Preschool children's ideas about the Earth as a cosmic body and the day/night cycle
Ideas de niños sobre la Tierra como cuerpo cósmico y el ciclo del día y la noche

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Abstract

In this paper we present the results of research studying preschool age children's representations of the shape of earth and the phenomenon of the day/night cycle. We initially approached this problem through the relevant bibliography and we designed a series of tasks in order to discuss preschool children's understanding of the day/night cycle and the earth as a cosmic body. Based on research planning and in the framework of individual interviews we administered a semi-structured interview to 76 children aged 5-6, which raised questions about the shape of the earth as well as the cause of the day/night cycle and the solar system. We asked the children to select 3-D objects of different shapes and cards representing solar systems of different shapes. On analyzing the children's answers we realized that several children had difficulties in explaining the day/night cycle since the rotation of the earth on its axis was absent from their responses. Although the majority of our subjects are aware of the earth's and the planets' shapes, the relationships between shape, rotation and the day/night cycle are obscure.

Key words*: pupils' representations, basic astronomy concepts, science education, preschool education.*

Resumen

Este artículo presenta los resultados de investigación sobre las representaciones de niños en edad preescolar de la forma de la tierra y del fenómeno del ciclo del día y de la noche. Se aborda este problema a través de la bibliografía pertinente y se organiza una serie de tareas con el fin de discutir la comprensión que tienen los niños acerca del ciclo del día y la noche y de la tierra como cuerpo cósmico. Basados en una investigación planificada y en el marco de entrevistas individuales, se hizo una entrevista semiestructurada a 76 niños de edades entre 5 y 6 años, que planteaba preguntas sobre la forma de la tierra, así como la causa del ciclo del día y de la noche y sobre el sistema solar. Con este fin los niños eligieron objetos tridimensionales de diferentes formas y tarjetas que representaban sistemas solares de variadas formas. El análisis de las respuestas de los niños mostró que varios de ellos tenían dificultades para explicar el ciclo del día y la noche puesto que, la rotación de la tierra sobre su eje estaba ausente en sus respuestas. Aunque la mayoría de los sujetos de esta investigación es consciente de la forma de la tierra y de los planetas, la relación entre la forma, la rotación y el ciclo del día y la noche no está clara.

Palabras clave*: representaciones de los alumnos, conceptos astronómicos básicos, educación científica.*

INTRODUCTION

There has been intensive research concerning the study of concept formation and representations of phenomena in the physical world for children of different ages. Recently, the focus of this research has shifted to preschool children, since learning theories now accept the importance of learning processes at this age and, moreover, research has provided strong evidence that appropriate teaching can help preschool children accept basic scientific ideas about common phenomena of the natural world (KAMII & DE VRIES, 1978; RUSSELL, HARLEN & WATT, 1989; RAVANIS, 1994; RAVANIS, BAGAKIS, 1998; RAVANIS, 1999; SHARP, 1995).

We find a series of obstacles in the reasoning of preschool age children, which are also reported in research with older students. These obstacles to children's thinking can be exploited educationally under certain teaching conditions, that is, when placed as target concepts in activities that are developed on the basis of organized teaching interventions. Our aim is to identify such obstacles in preschool age children's thinking about the earth as a cosmic body and about the day/night cycle. Young children have already received many stimuli from their social environment about planets and space and are able to observe changes in the phenomena of everyday life (day/night cycle, seasonal changes, apparent movement of the sun and moon), raising questions and forming relations between them.

Earth is the third of the nine planets of our solar system, which revolve around the sun and spin about their axes. The Earth's shape is a spherical ellipsoid and its surface consists of sea and land. The alternation of day and night depends on the earth's spinning around its axis. The earth's shape and its day/night cycle seem to be an attractive and rich area for the study of children's intuitive concepts, since research has revealed the decisive role that the natural world's pre-teaching recognition models play in the learning process. Understanding the earth's properties can't be accomplished solely through a process of direct observation and individual construction.

