This article was downloaded by:[University of Patras]
[University of Patras]
On: 20 May 2007
Access Details: [subscription number 731675702]
Publisher: Routledge
Informa Ltd Registered in England and Wales Registered Number: 1072954
Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK

International Journal of Early Years Education
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713425018

Changing Pre-school Children's Conceptions of the Day/Night Cycle Changer les Conceptions d'Enfants d'Age Prescolaire sur le Phenomene du Cercle 'Jour-Nuit' Cambiar las Concepciones de los Ninos Preescolares en el Ciclo Dia/Noche

N. Valanides; F. Gritsi; M. Kampeza; K. Ravanis

To cite this Article: Valanides, N., Gritsi, F., Kampeza, M. and Ravanis, K. , 'Changing Pre-school Children's Conceptions of the Day/Night Cycle Changer les Conceptions d'Enfants d'Age Prescolaire sur le Phenomene du Cercle 'Jour-Nuit' Cambiar las Concepciones de los Ninos Preescolares en el Ciclo Dia/Noche', International Journal of Early Years Education, 8:1, 27 - 39
To link to this article: DOI: 10.1080/096697600111725
URL: http://dx.doi.org/10.1080/096697600111725

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: http://www.informaworld.com/terms-and-conditions-of-access.pdf

This article maybe used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

© Taylor and Francis 2007

International Journal of Early Years Education, Vol. 8, No. 1, 2000

Downloaded By: [University of Patras] At: 18:20 20 May 2007

Changing Pre-school Children's Conceptions of the Day/Night Cycle

Changer les Conceptions d'Enfants d'Âge Préscolaire sur le Phénomène du Cercle 'Jour–Nuit'

Cambiar las Concepciones de los Niños Preescolares en el Ciclo Día/Noche

N. VALANIDES
University of Cyprus, Department of Educational Sciences, CY-1678 Nicosia, Cyprus

F. GRITSI, M. KAMPEZA & K. RAVANIS
University of Patras, Department of Pre-primary Education, Rion, Patras, GR-26500, Greece

ABSTRACT *A semi-structured interview was individually administered to 33 children aged 5–6. The interview raised questions about the shapes of the Sun and the Earth as well as the cause of the day/night cycle. A teaching intervention designed to teach pre-school age children these concepts was then implemented with groups of 6–7 children. The intervention's effectiveness was consequently evaluated (after 2 weeks) using an interview similar to that conducted prior to the intervention. The results of the study showed that the majority of children readily accepted certain aspects of the scientific explanations of the day/night cycle. Specifically, the majority accepted that the Sun and the Earth are separate spherical objects, but fewer children attributed the day/night cycle to rotation of the Earth on its axis. Most seemed puzzled by the simultaneous movements of the Earth around the Sun and around its axis. Educational and research implications are discussed.*

RÉSUMÉ *Une semi-directive interview individuelle était administrée à 33 enfants de 5 à 6 ans. L'interview contenait des questions sur le schéme du soleil et de la terre et aussi sur la cause du cercle 'jour–nuit'. Une intervention didactique était après introduite aux groups de 6–7 enfants et ses résultats étaient finalement évalués, en utilisant la même interview, deux semaines après l'intervention. Les résultats de cet étude montrent que la majorité d'enfants ont accepté certains aspects des points de vue scientifiques concernant le cercle 'jour–nuit'. Plus specifiquement, la plupart d'enfants ont accepté que les schémes du soleil et de la terre ressemblaient à une sphère, mais moins d'enfants ont attribué le cercle 'jour–nuit' à la rotation de la terre autour du soi-même. Quelques enfants n'ont pas developpé les correctes conceptions et c'était apparent qu'ils avaient des difficultés à comprendre les mouvements simultanés de la terre autour du soleil et du soi-même.*

0966-9760/00/010027-13 © 2000 Taylor & Francis Ltd

RESUMEN *Se administró individualmente una entrevista semiestructurada a 33 niños de edades comprendidas entre los 5 y 6 años. La entrevista incluja cuestiones sobre formas del sol y de la tierra y también la causa del ciclo día/noche. Luego se introdujo una intervención didáctica a grupos de 6–7 niños de edad preescolar para enseñarles estos conceptos. La efectividad de la intervención file evaluada 2 semanas más tarde, con una entrevista parecida a la realizada antes de la intervención. Los resultados del estudjo mostraron que la mayoría de los niños aceptaban fácilmente ciertos aspectos de las explicaciones científicas del ciclo día/noche. Más especialmente, la mayoría aceptaba que el sol y la tierra eran objetos esféricos diferentes, pero menos niños atribuían el hecho de que el ciclo día/noche se relacionara con la rotación de la tierra alrededor de sil eje. Muchos parecían sorprenderse con los movimientos simultáneos de la tierra alrededor del sol y alrededor de sí misma. Se discuten las implicaciones educativas y de investigación.*

