with children regarding their conceptions of the day and night cycle revealed that the apparent motion of the sun in the sky was the most common explanation for the day and night cycle offered by young children (Piaget, 1972). Subsequent studies with children from preschool to early elementary grades corroborated the findings of Piaget (e.g. Küçüközer & Bostan, 2010; Sharp, 1996; Valanides, Gritsi, Kampeza & Ravanis, 2000). For instance, in a study conducted with 33 five- to six-year-old Greek children, the movement of the sun in the sky was the most common explanation for the day and night cycle (Valanides et al., 2000). A similar response pattern was observed in a study conducted with over 100 Greek children (Kallery, 2011). However, a considerable number of children asserted that deviations in sun's strength during the course of the entire day are responsible for the day and night cycle. These children claimed that the sun is strong in the morning, it becomes stronger in the day, and the sun loses its strength toward the end of the day which darkens the sky.

Recent studies conducted with Turkish kindergartners indicated that the movement of the sun in the sky was the most popular explanation among young Turkish children (Doğru & Şeker, 2012; Küçüközer & Bostan, 2010). Küçüközer and Bostan (2010) observed that some children associated the day and night cycle with the existence or absence of the moon in the sky. These children explained that when the moon is not in the sky it is daytime, and when the moon is up in the sky, it is nighttime, showing no awareness that the moon can be observed both during daytime and nighttime. Some children asserted that by covering the sun at certain times, clouds cause the day and night cycle. Some children cited supernatural forces as the cause of the day and night cycle or offered non-causal utilitarian or functional explanations (e.g., The night is for people to sleep and the day is for work or school).

In a seminal study with U.S. children from kindergarten to fifth grade, Vosniadou and Brewer (1994) described several mental models of the day and night cycle. Younger children were most likely to have naive mental models where the movement of the sun away from earth or the blockages of sunlight by obstacles (like clouds) are offered as the reasons for the day-night cycle. Older children, however, were likely to hold the type of conceptual understandings, called synthetic mental models, which integrate the elements of scientific explanation with their naïve conceptual understandings. Synthetic mental models of the day and night cycle exhibit several misconceptions regarding the movement and the position of the celestial objects (i.e., the earth, the sun, and the moon) and their role in producing the day and night cycle. For example, some children with synthetic mental models might assert that the sun and the moon travel around the stationary earth in one day, while others claim that the earth and the moon travel around the sun in a day or the sun and the moon travel in an up and down direction relative to

earth causing the day and night cycle (Vosniadou & Brewer, 1994). Certainly, these children have been instructed regarding the concepts of revolution and rotation and attempted to integrate these scientific concepts with their intuitive mental models thereby constructing synthetic mental models.

Vosniadou, Skopeliti, and Ikospentaki (2004) also investigated five- to nine-year-old Greek children's conceptual understandings of the day and night cycle. Results indicated that the earths' movement around the sun was the most popular misconception possessed by older children. However, younger children favored the idea that the clouds or the mountains occlude the sun causing the day and night cycle. Findings of a study with Indian children (Samarapungavan, Vosniadou & Brewer, 1996) suggested that Indian children possess mental models of the day and night cycle similar to their European-American peers. While younger Indian children possess intuitive mental models, older Indian children tend to hold synthetic and scientific mental models of the day and night cycle. The intuitive mental models of younger Indian children were based on Indian mythology. For instance, young Indian children believed that the earth hovers on a large body of water and the sun and the moon sink into and rise from the water underneath the earth producing the day and night cycle (Samarapungavan et al., 1996). Collectively, the findings of these studies conducted with Greek and Indian children suggest that children from different cultures predominantly construct similar mental models of the day and night cycle.

