INTEGRATION OF INQUIRY AND PLAY: YOUNG CHILDREN'S CONCEPTUAL CHANGE IN ASTRONOMY[1]

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ABSTRACT

This study aims to introduce inquiry-based play activities and to examine their effectiveness on young children's conceptual understanding of the shape of the Earth and the day-night cycle. The inquiry-based play activities for preschool children were designed to support children to learn the concepts of the shape of the Earth and the day-night cycle. The activities were designed based on the Preschool Learning Cycle (Play, Explore, and Discuss). The study sample consisted of 80 children, 33 of whom are girls and 47 are boys. The children's ages ranged from 54 to 70 months. To measure children's conceptual understanding, Earth-2 (EArth Representation Test for cHildren-2) developed by Straatemeier et al. (2008) was used. Science journals were used to promote children's reflective thinking and to evaluate their learning. The results revealed that the inquiry-based play activities positively affected young children's conceptual understanding of the shape of the Earth and the day-night cycle.
Keywords: inquiry, play, early childhood, science education, astronomy.

SORGULAMA VE OYUNUN BÜTÜNLEŞTİRİLMESİ: KÜÇÜK ÇOCUKLARIN ASTRONOMİ İLE İLGİLİ KAVRAMSAL DEĞİŞİMLERİ

ÖZ

Bu çalışma, sorgulama temelli oyun etkinliklerini tanıtmayı ve bu etkinliklerin çocukların Dünya'nın şekli ve gece-gündüz döngüsü gibi astronomik olgulara ilişkin kavramsal anlayışları üzerindeki etkililiğini incelemeyi amaçlamaktadır. Okul öncesi dönem çocuklarına yönelik sorgulamaya dayalı oyun etkinlikleri, çocukların Dünya'nın şekli ve gece-gündüz döngüsü kavramlarını öğrenmesini desteklemek için tasarlanmıştır. Okul Öncesi Öğrenme Döngüsü (Preschool Learning Cycle), Oyna, Keşfet ve Tartış aşamalarından oluşmakta ve etkinliklerin öğrenme süreci bölümünde yer almaktadır. Araştırmanın örneklemini 33'ü kız 47'si erkek olmak üzere 80 çocuk oluşturmaktadır. Çocukların yaşları 54-70 ay arasındadır. Çocukların kavramsal anlayışlarını belirlemek için Straatemeier ve diğerleri (2008) tarafından geliştirilen Earth-2 (EArth Representation Test for cHildren-2) kullanılmıştır. Öğrenmenin değerlendirilmesi ve yansıtılması için bilim defterleri kullanılmıştır. Sonuçlar sorgulamaya dayalı oyun etkinliklerinin, küçük çocukların Dünya'nın şekli ve gece-gündüz oluşumu ilgili kavramsal anlayışlarını olumlu yönde etkilediğini ortaya koymuştur.
Anahtar kelimeler: sorgulama, oyun, erken çocukluk, fen eğitimi, astronomi.

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INTRODUCTION

Current thoughts about the importance of early science education derive from the demands for educating scientifically literate individuals and supporting the scientific understanding of children (Watters et al., 2001). There has been a widespread consensus in recent years that children learn science conceptually only when they actively participate in scientific activities (Kuhn & Pease, 2008). Although educators agree that science education should begin in preschool (Eshach & Fried, 2005; Spektor-Levy et al., 2013), there are important knowledge, research, and practice gaps for including science in preschool classes and planning activities that focus on scientific concepts for preschool children (French, 2004; Trundle & Saçkes, 2012). After the National Science Education Standards published by the National Research Council (NRC) in 1996 proposed the inquiry method as an instructional approach (NRC, 1996, 2000), science education literature has begun to emphasize that inquiry-based teaching is one of the most effective ways to develop conceptual understanding of scientific phenomena (Güçhan-Özgül et al., 2018; Samarapungavan et al., 2008).

Inquiry-based science teaching is a method of teaching science that engages students in posing questions, exploring the material, conducting experiments, collecting evidence, and sharing ideas (Padilla, 2010). During the inquiry process, children have opportunities to learn the nature of science by researching science concepts individually or collaboratively and reaching conclusions based on evidence (Kuhn et al., 2000; NRC, 1996). These aspects of inquiry-based teaching make it an effective pedagogical approach that can be used to teach children the nature of science and scientific concepts (Saçkes, 2015).