Early studies (NUSSBAUM & NOVAK, 1976; NUSSBAUM, 1979; MALI & HOWE, 1979), attempted to study children's ideas about the earth's shape and gravity concluding in a classification of these ideas into five notions starting from a naïve flat-earth notion and going towards the accepted view. Gradually, there were studies concerning the earth's shape, the sun and the day/night cycle (KLEIN, 1982), the sun-earth-moon system (JONES, LYNCH & REESINK, 1987; BAXTER, 1995), all of the above plus the stars, the phases of the moon and the solar system in general (SHARP, 1995,1996), that all came up with the fact that very few children could effectively model the relationships connecting the sun, the earth, and the moon based on accepted scientific conceptions.

Bringing children's mental constructs to light that differ from the scientifically accepted explanation of concepts plays an important role in education for all grades. The alternative frameworks that students hold interfere with the educational process during, and often, after instruction. A series of studies (SCHOON, 1992; SKAM, 1994; AKERSON, FLICK, LEDERMAN, 2000; DUNLOP, 2000; DOVE, 2002) focus on the development of teachers' awareness of alternative frameworks as they provide a basis for organizing of their teaching, helping the students identify their own explanations and challenging them in the light of new evidence.

Vosniadou and collaborators (VOSNIADOU & BREWER, 1992; 1994; VOSNIADOU, SKOPELITI, IKOSPENTAKI, 2005) further refined the models identified by previous research and concluded that young children's mental representations show variations which change with age and educational training. Their attempt was to show how the alternative explanations provided by the children were directly related to their model of the earth.

Differing from the above studies, some researchers claim that young children's concepts lack theoretical structure or coherence and the development of understanding of the earth involves a gradual accumulation of fragments of cultural information that may be wholly inconsistent with one another (NOBES *et al*., 2003; SIEGAL, BUTTERWORTH, NEWCOMBE, 2004). In other words, children can't form mental models before they gain an understanding of the prevailing cultural theory because some scientific information e.g. about the earth's shape, may only be available by cultural transmission. They suggest that cultural transmission of some or all of the fragments is primarily by means of language, perhaps through conversations, schools and the media.

There are also a few studies that test the effectiveness of a teaching strategy in an effort to transform intuitive representations into others, which are compatible with the characteristics of scientific models. Sneider and Ohadi (SNEIDER & OHADI, 1998) suggest a constructivist-historical teaching strategy in changing the student's misconceptions about the earth's shape and gravity. Valanides *et al*. (VALANIDES *et al*., 2000), Diakidou and Kendeou (DIAKIDOU, KENDEOU, 2001) took students' preconceptions into account in designing an instructional approach for the acquisition of basic astronomy concepts, placing emphasis on explanations and demonstrations that would maximize the plausibility of scientific models in comparison to initial conceptions.

The results of these studies, which mostly concern older children, and the fact that these children face difficulties in constructing a scientific understanding of basic astronomy concepts enhances our belief that these concepts should be part of preschool education. We propose that the introduction of basic astronomy concepts in nursery school can be effective only after identifying intuitive concepts of the earth's shape and motion that constitute basic cognitive obstacles to the acquisition of scientific knowledge. The objective of our study presented in this paper is to design a series of tasks, based on some of the techniques of earlier studies, whose aim is to identify preschool children's intuitive concepts of the earth's shape and the alternation of day/night, so that the teaching-learning interaction would facilitate a reorganization of the children's existing cognitive structures.

METHOD

Subjects

The study sample consisted of 76 preschool children (39 boys 37 girls) aged 5-6 years old. The subjects were selected at random among the total number of children from 5 nursery schools. Some children, who were unwilling to participate, were excluded. None of the children had yet received any formal or informal instruction concerning the respective topics. The nursery schools were in urban areas with a population from various socio-economic levels. The numbers 1-76 in the analysis of the results stand for the children in the sample.

Design

During the experimental process that was carried out during January and May 2005, the researcher held individual interviews, whose duration was 10-15 minutes, in a special and isolated place within the nursery school. The interview included a number of questions concerning two drifts: the shape of the earth and the day/night cycle on the one hand and the earth's and sun's movements and the solar system on the other. All interviews were video-recorded for later analysis (see below).