Downloaded By: [University of Patras] At: 18:20 20 May 2007

Introduction

There has been intensive research directed to students' alternative conceptions of various natural phenomena as well as the related issue of conceptual change. Recently, and for a number of reasons, the focus of this research has shifted to pre-school children. Foremost, learning theories now accept the importance of learning processes at this age and, moreover, research studies have provided strong evidence that appropriate teaching interventions can help pre-school children accept basic scientific ideas concerning common phenomena of the natural world (Kamii & De Vries, 1978; Crahay & Delhaxhe, 1988; Russell *et al*., 1989; Ravanis, 1994; Sharp, 1995). Research in this area, and also the various teaching strategies, can be categorised into three theoretically distinct groups (Inagaki, 1992; Ravanis & Bagakis, 1998): those based on empiricist notions of learning, those arising from the Piagetian paradigm, and, finally, those which combine both post-Piagetian and Vygotskian notions of learning in a socio-cognitive perspective.

Much of the research into science learning has been based on a constructivist view of learning as it is espoused by the third group. The present study has adopted this viewpoint, which posits that science is more generally learnt, at least in part, through the process of conceptual challenge and change (Posner *et al*., 1982; Driver & Erikson, 1983). Specifically, this approach argues that individuals idiosyncratically construct their own meanings from sensory inputs and that the differing conceptions so commonly found are the outcomes of this personal construction process (Gunstone *et al*., 1992). It is furthermore assumed that the acquisition and restructuring of knowledge (Carey, 1986) occur as intuitive ideas, which are usually based on direct sensory experiences, encounter culturally different views (Vosniadou & Brewer, 1987).

Astronomy seems to be an attractive and fertile domain for the study of children's conceptions and the process of conceptual change. As early as 1930, Piaget reported that most 9–10-year-old children considered the Earth to be flat and explained the day/night alternation by a peculiar movement of the sun that 'had to cross the sea by a tunnel which pierced what formed the floor of Europe and the roof of America' (Piaget, 1930, p. 296). He concluded, perhaps prematurely, that any attempts to teach the basic notions of the Copernican view of the solar system would not be effective due to children's inability to conceptualise it. He supported this conclusion with extensive evidence indicating that children's explanations give rise to the 'quaintest distortions'.

Later studies (Mali & Howe, 1979; Nussbaum, 1979; Nussbaum & Novak, 1976; Sneider & Pulos, 1983) found that 8–14-year-old children represent the Earth using qualitatively

Downloaded By: [University of Patras] At: 18:20 20 May 2007

different models ranging from egocentric or naïve to more scientific conceptualisations. In constructivist terminology, these 'distortions' are referred to as 'alternative frameworks' (Solomon, 1986; Driver *et al.*, 1994) and constitute the views or models that individuals employ to account for the respective phenomena. These alternative frameworks become more 'scientific' with increasing age and share a cross-cultural likeness, but there is also evidence that points to the importance of cultural influences on the formation of children's mental representations of the Earth.

Vosniadou & Brewer (1992) further refined the models identified by previous research and concluded that young children between the ages of about 6 and 14 ascribe to one of the identified models of the Earth (with variations), while the frequency profiles change with age. Their subjects also provided alternative explanations of the day/night cycle that were directly related to their model of the Earth. These explanations were accounted for by a small number of mental models. Klein (1982) and Jones *et al.* (1987), using 7–8-year-old American children and 8–12-year-old Tasmanian children, respectively, found that very few children can effectively model the relationships connecting the Sun, the Earth, and the Moon based on accepted scientific conceptions. A recent study (Diakidou *et al.*, 1997) provided evidence that 7–11-year-old American-Indian children's mental representations of the Earth shared certain characteristics common with those identified in the literature, while also containing different elements attributable to the children's specific culture.

Sharp (1995) examined 6–7-year-old children's conceptions of different astronomical phenomena after they had been involved in teaching activities targeting the various phenomena. The results showed that the majority of children recognised the shape of the Earth and the Sun as spherical and also indicated that the Sun is much bigger than the Earth. However, they could not provide adequate explanations for the day/night cycle. In another study, Sharp (1996) found that the majority of 10–11-year-old children concluded that the Sun and the Earth resemble the shape of a sphere, but they did not know and did not readily accept that the Earth rotates around its axis. They were, furthermore, unable to relate this movement to the day/night cycle.

The present study investigated pre-school children's conceptions related to the Earth's and Sun's shapes as well as the day/night cycle. Via a teaching intervention, children were introduced to the ideas that the Earth and Sun have spherical shapes and that the Earth rotates on its axis and around a stationary Sun. The intervention also related the rotation of the Earth to the day/night cycle. Children then participated in a playful activity exemplifying the Earth turning on its axis and moving in an orbit around the sun. The effectiveness of the intervention was evaluated 2 weeks later. The specific hypothesis tested was whether the intervention would improve pre-school childrens' initial limited representations. Our data and supportive evidence indicated that, subsequent to the intervention strategy, pre-school children could easily identify the shapes of the Earth and the Sun as well as the movement of the Earth around the Sun and around its axis and were able to realise that the day/night cycle is related to the turning of the Earth on its axis.