Inquiry-based teaching in early science education needs to consider some significant aspects and basic principles of early childhood development and education (Tu, 2006). Although the related research argues that young children have an inborn motivation in science and a deep interest in research (Cremin et al., 2015; French, 2004), children's short attention span, desire to engage in physical activities, and developmental levels should be taken into account while planning science activities. Therefore, the inquiry-based teaching method should be adapted when it is used with early childhood students. In inquiry-based teaching, using additional strategies to increase young children's motivation and active participation can enrich and deepen their learning process. Play "as an act of inquiry" (Youngquist & Pataray-Ching, 2004) is defined as the most natural way to support learning science (Bredekamp & Copple, 2006). Additionally, play is an essential source of active participation, motivation, and learning for young children (Bulunuz, 2012). As Akman and Güçhan-Özgül (2015) argued, play functions as an inner drive to learn and explore; therefore, it can be incorporated into early childhood education activities. Research studies showed that teaching activities involving play improve children's understanding of scientific concepts (Bulunuz, 2012, 2013; Cremin et al., 2015; Güçhan-Özgül et al., 2018). Based on the related literature, play is one of the most effective methods that can be incorporated into inquiry-based activities at the early childhood level. Therefore, play is integrated into the inquiry-based activities in the current study.

Preschool Learning Cycle

The Preschool Learning Cycle (PLC) was used in this study for integrating inquiry and play into early childhood science education activities. The PLC proposed by Trundle and Smith (2017) is designed as a play-based learning cycle for preschool children and is based on Bybee's five-step learning cycle (Bybee et al., 1989). In PLC, the hearts-on, hands-on, and minds-on approach is adopted (İnan & İnan, 2015). Whereas minds-on and hands-on primarily refer to children's intrinsic fascination and investigations about the world, hearts-on relates to children's thoughts and behaviors, including their pleasure, excitement, and love of scientific phenomena (İnan & İnan, 2015).

Trundle and Smith (2017) proposed a three-phase design for teaching activities based on the PLC: Play, Explore, and Discuss (Figure 1). In the play phase, children are encouraged to explore the materials, ask questions, and get curious about the concept. This phase focuses on the hearts-on learning. In the explore phase, children are asked to make predictions and observations using scientific process skills and to record them. This is where the hands-on

learning takes place. Finally, in the discuss phase, they are expected to share the data, evaluate them, create explanations, generate new questions, and reach conclusions. The discuss phase focuses on minds-on learning. As researchers suggest (Trundle & Smith, 2017), the PLC can be an effective method to design inquiry-based science activities for young children's conceptual learning. In this study, the PLC was used to develop activities in astronomy.

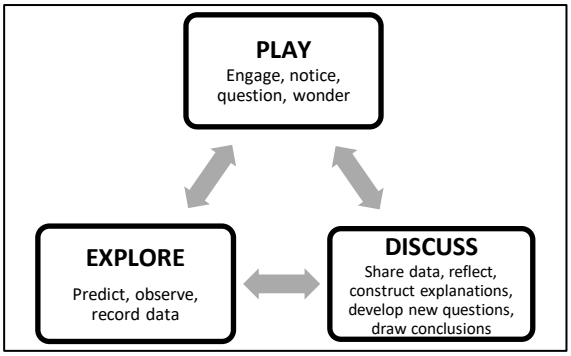


Figure 1. Preschool Learning Cycle (Trundle & Smith, 2017)

Astronomy Concepts in Early Childhood Education

Earth and space concepts are fascinating for children (Kallery, 2011; Özsoy, 2012; Saçkes, 2015). That's why children are curious about such concepts as the Earth's and other planets' physical features, the movements of Moon and Sun, and the day-night cycle. This curiosity leads to observations, questions, and interpretations. Even though young children can make accurate observations to explain scientific phenomena about Earth and space concepts, many research studies with children from various backgrounds indicate that children struggle to understand scientific facts of astronomical phenomena (Kampeza, 2006; Küçüközer & Bostan, 2010; Özsoy, 2012; Saçkes et al., 2016; Tao et al., 2013; Vosniadou et al., 2004).