Materials

At the beginning of the interview, the researcher used five wooden solids of different shapes: a cube, a pyramid, a disk, a hemisphere, and a sphere (for educational reasons in relation to preschool education, we may consider the earth as a sphere that revolves around the sun in a spherical orbit). The selection of these shapes was intentional and took into consideration children's representations of the earth as identified in the literature. Each child could use the same objects in order to represent his/her explanation of the day/night cycle. In addition, six cards representing the planets of our solar system were used, in which the first four presented the sun and the planets in shapes of cubes, pyramids, disks and hemispheres respectively, and the last two presented a geocentric and heliocentric solar system with spheres (figure 1).

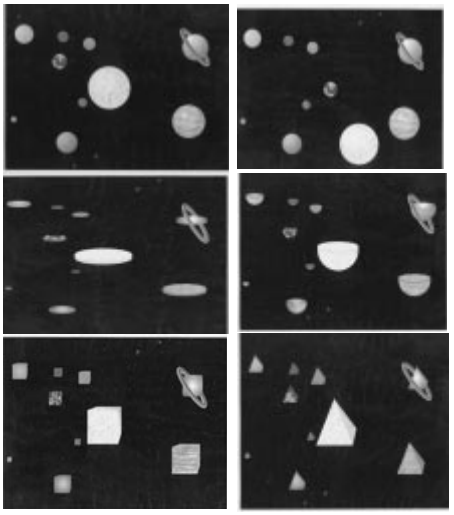

Figure 1. Cards of the solar system.

Process and tasks

The interview process required each child to respond to a number of questions relating to two different tasks.

Task A: The researcher presented each child with the five wooden solids asking a) which most resembles the shape of the earth "the place where all people live" in order to adopt a common code and avoid any confusion in the meaning of earth (in everyday Greek "earth" also means "ground" or "soil") b) to explain the alternation of day and night. The child could use the wooden solids to demonstrate his/her explanation.

Task B: The child, according to the selection of the shape of the earth he/she had made earlier, was presented with four of the six cards. The cards with the spheres and the disks were always presented while the fourth card depended on the previous selection of each child. For example, if he/she had selected cube as the earth's shape, the cards presented were cubes, disks and the two spheres. The reason why all the cards were not presented was because in an earlier pilot study it was found that the whole group of six cards confused preschool children making it difficult for them to focus on the difference between the shapes and the structure (concerning the spheres). When the researcher presented the cards she stated that they were made by someone who wanted to illustrate space and that one of them depicted it better than the others. After selecting one of the cards, the researcher and the child discussed what was represented via questions like: "Do you know what those are? Each has a name. Do you know any? Is the sun there? Show me. Some children told me that they believed that all of them move in space, some children told me they don't move. What do you believe? In what way do they move? Show me". There were solids for the earth and sun (yellow for the sun, blue for the earth) made of polystyrene foam with the respective shape of the objects presented in the card that the child had selected, which the child could place on the card and move as he/she wished. During the discussion the researcher tried to clarify as many terms and expressions as possible.

RESULTS

In the analysis of the results, which is presented below, the children's reasoning was recorded, organized and classified into categories. Table 1 presents the children's conceptions on the shape of the earth.

Table 1

Children's selection of the earth's shape

Solid		t
Cube	1,8,10,15,17,20,29,35,39,43,58,69,75	13
Disk	9,16,18,30,31,36,42,51,56,67,68,72,73,74	14
Pyramid	2,5,24,48,50,54	6
Hemisphere	6,53,71,76	4
Sphere	3,4,7,11,12,13,14,21,22,23,25,26,27,28,32,33,34,37,38,40,41,44,45,46,47,49,52,55,57,59,60,61,62,63,64,65,66,70	38

Subject 19 did not select a solid.

It seems that the majority of the children (38) selected the sphere from among the wooden solids in order to represent the earth. Among the remaining children who did not select the sphere, the alternative choices were spread among the cube (13), disk (14), pyramid (6) or hemisphere (4). The second most numerous category chosen was the disk, a solid that combines the spherical shape with a flat surface. There was only one child (subject 19) that did not want to select a solid during the first task.

Table 2 shows the children's explanations concerning the cause of the day/night cycle.