Methodology

Subjects

The study sample consisted of 33 pre-school children (25 girls and eight boys) whose mean age was 5.5 years, with a standard deviation of 0.18 years. Subjects were randomly selected from the total number of 5–6-year-old children in three kindergartens, from which 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 [shape or movement(s) of the Earth and the Sun]. The three kindergartens were selected from an urban area with a population of mixed socio-economic status.

Downloaded By: [University of Patras] At: 18:20 20 May 2007

The Process

A pre-test was first individually administered to each subject. This test consisted of a semi-structured interview which included a number of relevant questions on the shapes of the Earth and the Sun and on the day/night cycle. More specifically, the questions raised issues related to the shape and movement(s) of the Earth and the Sun. Interviews took place in a quiet and specially designed room in each kindergarten and were tape recorded and transcribed. The researchers also used special protocols, which permitted any relevant non-verbal responses to be encoded. Data were systematically analysed and the findings were applied to the design and implementation of a teaching intervention. The intervention presented counter information to children's existing conceptions in a purposeful attempt to create cognitive disequilibrium, so that the teaching–learning interaction would facilitate a reorganisation of children's existing cognitive structures. Two weeks later, a post-test, similar to the pre-test, was administered to each child and the results of both tests were compared.

Experimental Materials

Seven wooden solids of different shapes (a cube, a cylinder, a pyramid, a hemisphere, a disc and two spheres of different size) were used in both the pre- and post-test. The selection of these shapes was intentional and took into consideration children's representations of the Sun and the Earth as identified in the literature (Fig. 1). A wooden block with an irregular flat shape representing the universe was also employed. The wooden block had a number of holes indicating the possible positions of the Earth and the Sun. A set of six spheres of different sizes accompanied the wooden block. Each sphere was mounted on a support that could be inserted into a hole in the wooden block. Each child was asked to select two of the six wooden spheres and insert them into two holes in the wooden block such that the size and positioning represented the relevant sizes and positions of the Earth and the Sun (Fig. 2). At a later stage, the relative sizes of the Earth and the Sun were not taken into consideration, and the teaching intervention employed a model of the globe and a light source shaped as a bigger sphere representing the Sun (Fig. 3).

Pre- and Post-tests

Both the pre- and the post-test required each child to respond to a number of questions relating to two different tasks. In the first task, the seven wooden geometric blocks of different shape (a cube, a cylinder, a pyramid, a hemisphere, a disc and two spheres of different size) were presented, from which each child had to select two shapes to represent the Sun and the Earth. When a child did not select spheres, a researcher informed him (her) that some children had selected spheres. Then she initiated a discussion explaining that scientists accept that both the Sun and the Earth have the shape of a sphere. It was hypothesised that children in our culture are exposed to the information that the Earth is a sphere at an early age, and that only some children from deprived home and cultural environments would be unable to conceptualise the Earth as such. From this perspective, the discussion relating to the spherical shapes of the Earth and the Sun could be considered as a kind of intervention, as children's initial

Downloaded By: [University of Patras] At: 18:20 20 May 2007

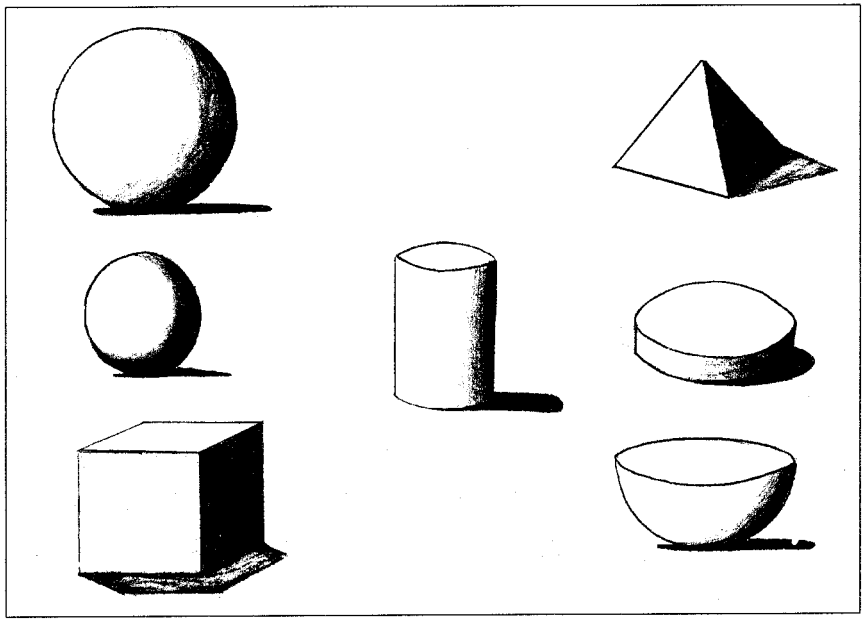

FIG. 1.

conceptions acquired from sensory experiences come into conflict with culturally accepted information.