The findings of the most recent studies on young children's conceptual understandings of the day and night cycle aligned with the results of the previous studies. For instance, Siegal, Butterworth, and Newcombe (2004) investigated four- to nine-year-old Australian and English children's ideas regarding the day and night cycle. Researchers employed two different interview protocols in gathering the study data. In the first interview protocol, called explicit questioning, models of the sun, earth, and the moon were used to reveal the children's ideas. The findings revealed that 70% of the Australian and 43% of the English children possessed a scientific explanation for the day and night cycle. In the second interview protocol, a procedure similar to that utilized in Vosniadou and Brewer's (1994) study was used to examine four- to six-year-old Australian children. The findings demonstrated that approximately one-third of the Australian children possessed a scientific conception of the day and night cycle. The apparent motion of the sun in the sky and clouds blocking the sun's light were the most frequently held alternative conceptions by the Australian children. In a more recent study, Tao, Oliver, and Venville (2012) investigated 36 eight-year-old Chinese and Australian children's conceptions of day and night cycle. Few Australian (11%) and Chinese (8%) children were able to provide the rotation of the earth around its axis as a causal explanation for the occurrence of the day and night. Chinese children predominantly (31%) provided a description of their observations when they were asked the cause of the day and night cycle. In general, children inclined to associate the appearance of the sun in the sky with the daytime and the moon and the stars with the nighttime. Teleological explanations often attributed to a supernatural agent, were popular among Australian children. The movement of the sun around the earth or behind the moon were also popular conceptions for the day and night cycle. In sum, young children begin to make observations of astronomical objects and phenomena early in their everyday lives and develop naïve and synthetic mental models of day and night cycle based on their observational knowledge and the cultural information provided.

Studies demonstrated that alternative explanations of the day and night cycle are persistent beyond the early childhood years. For instance, a study conducted with nine-year-old to 16-year-old children in England demonstrated that even children in upper elementary grades believe that cloud cover causes the day and night cycle and the apparent motion of the sun in the sky remains to be a popular alternative conception (Baxter, 1989). Another common alternative conception was that the earth travels around the sun in a day and the orbit of the earth around the sun causes the day and night cycle. This explanation of the day and night cycle seems to be a product of children's attempts to integrate scientific information provided either in or out of school context with their naïve understandings. This synthetic explanation of day and night cycle was reported to be a very prevalent conception among fifth- and ninth-grade Estonian children (Kikas, 1998) and sixth-grade Turkish children (Küçüközer, Korkusuz, Küçüközer, & Yürümezoğlu, 2009). These findings suggest that understanding the co-occurrence of the axial and the orbital motion of the earth appears to be very demanding for both young and older children. Valanides Gritsi, Kampeza, and Ravanis (2000) reported that, in their study, approximately 12% of the five- to six-year-old children developed a similar alternative understanding when the concepts of earth's rotation around its axis and earth's orbit around the sun were introduced.

Based on their studies of young children's understandings of astronomy and physics concepts (Vosniadou, 2002; Vosniadou & Brewer, 1992, 1994), Vosniadou and colleagues suggest that children represent scientific concepts in the form of theory-like structures that are internally coherent and empirically accurate. These mental structures are constrained by the presuppositions and intuitions known as "mental models." In the present study, the term "mental model" was also used in describing and explaining the children's cognitive representations of the day and night cycle. Utilizing a set of interview questions together with a 3D model of the sun and the earth, this study aims to describe causal explanations of kindergartners regarding the day and night cycle. Additionally, by presenting information regarding the mental models of young children who have yet to receive any formal instruction regarding the day and night cycle, this study aims to assist educators in designing more effective curricula and pedagogical practices to help children develop a scientific conception of the day and night cycle in early childhood and beyond.

Method

Research Design and Questions

This study employed a descriptive research design in examining kindergarten children's understandings of the day and night cycle. Through an interview protocol designed for the current study, qualitative data were collected and analyzed using model identification methodology (Brewer, 2008). Answers

Table 1
Day and Night Cycle Interview Protocol

Tasks	Prompts
Verbal Explanations	
	1) How do you know that it is nighttime?
	2) How do you know that it is daytime?
	3) According to you, how does the day and night occur?
	4) Why do you think we can see the sun sometimes and other times we can't see it?
Model Manipulation	
	5) A model of the sun (a yellow plastic ball) and earth (a plastic globe) is presented to the child and the child is informed that these models represent the sun and the earth, respectively (*a piece of cotton representing clouds should be kept away from the child's sight and given when the child's explanation involve blocking of sunlight by clouds*). A figure is placed on the earth component and named based on the child's gender (Ayşe for girls, Ahmet for boys). The model components are handed to the child and the following prompts are given respectively: i. "Please arrange the model so that Ayşe/Ahmet on the earth experiences night." Ask the child to explain his/her arrangement of the model components. ii. "Please arrange the model so that Ayşe/Ahmet on the earth experiences day." Ask the child to explain his/her arrangement of the model.
Model Labeling	
	6) The researcher takes back the model components from the child and arranges the model to represent nighttime and daytime respectively while asking the following questions. i. Please examine the model and tell me whether Ayşe/Ali experiences day or night? Why it is nighttime/daytime for Ayşe/Ali?  ii. Please examine the model and tell me whether Ayşe/Ali experiences day or night? Why it is nighttime/daytime for Ayşe/Ali? 

to the following questions were sought in the present study: 1) What are the most common mental models kindergartners have about the day and night cycle? 2) Do young boys and girls differ in their understandings of the day and night cycle?