Table 2

Children's responses for the alternation of day/night

		t
Description of a situation	3,4, 6,11,14,24,31,32,37,46,59,62,65,74,75	15
Succession (morning, evening, night)	20,28,48,56,61,69	6
Anthropocentric explanations	9,10,17,68,70	5
Religious or other explanations	22,64,67,71	4
No answer	1,2,5,7,8,12,13,15,16,18,19,21,23,25,26,27,29,30,33,34,35,36,38,39,40,41,42,43,44,45,47,49, 50,51,52,53,54,55,57,58,60,63,66,72,73,76	46

In this table, the majority of the children (46) was reluctant to express any ideas about the day/night cycle and was classified in the "no answer" category. The category "description of a situation" includes children who attributed the alternation of day/night to strictly observable situations from everyday experience, e.g. "the moon goes off and hides in the mountains and the sun comes"(subject 46), "the sun falls into the sea and then it becomes night and the moon and the stars come" (subject 62) and an unexplained succession of sun and moon e.g. "at night the moon comes out, then comes the sun"(subject 6), "the sun goes down and the moon comes up" (subject 32). Alternatively, children offered anthropocentric explanations referring to the role played by the sun and moon to the performance of various human activities e.g. "we sleep and then it becomes day again" (subject 9), "we go to sleep, it rains sometimes and then becomes morning" (subject 68). The category "succession of a day" comprised the responses that mention certain phases of the day as "in order to be night, the afternoon must pass so that the day can go to other countries" (subject 28), "first it is morning, then noon, then afternoon, and then night" (subject 56). The "religious or other explanation" refers to answers like "God makes it happen like that" (subject 67), "God changes the days" (subject 71) or "once its getting dark, once its light" (subject 64). None of the children attempted to explain the day/night cycle in terms of the earth's rotation.

Tables 3 and 4 show the children's selections of the card that most resembles space.

Table 3

Children's selection of the solar system card

		t
Cubes	8,39,48,69	4
Disks	5,6,9,15,24,40,55,66,74	9
Pyramides	54	1
Hemispheres	44,49,56,65,59	5
Spheres (geocentric & heliocentric)	1,2,3,4,7,10,11,12,13,14,16,17,18,19,20,21,22,23,25,26,27,28,29,30,31,32,33,34,35,36,37,38,41,42,43,45,46,47,50,51,52, 53,57,58,60,61,62,63,64,67,68,70,71,72,73,75,76	57

Table 4

Children's selection of geocentric and heliocentric card with spheres

		t
Geocentric card	1,2,4,10,12,13,14,16,17,18,19,21,23,25,26,27,29,31,32,36,38,41,43,47,50,57,58,6264,67,68,75	32
Heliocentric card	3,7,11,20,22,28,30,33,34,35,37,42,45,46,51,52,53,60,61,63,70,71,72,73,76	25

The first thing to be noticed is that the majority of the children (57) also chose spheres during this task. However, our additional aim here is to examine whether preschoolers choose heliocentric or geocentric cards when they choose spheres. This choice gives us a hint about preschoolers' intuitive concepts of the structure of the solar system. It appears that most of the children believe that the earth is at the center.

Once each child had chosen a card the researcher asked if he /she knows any of the names of the planets and if the sun is depicted on that card.

Table 5

Children's comments on the chosen card

	yes	f	no	t
Mention of names	3,7,12,13,22,23,25,27,44,46,47,57,61,62	14	1,2,4,5,6,8,9,10,11,14,15,16,17,18,19,20,21,24,26,28,29,30,31, 32,33,34,35,36,37,38,39,40,41,42,43,45,48,49,50,51,52,53,54,5 5,56,58,59,60,63,64,65,66,67,68,69,70,71,72,73,74,75,76	62
Recognition of the sun	1,3,7,9,11,12,13,14,17,19,20,22,25,26,27,30,31,34,3 5,36,41,42,43,44,47,48,51,52,53,55,57,62,63,64,67, 69,71,72	38	2,4,5,6,8,10,15,16,18,21,23,24,28,29,32,33,37,38,39,40,45,46,4 9,50,54, 56,58,59,60,61,65,66,68,70,73,74,75,76	38

Most of the children (62) did not refer to any names of the planets whereas recognition of the sun was accomplished by half of the subjects. The most common names of the planets among the preschoolers were those of Earth, Saturn, Jupiter, Mars, and Venus and often they referred to the moon.

After commenting on the card they had chosen, the researcher asked if the heavenly bodies shown on the card move or not and invited the children to show the movements of these bodies using the respective shape of solids for the sun and earth.