Thus, while we employed a common 'intervention' despite the children's idiosyncratic responses, this was considered necessary because in the second task only spheres were used to represent the Sun and the Earth. In this task, the irregularly shaped wooden block and the set of six spheres were presented to each child, and (s)he had to select two spheres and position them on the wooden block to represent the Earth and the Sun. Initially, researchers intended to correctly guide the children's selections. However, size was later excluded as a variable of the investigation, since the respective sizes do not affect the day/night cycle that was the main purpose of the study. After selection and positioning of the two spheres, each child was asked to explain the day/night cycle in terms of the experimental representation and with reference to the possible movement(s) of either the Sun or the Earth.

Teaching Intervention

The teaching intervention had a two-fold purpose: first to communicate to each child the notion that both the Sun and the Earth have spherical shapes; secondly, to explain that the day/night cycle results from rotation of the Earth around its axis. It was also explained that the Earth revolves around the Sun. Although the latter movement is, of course, unrelated to the day/night cycle, it is a basic notion of the correct scientific model of our planetary system. In this simplified model, the Sun was considered stationary, while rotation of the Earth around its axis was emphasised as the cause of the day/night cycle. The teaching intervention, of approximately 30 minutes duration, was presented to groups of six to seven children by a team of two researchers. One researcher acted the role of the teacher and the second was her assistant. The context of the intervention and its relaxed environment both encouraged the individual

Downloaded By: [University of Patras] At: 18:20 20 May 2007

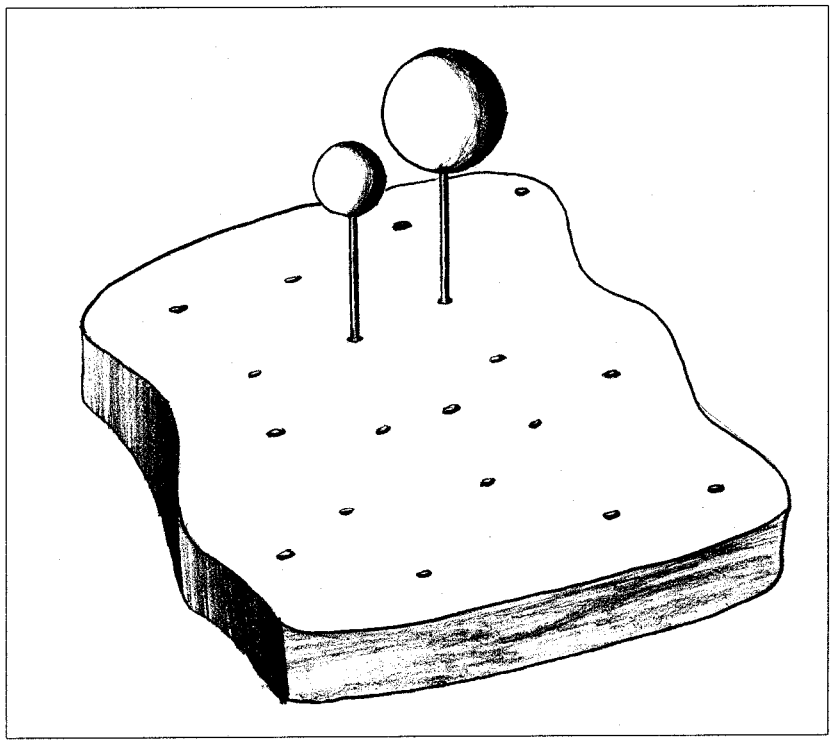

FIG. 2.

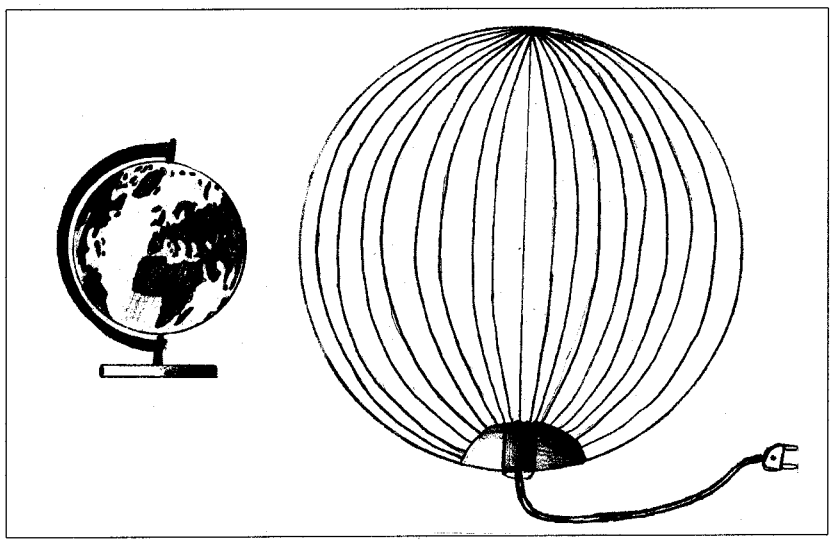

FIG. 3.

involvement of each individual child and facilitated the interaction among the children and between the researcher(s) and the children.