Vosniadou and Brewer's (1992, 1994) research on children's conceptual understanding about the shape of the Earth and the day-night cycle revealed that children might have three different mental models about these scientific phenomena. These mental models were identified as (1) the initial model, (2) the synthetic model, and (3) the scientific model. These models serve as a framework to understand children's conception of the physical features of Earth and the day-night cycle. *Initial models* are derived from daily observations/experiences and do not necessarily correlate with scientific knowledge. *Synthetic models* are blended with everyday experiences and cultural/instructional knowledge and may not be aligned with scientific knowledge. On the other hand, *scientific models* consist of understandings that correlate with the explanations of science. Children begin school with naive theories about astronomical phenomena that might be different from scientific explanations and that need to be addressed in science lessons. In this context, astronomy education at an early age serves to reveal and address possible misconceptions about the shape of the Earth and the day-night cycle (Ampartzaki & Kalogiannakis, 2016).

Preschool Curriculum (Ministry of National Education [MoNE], 2013) implemented in Turkish classrooms covers scientific concepts such as day and night, celestial bodies, and Earth. One of the prominent features of the curriculum is that it promotes activities that facilitate the integration of multiple disciplines and developmental areas. Thus, integration of inquiry-based activities and play into the preschool learning process could be a logical and practical way to teach scientific concepts and astronomical phenomena. This study aims to introduce inquiry-based play activities about the shape of the Earth and the day-night cycle and to examine their effectiveness on the conceptual understanding of young children.

METHODS

The study was designed as an embedded experimental model of mixed methods where quantitative and qualitative data were collected and analyzed in a pre-test post-test quasi-experimental design (Creswell, 2014). Data were gathered from multiple sources at various time points during the intervention procedure to evaluate the effectiveness of inquiry-based play activities. The participants consisted of 80 children (33 girls and 47 boys). At the time of the study, the children's ages ranged from 54 to 70 months. The necessary legal and ethical permissions were obtained from the local provincial directorate of national education.

The experimental intervention was implemented in the 2017-2018 academic year in six classes by the preschool teachers. Before implementing the inquiry-based activities, six preschool teachers of those classrooms were engaged in a professional development activity where they learned about the theoretical background of the study, practiced inquiry-based activities, and reflected on inquiry-based teaching.

Data Collection Tools and Analysis

The quantitative data source of the study included a pre-test and post-test. In order to measure the children's conceptual understanding of the shape of the Earth and the day-night cycle, Earth-2 (EArth Representation Test for cHildren-2) developed by Straatemeier et al. (2008) was used both as the pre- and post-test. The pre-test was administered before the intervention and the post-test was administered in a 2-week time frame after the intervention. The adaptation study of Earth-2 for Turkish children was carried out by Güçhan-Özgül and Saçkes (2015). Both Straatemeier et al. (2008) and Güçhan-Özgül and Saçkes (2015) reported that the test had high internal consistency with the Cronbach Alpha values of .79 and .69, respectively.

The Earth-2 is a structured, non-verbal, and forced-choice paper-pencil test designed to be used with young children. Earth-2 consists of 10 questions, including a sample question. The test includes seven questions for the shape of the Earth and two questions for the day-night cycle. In this study, the test questions were asked verbally to the participating children by the researcher (author); they were asked to show and / or express the answers and these answers were audio-recorded. The questions of Earth-2 allow to determine children's conceptual models (initial, synthetic, and scientific) regarding the shape of the Earth and the day-night cycle (Vosniadou & Brewer, 1992;1994). The researcher prepared a table to code the children's answers based on the conceptual models. Accordingly, children's responses to the test questions were coded as 0 (initial), 1 (synthetic), or 2 (scientific). In order to test the effectiveness of the inquiry-based play activities, the data obtained in the pre-test and post-test were analyzed using paired samples t-Test technique for different measurement time pairs. SPSS version 20 was used to analyze the data.

The qualitative data source of the study was children's science journals. Science journals allow students to record their observations during inquiry-based activities and provide researchers with opportunities to understand students' conceptual learning (Uysal et al., 2016). journal pages are preferred to guide children while recording their experiences, observations, and ideas in early childhood classrooms. In the current study, the children's drawings on semi-structured science journals were analyzed according to the mental model theory and its assumptions about the related phenomena (Vosniadou & Brewer, 1992;1994). These assumptions are based on scientific knowledge and enable to differentiate children's mental models, whether they are scientific (SC), initial (I), or synthetic (SY).