Table 6

Movements of the earth with solids

	Earth/planet	t
Around the axis	7,8,13,20,22,23,25,27,28,32,42,43,47,55,56,67	16
Other	5,6,10,11,14,16,17,18,19,21,24,30,31,34,38,41,44,46,49,52,53,54,58,59,60,61,64,65,68,71,72,73,74	33
No movement	1,2,3,4,9,12,15,26,29,33,35,36,37,39,40,45,48,50,51,57,62,63,66,69,70,75,76	27

Table 7

Movements of the sun with solids

	Sun	t
Around the axis	7,13,20,22,28,32,42,43,44,55,56,67,76	13
Other	6,10,11,14,16,17,18,19,21,23,24,31,34,35,38,41,46,47,49,52,53,54,58,59,60,61,64,65,68,71,72,73,74	33
No movement	1,2,3,4,5,8,9,12,15,25,26,27,29,30,33,36,37,39,40,45,48,50,51,57, 62,63,66,69,70,75	30

A remarkable number of the children's answers implied that the earth (27) and the sun (30) don't move (although they were able to observe the apparent movement of the sun in the sky). However, most of the children offered answers in which the earth (33) and sun (33) carried out other movements (e.g. they shift them from right to left or make them collide). Very few rotated them around their axes (in the case of spheres the shape itself induced them to spin them) and none moved the earth around the sun.

DISCUSSION

In the framework of Science Education, several researchers (e.g. Vosniadou, Brewer, 1992, 1994; Skam, 1994; Baxter, 1995; Sharp, 1995, 1996; Akerson, Flick, Lederman, 2000; Dove, 2002) have pointed out that alternative views are potential constraints on the knowledge acquisition process, when they are not taken into consideration. This becomes very important when there is a sequence in which concepts are acquired in a conceptual domain. For example, understanding that the earth is a separate spherical body seems to be a necessary, although not sufficient, condition for a correct explanation of the day/night cycle, the seasonal changes or the understanding of the structure of our solar system with the spherical planets revolving around the sun.

The results of our study show that although most children select the sphere as the earth's shape, they don't seem to use any of the socially transmitted information about the earth's rotation and the relation between those two in the explanation of the day/night cycle. Alternation of day and night is usually explained by experience–based observations that provide the main source of information that children use. In addition, when they cope with the solar system cards, they also select the card presenting spheres (with the geocentric card getting the highest percentage) but only a few mention planets' names, while half of them recognize the sun as part of our solar system. Many children mention that earth and sun move but only a few (in which the majority had selected the sphere card) demonstrated a movement around the axis. The tables presented earlier allow us to note that although most of our subjects are aware of the earth's and the planets' shape, this information, if it is not related to the earth's rotation, does not suffice for the children to construct an elementary astronomy model that is compatible with the scientific model.

In our results, we should particularly point out the fact that many of the children who chose spheres in the card selection task, had chosen one of the other solids in the earth's shape selection task and vice versa (e.g. subjects 1,2,10,16,17,18,20,29,30 et al). This may be explained if we consider that preschool children's thought concerning astronomy concepts is not based on a theoretical structure or a model according to which they form relations that remain stable through all the tasks of the study. It is possible that they cope with every task separately, using fragments of their intuitive constructions in order to respond to the specific problem without caring about the consistency of their replies with their previous responses. Furthermore, in the results relative to the alternation of day and night few children attributed it to God's interference, an explanation that seems to come from the children's cultural environment. As some researchers claim (Samarapungavan, Vosniadou & Brewer, 1996; Diakidou, Vosniadou & Çawks, 1997), mental representations of the earth held by children who live in different cultural environments share common characteristics, whereas they also contain different elements from their specific culture.

The present study should be considered as the first step in the process of designing the introduction of basic astronomy concepts in nursery school. Our aim is to prepare the ground for the use of these ideas by the teachers in order to design classroom activities during which they will deal with the difficulties encountered by children by creating situations where they can construct knowledge together. The knowledge that children might acquire through these activities and their ability to use non-obvious data to conceptualize the natural world may serve them well for the elementary predictions or causal understanding that will be better understood in late childhood.

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