The teaching consisted of a sequence of two independent activities. Initially, the globe was

Downloaded By: [University of Patras] At: 18:20 20 May 2007

presented to the group of children, who were to describe and compare it with a spherical shape. The purpose was to communicate the idea that the globe represents the Earth, which resembles a sphere. Later, they were asked to locate on the globe the land, the sea, some known countries and their homeland (Greece) in particular, whose position was then marked with a coloured stick. A yellow light source shaped as a bigger sphere was employed to represent the sun. The light source was turned on, and the children were asked to discuss its relevance to the day/night cycle. The majority of children considered the light source as a representation of the Sun, which is illuminating the Earth.

The light source was then positioned side-by-side with the globe so that Greece was illuminated. The children were asked to explain whether it could be day or night in Greece. Most children easily understood that the model represented the respective positions of the Sun and Earth during daylight hours 'because the sun throws its light on Greece.' These children were then asked to instruct those who had given an incorrect, or no, answer. This discussion continued until the researchers felt confident that all children understood the conditions that Greece would experience daylight.

Subsequently, the children were asked to predict the conditions under which it would be night in Greece. The most common answer was that the sun 'moves and changes its position,' throwing its light on other countries. When they were asked to exemplify the movement of the sun, none of the children were able to provide any concrete movement. The children were then asked whether it was the Earth that 'moves and changes its position' to cause the day/night cycle. During this phase of the teaching intervention, most children suggested possible movement of the Earth, which was then explained as rotation around its axis. If there was no breakthrough in the discussion, the researcher herself referred to the rotation of the Earth on its axis, while the sun was considered stationary. Each child, in turn, was then asked to justify when (s)he expected to have day or night in Greece or any other country. Any incorrect interpretations of the day/night cycle were open to discussion and final correction by the other members of the group.

The subsequent attempt to provide explanations and representations of the two simultaneous movements of the Earth was difficult, and the children seemed unable to conceptualise them. Even when they made explicit references to both movements, their explanations were only able to consider one movement. We then invented a game where each group of the six (or seven) children were divided into pairs. When the total number of children was an odd number, one of the researchers participated as a member of a pair. The paired children were to touch back-to-back. Each pair represented the Sun, the Earth, or a planet (or more than one planet when we had four pairs) although, for the purpose of the game, the planet or planets followed the same orbit as the Earth. The pair representing the Sun was located in a steady position in the centre of a room and the other two (or three) pairs imitated the movements of the Earth (or a planet) around the Sun and around its axis. Periodically, we demanded that the moving pairs instantly remain still, and one child was asked to justify whether in his(her) position (s)he expected day or night. The child was also asked to explain what change in his position would result in a change from day to night or vice versa. The pairs alternately represented the Sun, the Earth, or a planet, so all children could experience the situation from different perspectives.

Results

Table I presents children's conceptions on the shape of the Earth and the Sun, both prior to and after the intervention. In the following discussion, numbers in parentheses represent the number of children who selected the respective shape.

Downloaded By: [University of Patras] At: 18:20 20 May 2007

TABLE I. Frequencies of students' conceptions of the shape of the Earth and the Sun ($n = 33$)

Choice of shape	Earth Pre-test Subjects	*f*	Post-test Subjects	*f*	Sun Pre-test Subjects	*f*	Post-test Subjects	*f*
Sphere	1–3, 13, 14, 16–23, 27–29, 32, 33	18	1–3, 5–24, 27–30, 32, 33	29	1, 3, 6–10, 12, 14–17, 19–23, 25–29, 31, 33	24	1–3, 6–21, 23–33	30
Hemisphere	10	1	4	1	2	1		0
Disk	15	1		0	5, 18, 32	3	5, 22	2
Cube	4, 6, 7, 9, 25	5	25, 31	2	13, 30	2		0
Pyramid	26, 30	2	26	1	4	1	4	1
Complex	31	1		0		0		0
No selection	5, 8, 11, 12, 24	5		0	11, 24	2		0

1–25, girls; 26–33, boys.
Prior to the intervention, subjects 2, 13, 18 and 32 conceived of the Earth as spherical but not the Sun.
After the intervention, subjects 5 and 22 conceived of the Earth as spherical and the Sun to resemble a disk, and subjects 25, 26, and 31 conceived of the Sun as spherical but not the Earth.