ACTIVITY IMPLEMENTATION

The inquiry-based play activities were designed in light of the science teaching standards of NRC (2012) and the preschool curriculum of MoNE (2013). The science teaching standards address the concepts of the shape of the Earth and the day-night cycle under the main title of Earth and Space Sciences (NRC, 2012). The activities were planned using the activity format given in the preschool curriculum of MoNE (2013). In addition to the learning objectives and performance indicators of the preschool curriculum (MoNE, 2013), additional learning objectives and performance indicators were determined based on the related literature of preschool science education to guide the design of the teaching and assessment processes of the activities (Table 1).

The inquiry-based play activities planned in this study are grounded in the scientific knowledge about the concepts of Earth, gravity, celestial bodies, and day-and-night. The activities aim to develop students' inquiry skills and to enhance their conceptual understanding about the shape of the Earth and the day-night cycle. To achieve these aims, developmentally appropriate teaching approaches such as play, exploratory learning, and collaborative learning are used based on the PLC. Each activity consisted of the Play, Explore, and Discuss phases of the PLC.

Table 1. Learning Objectives Addressed in the Activities

Cognitive Development
Learning Objective (LO) 2. Makes predictions about objects/situations/events.
LO 3. Remembers prior perceptions.
LO 5. Observes objects and entities.
LO 6. Pairs objects and entities according to their characteristics.
LO 7. Groups objects and entities according to their characteristics.
LO 10. Follows spatial directions.
LO 17. Construct cause and effect relationships.
Additional LO 22. Explains the shape of the Earth in a scientific way.
Additional LO 23. Explains the differences between day and night.
Additional LO 24. Explains the day-night cycle in a scientific way.
Language Development
LO 5. Uses language for communication purposes.
LO 7. Understands the meaning of what s/he listens/watches.
LO 8. Expresses what s/he listens/watches in various ways.
Social-Emotional Development
LO 3. Expresses her/himself in creative ways.
LO 9. Explains different cultural characteristics.
Motor Development
LO 1. Performs gross motor movements.
LO 3. Performs movements that require object control.
LO 4. Perform movements that require fine motor skills.

The activities follow a progression from general to specific and from simple to complex, and at the same time, there is a hierarchical order to ensure a conceptual consistency between the activities. For example, activities related to the characteristics of Earth are followed by the activities related to gravity and the shape of the Earth. Afterwards, the activities related to the day-night cycle take place. There are a total of 12 activities with four activities related to the shape of the Earth and eight activities related to the day-night cycle. All activities were implemented using an integrated approach as suggested by the preschool curriculum (MoNE, 2013). The integrated disciplines mainly include science, language arts, drama, and physical education. Each activity takes about 45-90 minutes of classroom time. The second and the 12th activities will be described in detail. The names, order, and brief content of the other 10 inquiry-based play activities are as follows:

Activity 1: Getting to Know our Earth

In this activity, children get to know Earth by playing a game that includes planets and celestial bodies and encourages children to express their prior knowledge. The teacher plays a music. Children wear planet badges and dance until the music stops. Then, they pair with a student standing nearby and talk about the planet or the celestial body that they have on their badges. The teacher observes children and takes notes about their conversations, particularly the questions that they ask to each other. After the game is over, the teacher reads the questions that she noted and asks children to think about the questions. Teachers should have books, magazines, and documentaries about astronomy and Earth in the classroom for children to examine. At the end of the research process, the class reviews the questions and shares their answers with each other.

Activity 3: The Shape of the Earth

At the beginning of the activity, children are encouraged to interact with Earth models, maps, and atlas. The following questions are posed to the students to promote inquiry: What is the shape of the Earth? Might there be a place where the world ends? Where does a walk starting from any point of the Earth end? This activity mainly focuses on different countries and people from different cultures. Children's literature books were used for introducing various cultures and nations. The countries mentioned in the book are located on the Earth model. Children are encouraged to recognize that people can live on different parts, top or bottom, of the Earth. The questions asked in the beginning are revisited again using the Earth model.

Activity 4: Question Wheel

This activity includes a game that is played by spinning a question wheel. The game requires children to answer "what if" questions about the shape of the Earth and to perform the tasks on the question wheel. Some examples of questions are as follows: What would happen if the Earth were flat? Where would you end up if you walked straight without stopping? What would happen if the world did not rotate? An example task is "Find the badges hidden under the objects that have an Earth-like shape." Teachers

can prepare the question wheel by using a cardboard and making a hole in the middle of it to place a small ball. The small ball placed in the middle will make the wheel spin.