Participants

A convenience sampling technique was employed in selecting the participants of this study (Johnson & Christensen, 2004). A total of 46 kindergartners participated in the study, ranging from 60 to 75 months with a mean age of 67 months. A total of 22 boys and 24 girls, all of whom came from middle socio-economic status (SES) families, participated. The children were recruited from three state funded preschools in Balıkesir. Permissions to collect study data were obtained from legal authorities and parents. All children provided verbal assent prior to data collection.

Data Gathering

To reveal children's understanding of the day and night cycle, semi-structured interviews were conducted using a set of interview questions and a 3D model of the sun and the earth [See Table 1]. Children were individually interviewed in a quiet room and brief notes were taken during the interviews. The interviews were audio-taped and transcribed. It typically took approximately 10 minutes to complete the interview. The first four interview questions were asked to engage children with the interview topic and get them prepared cognitively and emotionally for the subsequent model manipulation task. The first two questions were designed to reveal the contents of the children's observations of the day and night sky and whether the children are able to support their responses with evidence. The third and fourth questions were designed to invite children to provide their verbal causal explanations of the day and night cycle. The fifth question involved a model manipulation task. The task was designed to encourage children to visually demonstrate and verbally explain what they thought caused the day and night cycle using a 3D model of the sun and the earth. The last question involved a model-labeling task where children were requested to identify the particular arrangement of the model presented by the researcher as either day or night and provide a rationale for their descriptions.

Data Analysis

In many aspects, the data analysis method utilized in the present study is similar to the "model identification methodology" of Vosniadou and Brewer (1992; 1994). The model identification methodology encourages researchers (1) to generate hypotheses regarding the possible mental models children might have about the studied phenomena, and then, (2) to determine the indicators of each mental model that can be identified from children's responses, and finally, (3) to compare mental models identified and their indicators to the children's responses (Brewer, 2008). The first four interview questions were asked to engage the children with the interview topic and cognitively and emotionally prepare them for the subsequent model manipulation task. Special attention has been provided to children's model arrangements and their explanations and rationale for particular arrangements in classifying their explanations into mental model categories. Children's responses to the interview questions and their performances in the model arrangement task were independently coded by two researchers. Cohen's Kappa value was calculated to examine inter-rater agreement (Cohen, 1968). The kappa value was κ=0.85, indicating a high agreement between the coders. To examine a possible gender difference between girls and boys, Fisher Exact Test was performed using SPSS version 18.

Results

Responses to the Verbal Prompts

Examination of children's responses to the verbal explanations task indicated that 14 children (7 boys and 7 girls) were able to describe typical celestial objects associated with the night sky. These children described the appearance of stars and the moon in the sky as indicators of nighttime. A total of 14 children (6 boys and 8 girls) cited daily activities and routines (e.g., bedtime, dad coming home from work) as indicators of nighttime. A total of 13 children (6 boys and 7 girls) mentioned color change (e.g., dark sky) as an indicator of nighttime. One boy and one girl associated nighttime with the disappearance of the sun. Two girls did not respond to the first prompt of the verbal explanations task.

A total of 18 children (9 boys and 9 girls) mentioned existence of the sun in the sky as an indicator of daytime, while one boy and one girl offered existence of the moon as an indicator of daytime. Five girls and five boys associated sunny, bright sky

with daytime. A total of 13 children (five boys and eight girls) described daily activities and routines (e.g., getting out of bed, having breakfast, going to school) as indicators of daytime. Two boys and one girl did not respond to the second prompt of the verbal explanations task.

When children were prompted to provide causal explanations for the day and night cycle, most children (fourteen (seven boys and seven girls)) did not provide any causal explanations and merely described daily activities and routines as the causes of day and night cycle. Seven children (four boys and three girls) described supernatural forces (i.e., Allah) as being responsible for the occurrence of day and night cycle. One boy and two girls claimed that the sun orbits the earth causing the day and night cycle. Two boys indicated that clouds either block or unblock the sunlight causing the day and night cycle. Two boys and two girls mentioned the earth's rotation around on its axis causing the day and night cycle. Seven children (two boys and five girls) mentioned the displacement of the sun (e.g., the sun goes up and down, the sun goes away and gets closer) as the causes of the day and night cycle. Nine children (four boys and five girls) failed to respond to the third prompt of the verbal explanations task.