Downloaded By: [University of Patras] At: 18:20 20 May 2007

The results in Table I indicate that, prior to the intervention, the majority of children selected one of the spheres among the seven wooden blocks to represent either the Sun or the Earth. Almost half of the children (14) selected a sphere to represent both the Earth and the Sun. Nevertheless, more children (24) proposed that the shape of the Sun resembles a sphere than those who believed the same of the Earth (18). Four children who selected a sphere as a representative of the Earth's shape failed to do the same for the Sun. These children selected the disc (2), the hemisphere (1) or the cube (1). The greater tendency among the children to select a sphere as representative of the shape of the Sun is partially attributable to their everyday experiences, because the shape of the Sun as it appears in the sky excludes some of the presented shapes, such as the cube and the pyramid. This fact also likely minimised the number of undecided children. Of the additional 10 children (of the group of 24) who selected the sphere to represent the Sun but not the Earth, four selected the cube, one chose the pyramid, two were undecided, and three selected the hemisphere, the disc or a complex shape as a representation of the Earth.

The teaching intervention induced more children to select one of the two spheres as a representation of the shape of the Earth (29) or the Sun (30), and 27 selected a sphere to represent both the Sun and the Earth. From this perspective, and in terms of this aim, the intervention was very effective. However, the main purpose of the study was to determine the effect of the teaching intervention on students' conceptions relating to the day/night cycle. Thus, we did not raise questions to test the generativity of their acceptance relating to the shape of the Earth and the Sun or to uncover possible misinterpretations (cf. Vosniadou & Brewer, 1992).

The few children who did not select one of the two spheres to represent either the Earth (4) or the Sun (3) alternatively chose the disc, cube, hemisphere, or pyramid. Three children did not conceive of the Sun as spherical but they did so for the Earth. Similarly, two different children insisted that the sun resembles a disc, although they selected a sphere as a representation of the Earth. This seems to indicate the dominant effect of children's sensory experiences on their interpretation of natural phenomena.

Table II shows children's explanations concerning the cause of the day/night cycle prior to and after the teaching intervention.

Prior to the intervention, the majority of children (14) seemed surprised and reluctant to express any ideas about the day/night cycle. Some children resorted to religious or mythological explanations (3), others attributed the day/night cycle to a situation (4) or gave explanations in terms of a kind of movement of the Sun (10). Only two children attempted to explain the day/night cycle in terms of the movement(s) of the Earth, and one of them correctly attributed the day/night cycle to rotation of the Earth on its axis. The other child gave a correct description of the two simultaneous movements of the Earth around the Sun and on its axis, but did not seem to understand that rotation of the Earth on its axis alone could explain the day/night cycle.

In the category 'religious or mythological' explanations, two children made references to God as responsible for the day/night cycle, while another distorted the meaning of an ancient Greek myth. These cultural influences on conceptions of natural phenomena are usually referred to as the cultural mediation hypothesis. Evidence in favour of this hypothesis has been provided by Mali & Howe (1979), who reported that Nepali subjects exhibited the conception 'that the Earth is a large, flat mass supported on four corners by an enormous elephant' (p. 687). Diakidou *et al*. (1997) also provided evidence for the existence of specific conceptions related to certain cultural groups, such as the 'Lakota cultural model', which views the Earth as a flat disc covered by the sky in the shape of a dome.

Downloaded By: [University of Patras] At: 18:20 20 May 2007

TABLE II. Children's conceptions related to the day/night cycle ($n = 33$)

Conception	Pre-test Subjects	f	Post-test Subjects	f
The Earth revolves around the Sun and rotates on its axis	29	1	1, 3, 7–10, 13, 15, 19–21, 27, 33	13
The Earth rotates on its axis	1	1	2, 28, 29, 32	4
The Earth revolves around the Sun		0	14, 23, 25, 31	4
The Sun moves	2, 3, 12, 14, 15, 19, 27, 28, 31, 32	10	4, 24	2
Description of a situation	17, 20, 22, 25	4	12, 17	2
Religious or mythological explanations	7, 18, 24	3	11, 16, 18	3
No answer	4–6, 8–11, 13, 16, 21, 23, 26, 30, 33	14	5, 6, 22, 26, 30	5

1–25, girls; 26–33, boys.

Downloaded By: [University of Patras] At: 18:20 20 May 2007

The category 'description of a situation' refers to a variety of answers to explain the day/night cycle: the different colour of the clouds (during daylight clouds are white, while at night they are black), our needs (daylight is necessary so that children can attend school and night is necessary because we must sleep), a mechanical alternation of day and night that was unrelated to sunlight or an alternate and 'magic' appearance of the Moon and the Sun. The category 'the Sun moves' comprised such responses as 'the Sun hides behind the mountains or the Moon sinks into the sea or goes to other countries'. Similar ideas have been identified among older subjects (Klein, 1982; Nussbaum & Novak, 1986; Jones *et al*., 1987; Vosniadou & Brewer, 1994; Sharp, 1996).