Activity 5: Light and Shadow

There are flashlights and different materials (transparent, translucent, non-transparent, ball, hand puppet, etc.) in one corner of the classroom. Children examine these materials in pairs and experience the concepts of light and shadow. The teacher makes scientific explanations about shadow and light. S/he draws attention to the differences between light and dark surfaces. Students are encouraged to discuss the following questions: How do we see our surroundings during daytime? How do we see in the dark? How are the day and night sky alike and different?

Activity 6: Day and Night Story

The children are asked what they know about day and night. They talk about the activities that they do during the day and during the night. A scientific story book about day and night is read. Questions about the scientific explanations in the book are asked to children: Why is there day and night? What do we know about the moon and stars? What comes to your mind when you talk about sleep and dreams? What do we know about the Sun? Afterwards, the explanations in the book are read. The teacher summarizes what has been discussed about the day and night.

Activity 7: Day Sky Observation

This activity starts with a well-known hidden object game. The teacher prepares cards on which there are celestial bodies and hides them in different places of the classroom. The children are asked to find these cards according to the directions of "day and night" instead of "hot and cold." Then, an outdoor activity takes place. Children go outside to observe the daytime sky. While they are observing, they seek to answer the following questions: What is the day sky like? Can we see the Sun? (The children are told not to look at the Sun directly and are informed about the dangers of staring at the Sun.) What else do we see in the sky? Can we see the Moon in the daytime? Can we see the stars? Observations are recorded in the science journals and are discussed in the class. The detailed lesson plan of this activity is given in the Appendix as an example lesson plan.

Activity 8: Night Sky Observation

In this activity, a technology-assisted learning environment is required. As the observation of the night sky during the daytime is not possible, an application named *Stellarium* is used to help children observe the night sky (Zotti, 2021). This application is available on the internet and is free to download. The night view is examined according to the date of the activity with the children, and they are asked to record this observation in their science journals. The questions about the characteristics of the night sky (e.g., the color of it, the appearance of celestial objects) guide children's observations. The teacher facilitates a whole class discussion using the children's science journal drawings and the following questions: Why is the night sky dark? Which celestial objects did you see in the night sky? What did you record? Could you see the Sun in the sky?

Activity 9: Sensory Bottles

This activity integrates science with art and play. Children prepare sensory bottles using plastic bottles, paints, and craft materials to represent the day and night sky. Each small group of children have their own day and night bottles, and then they put all the bottles together to play bowling. Children win stickers and stick them on their science journals. Differences and similarities between the day and night sky are discussed.

Activity 10: Day and Night

This is an integrated science and drama activity. A circle is drawn on the ground using electrical tape. This circle represents the Earth. The classroom lights are turned off, and a dimly dark environment is created. Children are asked to gather on the circle and walk around it slowly, representing the rotation of the Earth. A child is asked to pretend to be the sun using a flashlight at a corner of the class. Based on their location on the circle with respect to the sun, the children decide whether they are in the night or daytime. While the children are rotating around the circle, the teacher plays music, and then suddenly stops it. When the music stops, children in the dark side act night routines, and

children in the daytime pretends to be doing the daytime routines. Children ask questions and share explanations about the day-night cycle during the discussion of the activity. The teacher introduces the scientific explanation of the day-night cycle.

Activity 11: Day and Night on Earth

A question-answer game known as "Scavenger hunt" is introduced to children. Hidden question cards are found by following a map previously prepared by the teacher. The questions are read one by one by the teacher, and the children share their answers. The children are asked to stick their cards in their science journals and make drawings to answer the questions on the cards. Questions may include concepts related to the shape of the Earth and the day-night cycle.

In the following sections, Activity 2 and Activity 12 will be described in detail. Activity 2 is about the shape of the Earth and Activity 12 is related to the day-night cycle.

Activity 2: Gravity

Learning Objectives

This activity targets the learning objectives 2, 7, and 22 in the cognitive development domain; the learning objective 4 in the motor development domain; and the learning objectives 7 and 8 in the language development domain (Table 1).

Materials

The following materials are needed for this activity: an Earth model, magnets, feathers, balls, potatoes, paper planes, balloons, and stones. The Earth model preferably should be divisible into two parts. This is required for the gravity experiment in the *explore* phase. The teachers and the researcher created the Earth model used in the activity (Photograph 1).