For the last prompt, where children were again asked to provide causal explanations for the day and night cycle, the highest proportion of most children (eight boys and 12 girls) failed to provide any causal explanations and continued to describe their daily activities and routines as the causes of the day and night cycle. Three boys and one girl indicated that clouds either block or unblock the sunlight, thereby causing the day and night cycle. Three boys and eight girls offered various weather phenomena (e.g., raining, snowing, cold or warm weather) as the causes of the day and night cycle. Four boys and three girls indicated that the sun's movement in forward and backward direction causes the day and night cycle. These seven children suggested that when the sun moves away from the earth, it is nighttime and that when the sun moves closer to the earth, it is daytime. Two children, a boy and a girl, mentioned the earth's rotation around its axis causes the day and night cycle. Five children (3 boys and 2 girls) failed to respond to the last prompt of the verbal explanations task.

Models of Day and Night Cycle

The results demonstrated that almost all children possess a conceptual understanding of the day and night cycle, and their conceptual understandings could be characterized as coherent cognitive representations. Seven types of mental models of the day and night cycle were identified in this study: four initial (naïve) models, two synthetic models, and one scientific model. The following initial mental models were identified: (1) Distance model: a model where the sun goes far away and comes back, (2) Sun set model: a model where the sun goes up and down, (3) Occlusion model: a model where the sun is occluded by physical objects, and (4) Supernatural forces: a model where supernatural forces are cited as being responsible for the existence of day and night cycle.

Table 2
Excerpts for the Initial, Synthetic, and Scientific Models of the Day and Night Cycle

Initial (Naïve) Model	Synthetic Model	Scientific Model
Researcher: According to you, how does day and night occur? Child (G, 63M): When the sun get closer to the earth, it (earth) gets too much light and becomes day. When it (sun) goes away it is night (*Distance model*). Researcher: Please arrange the model so that Ayşe on the earth experiences night? Child (G, 63M): [*The child placed the sun component further away from the earth component*] (*Distance model*). Researcher: Does Ayşe experience night? Child (G, 63M): Yes. Researcher: Why? Child (G, 63M): Because the sun is away, (Ayşe) can't see the sun (*Distance model*).	Researcher: According to you, how does day and night occur? Child (B, 70M): The sun turns around the earth and sends its lights to some cities (Orbit model). Researcher: What happens in these cities where they get sun lights? Child (B, 70M): Daytime! Researcher: What about the other cities… Child (B, 70M): It is nighttime, because the sun does not shine on them. Researcher: Please arrange the model so that Ali on the earth experiences night. Child (B, 70M): [*The child placed the sun component in front of the earth component, the child figure was located on the other side of the earth*] It is night. Researcher: Why is it nighttime for Ali? Child (B, 70M): Because the sun does not shine on him. Researcher: Please arrange the model so that the Ali on the earth experiences day. Child (B, 70M): [*The child moves the sun component in front of the child figure located on the earth component*] (Orbit model).	Researcher: According to you, how does day and night occur? Child (G, 69M): As the earth turns around, the sun lights hit on it, which makes it day, when the earth turns the other side it becomes night (Earth's rotation). Researcher: Please arrange the model so that Ayşe on the earth experiences night. Child (G, 69M): [*The child placed the earth component in front of the sun component while the side of the earth with the child figure facing away from the sun component*] (Earth's rotation). Researcher: Why is it nighttime for Ayşe? Child (G, 69M): Because the sun shines on this part of the earth [pointing to the side of the earth component facing the sun component] (Earth's rotation). People work here. People on the other side still sleep. Researcher: Please arrange the model so that Ayşe on the earth experiences day. Child (G, 69M): [*The child turned the earth component around itself until the side of the earth with the child figure faces the sun component*] (Earth's rotation). Researcher: Why is it daytime for Ayşe? Child (G, 69M): Because the sun is in front of it. It shines on Ayşe now.

Two synthetic mental models were observed: (5) Orbit model: a model where sun orbits the earth and (6) Rotation + Distance model: a model where earth's rotation around on its axis and sun's going far away and coming back produce the day and night cycle. A scientific model includes the idea that (7) the earth's rotation on its axis causes the day and night cycle. The results of the Fisher Exact Test indicated that the boys and the girls did not differ regarding the type of mental models they held ($p = 0.48$). Table 2 demonstrates excerpts from the interviews for the models identified in the study.