After the intervention, only six children gave the same responses as in the pre-test. Four were initially reluctant to give any answer and, after the intervention, one child insisted on her mythological explanation and another held to her description of a situation as the cause of the day/night cycle. There was also a redistribution of six more subjects among the four categories of responses which did not mention any kind of movement of the Earth. The majority of subjects (21) attributed the day/night cycle to the movement(s) of the Earth. Thus, the intervention was successful for 19 children who abandoned their previous ideas and shifted to explanations of the day/night cycle in terms of the movement(s) of the Earth. Prior to the intervention, nine of these children explained the day/night cycle in terms of a kind of movement of the Sun, seven gave no answer, and the rest attributed it to a situation (2) or to God (1).

Among the 21 children, only four attributed the day/night cycle to rotation of the Earth on its axis. All of these children had initially accepted the spherical shape of the Earth, two described the Sun as spherical, one child considered the Sun to be disc-shaped and another gave it a hemispherical shape. Prior to the intervention, three of these children attributed the day/night cycle to a kind of movement of the Sun, while the fourth child explained the day/night cycle in terms of the two movements of the Earth around the Sun and on its axis.

Thirteen children explained the day/night cycle in terms of the two simultaneous movements of the Earth around the Sun and around its axis. All accepted, either prior to (8) or after the intervention (5), the spherical shape of the Earth. The Sun was also considered to be spherical either prior to (12) or after (1) the intervention. Prior to the intervention, four of these children attributed the day/night cycle to a kind of movement of the Sun, to other incorrect reasons (2) or gave no answer (6). Although the playful activity had a major impact on these children, it failed to convey to them the day/night cycle in terms of rotation of the Earth on its axis. Their ideas seemed rather to attribute the day/night cycle to the two movements of the Earth around the Sun and on its axis. These children could not of course realise that the revolution of the Earth around the sun is related only to the duration of day and night and not to the alternation of day and night.

Among the 12 children who did not attribute the day/night cycle to the movement(s) of the Earth, only two had initially accepted the spherical shape of the Earth, while two did not consider the Earth to be spherical even after the intervention. Similarly, only three children conceptualised the Sun to be spherical prior to the intervention, and another three did not consider the Sun to be spherical even after the intervention. Among these 12 children, five gave no answer concerning the day/night cycle, three resorted to religious or mythological explanations, two attributed it to a situation, and another two attributed it to some kind of movement by the Sun.

It seems that the explanation of the day/night cycle in terms of the Earth's rotation on its axis had a retroactive and positive effect on the children's conceptions regarding the shape of the Earth (and/or the Sun). The teaching intervention made the notions of a spherical Earth and

Downloaded By: [University of Patras] At: 18:20 20 May 2007

a spherical Sun more plausible and intelligible. The results of the present study do not, however, corroborate the results reported by Sharp (1996), who found that 6–7-year-old children do not readily accept that the Earth rotates around the Sun or that this movement is related to the day/night cycle. Finally, from the information presented in Tables I and II no differences between boys and girls could be identified, and no further attempt was undertaken to examine such differences.

Discussion

The results of the study appear consistent with a general constructivist view. Children are not 'empty vessels' who passively absorb information; rather, they always bring to any teaching–learning situation their own commonsense views of the world in which they live. Among the 33 children, the range of naïve ideas about the shapes of the Earth and the Sun as well as the cause of the day/night cycle are the outcomes of a personal construction process showing that individuals idiosyncratically construct their own meanings from sensory inputs. These alternative views are potential constraints on the knowledge acquisition process, when they are not taken into consideration. This becomes more 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 in terms of rotational movement of the Earth (Vosniadou & Brewer, 1994).

The results of the present study corroborate this conclusion. The children who were unable to conceptualise that the Earth is a separate spherical body, either prior to or after the intervention, made no attempt to explain the day/night cycle in terms of the Earth's rotation on its axis. On the other hand, only a few children accepted the 'scientific' explanation of the day/night cycle, although the majority seemed to accept that the Earth (and the Sun) is like a ball. In fact, most children were rather confused by the two simultaneous movements of the Earth, as these had been exemplified in the playful activity, and tended to attribute the day/night cycle to both movements rather than to the Earth's rotation on its axis. This activity seems to have imposed an extra cognitive load on the children, confusing rather than clarifying the issue of the Earth's rotation on its axis in relation to the day/night cycle.

From this perspective, it seems quite legitimate to attempt to replace the false notion of a stationary Earth with an equally false notion of a stationary Sun. The Earth's rotation on its axis constitutes the *sine qua non* condition for explaining the day/night cycle. A stationary Sun, on the other hand, simplifies explanation of the day/night cycle, while a non-stationary Sun may impose an unnecessary cognitive load for children of this age. This proved to be true when the two simultaneous movements of the Earth were introduced during the playful activity. It could have been more beneficial for the children in this study if the day/night cycle had been explained without reference to the revolution of the Earth around the Sun. The latter movement of the Earth and the notion of a non-stationary Sun could have been introduced as subsequent steps in the sequence relating to the conceptual domain of the solar system.