Play

Children were allowed to play with and experience the materials freely. They investigated the materials mainly in terms of physical properties during the free play, and began to role-play such as juggling with stones, cooking with potatoes, and flying paper planes. Then, the teacher asked, "Which of these materials can fly in the air?" and "Which ones would fall down to the ground?" The children shared their predictions regarding the teacher's questions and explained their reasoning. The children's answers were generally related to the objects' weight. For example, one boy spoke "the paper plane would fly, but the stone would crash to the ground because it is too heavy." The children recorded their predictions in the science journals.

Photograph 1. The Earth Model

Explore

In this phase, the children tested their predictions that they made in the play phase. Each object was put in the air and the outcome was observed (Photograph 2).

Photograph 2. Gravity Experience

The children compared their predictions to the actual outcomes. The teacher explained that what causes the objects to fall down to the ground is gravity. It is an inward force from the center of the Earth and prevents objects on Earth from flying off into the space. This situation is experienced by splitting the earth model into two parts and holding a magnet inside (Photograph 1). Then, some objects were put on

the outside of the earth model. The children observed that the objects stayed on the surface due to the magnet's force and did not fall down.

Discuss

The children discussed that gravity allows living things to live in any part of the Earth just like the objects that stayed on the Earth's surface in the experiment. They also discussed about the free fall experiment where they tested which object would float in the air and which would fall down. They drew in their science journals about what they observed and learned in the explore phase of the activity.

Activity 12: Sky, Cave, Day, Night

Learning Objectives

This activity targets the learning objectives 3, 5, 10, and 24 in the cognitive development domain and the learning objectives 1 and 4 in the motor development domain (Table 1).

Materials

The following materials are needed for this activity: an Earth model that can rotate around its own axis, flashlight, stickers, 3D objects (e.g., animal figures, cars), play dough.

Play

The chairs were placed in a circle. The leader of the game (teacher) stood in the middle. The other players sat down. When the game leader said the following words, the players performed the specified actions (Photograph 3).

Sky: Sit on the chair, raise your arms!
Cave: Get under the chair!
Day: Face the chair!
Night: Turn your back to the chair!

Photograph 3. Sky, Cave, Day, Night Game

Precautions should be taken against the dangers that may occur during the game. Each player was given a sticker when s/he made a mistake, and the game continued until each player received a sticker.

Explore

The classroom was made dim. The teacher asked the children what they knew about the day and night cycle. After the children shared their prior knowledge, the teacher said that they would use a flashlight as the sun in the activity. An Earth model which can rotate around its axis was introduced to the class. The Earth model was placed directly opposite of the sun (flashlight). Some of the countries that the children knew were located on the Earth model, and 3D objects (e.g., animal figures, cars) were stuck on the Earth model (according to the country's place). Students explored the model by rotating it and examined what parts of the Earth receive light from the sun. They discovered that due to Earth's rotation around its axis, daytime is experienced in areas facing the sun and night is experienced in the other areas. The teacher rotated the Earth model and asked, "Is it night or daytime for X (a particular object stuck on Earth)?" The children answered the question based on their observations. The teacher continued to ask similar questions for the other objects as well. In this phase, the teacher might elaborate on children's answers and expand the topic to include countries, continents, and oceans.

Discuss

After the day and night cycle experiment, the children were asked to reconstruct their observations using play dough. They were grouped in pairs. Two different colors of play dough and a child figure (toy) were given to each pair. They made Earth and Sun models from the play dough and placed their figure on the part of the Earth where that figure may live. After this construction task, the children were asked to repeat the day and night cycle experiment, holding the Sun and Earth in their hands. At the end of the activity, a whole group discussion was conducted about the scientific explanation of the day-night cycle. The teacher asked reflective questions about the positions of Earth and Sun and encouraged the children to

provide scientific explanations for the day and night cycle.

FINDINGS

In order to examine the effectiveness of the inquiry-based play activities on the conceptual understanding of young children about the shape of the Earth and the day-night cycle, the children's pre-test and post-test scores were analyzed using the paired samples t-Test. Regarding the concept of the shape of the Earth, there was a statistically significant difference between the pre-test scores (M= 1,00, SD= ,389) and the post-test scores (M=1,437, SD= ,49) with t(79)=-6,383 and p=.000. Similarly, the children's scores on the day-night cycle questions significantly increased from the pre-test (M= ,112, SD= ,355) to the post-test (M= ,962, SD= ,906) with t(79)=-8,182 and p=.000. These findings show that the inquiry-based play activities positively affected the conceptual understanding of the children about the astronomical phenomena discussed in the activities. The findings indicate that the intervention procedure created a conceptual shift from the initial or synthetic concepts to the scientific explanations.