The majority of the children (63%) had initial (naïve) mental models of the day and night cycle. The distance model was the most common initial model held by the children. The children who held the distance model believed that the sun moves in a back-and-forth direction to the earth and when the sun is far away from the earth it is nighttime and when it is close to the earth it is daytime. Nine boys and eight girls held the distance model. The sun set model was the second most common initial mental model held by the children. A total of 10 children, six boys and four girls, held this model. The children who possessed the sun set model believed that the sun moves in an up-and-down direction that is relative to the earth's horizon and when the sun is up above the horizon it is daytime and when it is down below the horizon it is nighttime. The occlusion model, where the cause of the nighttime is described as blocking of sunlight by physical objects such as clouds, and the supernatural model, where Allah is cited as the producer of the day and night cycle, were the other initial models observed in the study. Each model was held by a single child, a boy and a girl, respectively.

Eight children (18%) held synthetic models of the day and night cycle. Three girls and a boy held the orbit model. The children who held the orbit model asserted that the sun moves around the earth and illuminates different parts of the earth as it moves. The parts that are illuminated by the sun experience daytime, while the other parts experience nighttime. Two girls and two boys held the rotation + distance model. The children who held this model believed that both the earth's and the sun's movement cause the day and night cycle. Predominantly, these children believe that the earth's rotation around on its axis and the movement of sun in a back-and-forth direction toward the earth cause the day and night cycle.

A total of six children (three boys and three girls, 13%) held a scientific model of the day and night cycle. These children explained that the earth's rotation around on its axis causes the day and night cycle. As the earth rotates, different parts of the earth are exposed to the stationary sun's light, and the part of the earth that is illuminated by the sun experiences daytime, whereas the part of the earth that is not facing the sun experiences nighttime. While 43 out of 46 children (97%) were able to be placed into one of seven mental model categories, three children, all girls, were unable to be categorized. These three children did not produce sufficient utterances during verbal explanations task and failed or refused to manipulate or label models during the model manipulation and model labeling tasks. Table 3 demonstrates the number of children assigned into specific mental model categories by gender.

Table 3

Models of the Day and Night Cycle

Models	Gender		Total
	Boys	Girls	
Initial (Naïve) Models			
Distance model	9	8	17 (37%)
Sun set model	6	4	10 (22%)
Occlusion model	1	0	1 (2%)
Supernatural model	0	1	1 (2%)
Synthetic Models			
Orbit model	1	3	4 (9%)
Rotation + Distance model	2	2	4 (9%)
Scientific Model			
Earth's rotation	3	3	6 (13%)
None	0	3	3 (6%)

Discussion and Conclusion

The current study examined kindergarten children's mental models of the day and night cycle, using semi-structured interviews involving three tasks. The results demonstrated that more than half of the children had naïve mental models of the day and night cycle with the distance model being the most common naïve model held by the children. Eight children held synthetic models of the day and night cycle, while only six children held a scientific model of the day and night cycle. Almost half of the children had difficulty providing verbal causal explanations for the day and night cycle. However, nearly all of these children were able to provide causal explanations during the model manipulation and model labeling tasks. No difference was observed between the boys and the girls regarding the type of mental models they held.

The findings of the present study demonstrated that more than half of the children possessed naïve mental

models of the day and night cycle. The distance model was the most common naïve model held by the children followed by the sunset model, occlusion model, and supernatural model. In previous studies, these explanations have also been reported among young children (Doğru & Şeker, 2012; Kallery, 2011; Küçüközer & Bostan, 2010; Valanides et al., 2000; Vosniadou & Brewer, 1994; Vosniadou et al., 2004). The sun-movement-based mental models or explanations of the day and night cycle appears to be enduring beyond the early childhood years. Baxter (1989) reported that the apparent motion of the sun remains to be a very common mental model of the day and night cycle among older elementary children, beyond the age of children in the present study. In the current study, only one child held the supernatural model and occlusion model. Although the prevalence of supernatural explanations tends to pass by as children get older, even some older elementary school children may continue to assert that cloud cover involves causing the day and night cycle.

A total of eight children held synthetic models of the day and night cycle. These children either claimed that the sun moves around the earth and illuminates different parts of the earth as it moves or believed that both the earth's and the sun's movement involve causing the day and night cycle. These synthetic models were also reported in previous studies that involved preschoolers to ninth-grade students (Dunlop, 2000; Kikas, 1998; Küçüközer, Korkusuz, Küçüközer, & Yürümezoğlu, 2009; Valanides et al., 2000; Vosniadou et al., 2004). Synthetic models of the day and night cycle appear to be a product of children's attempts to integrate scientific information provided in and out of school with their naïve conceptual understandings of the day and night cycle. The co-occurrence of axial and orbital motion of the earth seems to be a challenging concept for young children and even for children in upper grades. In the present study, only six children held a scientific model of the day and night cycle. The teachers in the classrooms, in which the study participants were selected, reported that they did not implement any activity targeting the day and night cycle in their classrooms. Despite the lack of formal science activities introducing the day and night cycle, six children held a scientific model of the day and night cycle. These children, along with their peers who held synthetic models, appear to have encountered scientific explanations either in their previous schooling or in informal settings.