It is also possible that children were totally absorbed in the playful activity and, not considering it a learning activity, they failed to take any learning advantage from it. The spherical shape of the Sun also does not seem to help in understanding the day/night cycle, which can be correctly explained even if the Sun has a different shape (i.e. disc-shaped).

The results of the present study seem to justify the inclusion of a formal astronomy component in the pre-primary phase of schooling. Our research suggests, however, that the teaching–learning activities should be tailored to the specific needs of the children. Thus, not

only must children's conceptions be initially identified, but a careful task analysis at the level of component skills and the order of their attainment must also be made. Evidently, teaching aspects of the Copernican view of the solar system to pre-school children is still open to further investigation.

Downloaded By: [University of Patras] At: 18:20 20 May 2007

References

CAREY, S. (1986) Cognitive science and science education, *American Psychologist*, 41, pp. 1123–1130.

CRAHAY, M. & DELHAXHE, A. (1988) *Agir avec les Aimants. Agir avec les ressorts* (Bruxelles, Labor).

DIAKIDOU, I., VOSNIADOU, S. & HAWKS, J. (1997) Conceptual change in astronomy: models of the earth and of the day/night cycle in American-Indian children, *European Journal of Psychology of Education*, 7, pp. 159–184.

DRIVER, R. & ERIKSON, G. (1983) Theories-in-action: some theoretical and empirical issues in the study of students' conceptual frameworks in science, S*tudies in Science Education*, 10, pp. 37–60.

DRIVER, R., SQUIRES, A. RUSHWORTH, P. & WOOD-ROBINSON, V. (1994) *Making Sense of Secondary Science* (London, Routledge).

GUNSTONE, R.F., GRAY, C.M.R. & SEARLE, P. (1992) Some long-term effects of uniformed conceptual change, *Science Education*, 76, pp. 175–197.

INAGAKI, K. (1992) Piagetian and post-piagetian conceptions of development and their implications for science education in early childhood, *Early Childhood Research Quarterly*, 7, pp. 115–133.

JONES, B.L., LYNCH, P.P. & REESINK, C. (1987) Children's conceptions of the earth, sun and moon, *International Journal of Science Education*, 9, pp. 43–53.

KAMII, C. & DE VRIES, R. (1978) *Physical Knowledge in Pre-school Education: implications of Piaget's theory* (New Jersey, Prentice-Hall).

KLEIN, C. (1982) Children's concepts of the earth and the sun: a cross-cultural study, *Science Education*, 65, pp. 95–107.

MALI, G.B. & HOWE, A. (1979) Development of earth and gravity concepts among Nepali children, *Science Education*, 63, pp. 685–691.

NUSSBAUM, J. (1979) Children's conceptions of the earth as a cosmic body: a cross-stage study, *Science Education*, 63, pp. 535–550.

NUSSBAUM, J. & NOVAK, J.D. (1976) An assessment of children's concepts of the earth utilising structured interviews, *Science Education*, 60, pp. 535–550.

PIAGET, J. (1930) *The Child's Conception of Physical Causality* (London, Routledge & Kegan Paul).

POSNER, G.J., STRIKE, K.A., HEWSON, P.W. & GERTZOG, W.A. (1982) Accommodation of a scientific conception: toward a theory of conceptual change, *Science Education*, 66, pp. 211–227.

RAVANIS, K. (1994) The discovery of elementary magnetic properties in pre-school age. A qualitative and quantitative research within a Piagetian framework, *European Early Childhood Education Research Journal*, 2(2), pp. 79–91.

RAVANIS, K. & BAGAKIS, G. (1998) Science education in kindergarten: sociocognitive perspective, *International Journal of Early Years Education*, 6, pp. 315–327.

RUSSELL, T., HARLEN, W. & WATT, D. (1989) Children's ideas about evaporation, *International Journal of Science Education*, 11, pp. 566–576.

SHARP, J. (1995) Children's astronomy: implications for curriculum developments at key stage 1 and the future of infant science in England and Wales, *International Journal of Early Years Education*, 3(3), pp. 17–49.

SHARP, J. (1996) Children's astronomical beliefs: a preliminary study of Year 6 children in southwest England, *International Journal of Science Education*, 18, pp. 685–712.

SNEIDER, C. & PULOS, S. (1983) Children's cosmographies: understanding the earth' s shape and gravity, *Science Education*, 67, pp. 205–221.

SOLOMON, J. (1986) Children's explanations, *Oxford Review of Education*, 12(1), pp. 41–51.

VOSNIADOU, S. & BREWER, W.F. (1987) Theories of knowledge restructuring in development, *Review of Educational Research*, 57(1), pp. 51–67.

VOSNIADOU, S. & BREWER, W.F. (1992) Mental models of the earth: a study of conceptual change in childhood, *Cognitive Psychology*, 24, pp. 535–585.

VOSNIADOU, S. & BREWER, W.F. (1994) Mental models of the day/night cycle, *Cognitive Science*, 18, pp. 123–183.