The children's science journal entries written during the inquiry-based learning activities provided qualitative data about their learning process. The themes emerged from the analysis of science journals in light of the related literature (Vosniadou & Brewer, 1992, 1994) is given in Table 2. In the first activity titled "Getting to Know our Earth", the children researched Earth's physical and social characteristics (i.e., the shape of it, oceans, countries, people). They examined pictures of the Earth using the resources that the teacher provided and discussed about their observations and experiences. At the end of the activity, the children made drawings about what they have learned in the activity. The children's drawings fell within the gravity theme of Table 2 and reflected a scientific mental model about the shape of the Earth. They drew countries and/or objects on Earth. Typical drawings from the children's journals are given in Photograph 4. They placed entities such as trees, buildings, or houses on different parts of the Earth, indicating that they did not think that those objects would fly off away from Earth or fall down.

Table 2. Themes Emerged from the Qualitative Analysis of Children's Journal Entries

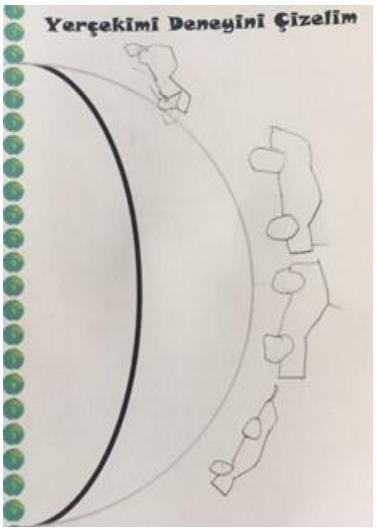
	The Shape of the Earth
Gravity	The placement of objects on Earth (on top (SY&I), on various parts of the Earth (SC)) The movement of objects (falling down to the ground or floating in the air (PR*))
Shape	Flat (I), Hollow Sphere (SY), Dual Earth (SY), Ring (I), Sphere (SC)
	The Day and Night Cycle
The Place of Sun	Movement (up & down, near & far (I)), the rotation of Sun (SY)
Obstacles	Clouds, Mountains (I)
Earth	Rotation (SC)
Sky Observation	Celestial bodies appear at different times of the day, the color of the sky (OB*)
Daily Activities	Differentiation of activities according to day and night (PR*)

* SY=Synthetic model, I=Initial model, SC= Scientific model PR=Prediction, OB=Observation

Photograph 4. Children's Drawings of Earth

In the second activity titled "Gravity", the children made predictions about which objects would float in the air and which ones would fall down to the ground. Then, they tested their predictions and compared their observations to

the initial predictions. At the end of the activity, the children wrote in their science journals about what they learned in the gravity experiment. The children's drawings reflected the class discussions about how gravity pulls objects towards the Earth. One child's drawing is given in Photograph 5. The child's drawing correctly represents the movement of a car.



Photograph 5. A Child's Drawing about the Gravity Experiment

During the learning process of Activity 10, Day and Night, the children had a chance to role-play different daytime and night time activities and to discuss their similarities and differences. They also discussed the properties of day and night sky. Similar experiences took place in other activities as well, particularly in the Activities 6, 7, 8, and 9. As part of the Activity 10, the children made drawings about the differences between day and night in their journals. An example is given in Photograph 6. The example illustrates a child's classification about what s/he knows about day and night. The majority of children made accurate and explicit representations of their observations.

Findings revealed from the qualitative analysis of science journals support the statistically significant differences in children's understandings of the shape of the Earth and the day-night cycle. While writing in the science journals, they reflected on their prior knowledge, emergent learning, and experiences in the inquiry-based activities. Moreover, the teachers and the researcher had a chance to monitor and assess the intervention process.