The findings of this study demonstrated that almost half of the children had difficulty providing verbal casual explanations for the day and night cycle. These children appeared to have difficulty in discerning the cause of the day and night cycle from its observed effect in their daily life and generate causal explanations that reflect transductive reasoning facilitated by syncretic thinking (Piaget, 1972). However, during the model manipulation and model labeling tasks, almost all of these children were able to provide causal explanations. These findings suggest that young children have limitations in verbally providing such explanations. The use of model components helped children in expressing their ideas in a more competent way, thereby overcoming their limitations in producing verbal explanations. Further studies investigating young children's understandings of scientific phenomena should utilize 3D models and their manipulations; such studies should not be solely based on young children's verbal explanations.

The descriptions of children's understanding of the day and night cycle provided in this study may lead to the design of a more effective curriculum and instructional strategies for children in kindergarten and early elementary grades. Researchers have contended that young children's conceptual understandings of the shape of the earth may influence their conception of the day and night cycle (Samarapungavan et al., 1996; Vosniadou, 1991). In other words, scientific understanding of the cause of the day and night cycle requires scientific understanding of the shape of the earth. Children who believe that the earth is flat or disc-shaped are unable to understand how the earth's rotation around its axis produces the day and night cycle (Vosniadou, 1991). A recent study indicated that children who believed that the shape of the earth is spherical were more likely to possess a scientific understanding of the day and night cycle (Tao et al., 2012). Preliminary evidence suggests that children's conceptual understandings of the shape of the earth should be promoted before introducing the concept of the day and night cycle in early childhood classrooms (Samarapungavan et al., 1996; Tao et al., 2012; Vosniadou, 1991).

In other words, early childhood teachers should begin introducing the concept of a spherical earth to children and ensure that all children develop a scientific model of the earth prior to implementing activities on the cause of the day and night cycle. Early childhood teachers should not solely rely on children's verbal utterances in revealing children's ideas and examining the effectiveness of activities on the shape of the earth. Furthermore, teachers should elicit children's ideas by encouraging

children to produce the model of the earth using play dough. The play dough models of the earth constructed by the children could be kept and utilized in the subsequent activities wherein the cause of the day and night cycle is introduced. Using these preconstructed models would provide children the opportunity to demonstrate their understanding of the cause of the day and night cycle using their own models of the earth. Such activities may help children recognize how the earth's rotation around its axis produces the day and night cycle and how the rotation would only work when the earth is spherical but not in other shapes.

Science activities conducted with young children should be inquiry-based, informed by the children's existing mental models or ideas regarding the targeted phenomena, and present developmentally appropriate hands-on activities that invite children to be physically, mentally, and emotionally active participants in the learning environment (Saçkes et al., 2011). Play is considered as an effective and developmentally appropriate pedagogical tool for young children in the Turkish Preschool Education Program (MEB, 2012). Inquiry-based science instruction in the early years can be easily integrated with play, and such science learning activities are likely to facilitate young children's engagement, promote scientific thinking skills, and develop conceptual understanding of scientific phenomena (Akman & Güçhan Özgül, 2015; Baldwin, Adams, & Kelly, 2009; Bulunuz, 2013; Fleer, 2011; Miller, Trundle, Smith, Saçkes, & Mollohan, 2013; Trawick-Smith, 2012). Therefore, early science learning activities targeting space science concepts, including the day and night cycle, should be inquiry-based and presented within the context of play.

A scientific understanding of the cause of the day and night cycle in kindergarten might facilitate children's understanding of more complex astronomical phenomena, such as lunar phases, in early and upper elementary grades and beyond (Hobson et al., 2009). Therefore, early science learning opportunities in preschools and kindergartens should be carefully designed, be informed by the studies that provide descriptions of children's understanding of various science phenomena, and report the effectiveness of pedagogical interventions to promote learning science in young children. Further research should focus on the effectiveness of instructional interventions in helping young children construct scientific understandings of fundamental astronomy concepts.

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