Photograph 6. A Child's Journal Page for the Day and Night Activity

CONCLUSION and SUGGESTIONS

The present study was designed to introduce inquiry-based play activities and to examine their effectiveness on the conceptual understanding of young children about the shape of the Earth and the day-night cycle. Both the qualitative and quantitative findings indicate a conceptual shift in children's understanding of the shape of the Earth and the day-night cycle toward a scientific model, pointing out the effectiveness of the intervention. The current findings add to a growing body of literature on the effectiveness of inquiry-based activities. The results of this study are consistent with the previous research studies that reported the positive impact of inquiry-based teaching on young children's conceptual development (Ampartzaki & Kalogiannakis, 2016; Bahar & Aksüt, 2020; Bulunuz, 2013; Cremin et al., 2015; Doğru & Şeker, 2012; Samarapungavan, et al., 2008; Samarapungavan, et al., 2011; Türkmen & Topkaç, 2015; Youngquist & Pataray- Ching, 2004). The current study contributes to the existing knowledge on inquiry-based teaching in early science by providing sample activities designed based on the PLC model for preschool teachers. The PLC model can be used to explore different scientific concepts and phenomena in preschool classrooms. This study implies that both inquiry-based approach and play should be taken into account when designing effective science activities for young children. The current study focused on Earth and space sciences; further research on other science concepts and phenomena would help us to establish a broader view on early science teaching.

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Appendix

The Lesson Plan of the Activity 7: Day Sky Observation

Activity Type: Science and Play (large and small group activity)

Age : 60-72 Months

Learning Objectives (LO) and Performance Indicators (PI):
Cognitive Development:
LO 3. Remembers prior perceptions.
PI: *Retells an event. Describes a situation. Applies prior knowledge to new situations.*
LO 5. Observes objects and entities.
PI: *Names and describes an object using its color, shape, size, length, texture, sound, smell, material, taste, and usage purposes.*
LO 6. Pairs objects and entities according to their characteristics.
PI: *Detects identical objects / entities. Matches object / entities with their shadows or pictures.*
LO 10. Follows spatial directions.
PI: *Follows the teacher's spatial instructions*.
Additional LO 23. Explains the differences between day and night.
PI: *Distinguishes the objects in the sky during the day from the objects in the sky during the night. Gives examples of different activities performed during the day or night.*
Motor Development:
LO 1. Performs gross motor movements.
PI: *Walks according to the teacher's instructions.*
LO 4. Perform movements that require fine motor skills.
PI: *Paints using different materials.*
Language Development:
LO 5. Uses language for communication purposes.
PI: *Starts a conversation. Participates in conversation.*

Materials: Storybook, science journals, colored crayons, daytime cards prepared by the teacher.

Vocabulary and Concepts: Day, Sun, Moon, Star, Sky

The Teaching and Learning Process

Play
First, children are asked to think about the daytime activities: What kind of activities do we engage in during the daytime?
A storybook with drawings of the day sky is read. Daytime activities, celestial bodies, and entities that are observable in the sky during the day are discussed. Prior to the lesson, the teacher prepares cards on which there are celestial bodies and daytime sky objects/entities. These cards are hidden in different parts of the classroom. Children are asked to find these cards. There is a card for each child. Each student tries to find his/her card according to the teacher's directions. Directions are as follows: "Day" as s/he gets closer to the card and "Night" as s/he gets farther away from the card. These same cards are also available on the observation record desks prepared in the schoolyard so that children will find out which table and chair they will sit on.

Explore
Children find their chairs by matching their cards with the cards on the chairs. Children examine the related page of their science journals and the questions that they need to answer during the daytime observation.

- What does the day sky look like?
- Can we see the Sun?
- What else do we see in the sky?

- Can we see the moon during the day, too?
- Can we see the stars?

Children make observations to answer these questions. They are told not to look at the Sun directly and are informed about the dangers of staring at the Sun. During the observation, the teacher reminds the questions if needed and records new questions that students generate for the class discussion. At the end of the observation process, children keep records in their science journals.

Discuss

The science journals are examined once the children are back in the classroom. The children share their drawings with the class and explain their reasoning. The teacher asks the questions generated for the observation and elaborates students' answers by presenting scientific information about the properties of celestial bodies and the sky.

Assessment

During the discuss phase, the following questions can be asked to children to assess their learning:

- What did we pay attention to during the daytime observation?
- What did we observe in the sky?
- What have we learned about the Sun? Moon? and Stars?
- Is the moon only visible at night? Why?
- If you observe daytime sky another day, will your observations differ? Why?
- Did you enjoy the activity?
- What part of the activity was difficult for you?

Family Participation

Parents may be asked to continue this activity at home. The children can keep observation records focusing on the Sun's position at different times of the day during the weekend.

Other Suggested Activities

- The same activity can be done in different seasons, and observations can be compared.
- Animations about the day and night concepts may be watched.