Children's understanding of the earth's shape: an instructional approach in early education

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Abstract
Research findings in the field of early childhood education have supported the view that young children are capable of approaching the natural world in a systematic way. The present paper presents a pilot study on the construction of a precursor model concerning the earth's shape through a series of activities during which children are using two-dimensional and three-dimensional tools of representation of the earth (the map and the globe). Three educators and 73 children participated in the teaching intervention during which children had to exchange ideas concerning what is represented, follow the route of a hero on the map and the globe and argue about similarities and differences between the map and the globe.

Key words

Children's ideas - Cultural artifacts - Earth's shape - Group discussions

Introduction

During the last decades there is plenty of research evidence on children's learning processes and especially on how young children understand the natural world. The representations that children form on the basis of their everyday experience about the phenomena of the natural world and science concepts often display features that are incompatible with scientific knowledge. When children encounter something new to them, they usually attempt to make sense of it using ideas formed from earlier experiences. Teachers need to have an understanding of the knowledge children bring to their learning and be able to identify opportunities for extending children's learning (McLachlan, Fleer & Edwards, 2010).

Astronomy evokes children's interest since they can observe phenomena such as the alternation of day and night while at the same time in the social milieu there are several depictions (realistic or not) of the earth and the other planets in games, books or toys that familiarize them with relevant concepts and phenomena. On the other hand, Astronomy is one of the fields where children meet great difficulties due to the inconsistencies between what is experienced and what is taught. "*The appearance-reality distinction is fundamental to knowledge in any causal domain, from biology to psychology and from physics to cosmology. For example, children need to learn that, although the earth looks flat, in reality it is spherical*" (Siegal & Surian, 2004, p.535). In addition, children's ideas become more scientific with age and exposure to educational contexts. Therefore, knowledge in this field has to be "taught" by transmission through adults' explanations and exposure to cultural resources. Astronomy learning appears to take place mainly through acts of personal and social cognition rather than direct observation (Sharp & Sharp, 2007).

Theoretical Framework

In the field of children's knowledge of the earth, there has been a body of research outlying two approaches. The mental model account (Samarapungavan, Vosniadou, & Brewer, 1996; Vosniadou & Brewer, 1992; Vosniadou, Skopeliti, & Ikospentaki, 2004), states that young children construct initial, synthetic or scientific 'mental models' of the earth, while the fragmentation account (Nobes et al., 2003; Panagiotaki et al., 2006), describes the development of children's knowledge of the earth as a gradual accumulation of fragments of information up until children acquire the scientific theory of the earth. More specifically, Vosniadou and her colleagues have proposed that children have theory-like misconceptions. Young children initially have a naïve notion of the earth's shape founded on the "entrenched presuppositions" that there has to be a flat plane to stand on and that unsupported objects fall down. As children grow older and get informed of the culturally accepted view they form synthetic mental models in an attempt to combine their naïve theory and the culturally received view. These models maintain characteristics from everyday experience and are in a way adjusted to the scientific information. It is only in late childhood that children can overcome their synthetic models and acquire the scientific model.

From the point of the fragmentation approach, it is argued that acquisition of knowledge of the earth is a process of gradual enrichment through the accumulation of 'fragments' from the culture that are not necessarily consistent with each other. Findings from several studies suggest that the questioning methods used in previous research might have underestimated children's knowledge (Frède et al., 2011; Panagiotaki et al., 2006; Panagiotaki et al., 2009; Schoultz, Säljö & Wyndhamn, 2001). Studies using cultural artifacts have shown that when children can use a model as an anchor, they display a significantly better understanding of elementary astronomy than shown previously (Panagiotaki et al., 2006; Schoultz et al., 2001; Siegal et al., 2004). Using a situated and sociocultural framework, Schoultz et al. (2001) claim that the introduction of a globe to an interview results in substantially different responses from children compared to tasks in which the children had to think abstractly.

The important implications for teaching that derive from the juxtaposition of relevant research concern the necessity of helping children overcome their misconceptions at an early age since the earth's shape is a central concept for the construction of a representation that is compatible to the scientific model and the use of cultural artifacts that facilitate communication. Our attempt to design a teaching intervention was based on a theoretical framework where learning is understood as a product of systematic socio-educational interaction, during which we focus on targets that we have designated by research to constitute obstacles to children's thought. This perspective enables a more systematic work with young children helping them, under certain conditions, to construct precursor models in their thought. Precursor models are cognitive entities of limited range of application, which include a restricted number of elements from and relationships between the actual scientific models. Their educational role is important because they are introduced as intermediate entities between the children's first representations and the scientific models. If precursor models are successfully constructed they may offer a stable basis for the preparation of young children's thought for the construction of actual scientific models (Ravanis, 2010; Weil-Barais, 2001).

The purpose of this study is to propose a teaching intervention in kindergarten concerning the earth's shape in an attempt to support the construction of a precursor model in young children's thought. The use of cultural artifacts such as maps and globes, serve as a means for helping the wealth of children's ideas to emerge, offer a context of discussion among children and educators and therefore help children comprehend those properties of the Earth that lie outside direct experience.

Methodological Framework

Subjects

The proposed activities were implemented in the framework of a pilot study in three public kindergartens of Patras, between February and May 2010 by the teachers of each class who had previously participated in a seminar regarding the application of principles of a science inquiry-based approach. Seventy three children aged 4-6 participated. No similar educational program had been previously realized in those kindergartens. The intervention lasted two days for each group and it was organized in terms of a daily schedule in Greek kindergarten. Research data included children's drawings and transcribed group discussions.

Process

The activities were interrelated on the basis of a scenario in order to activate children's involvement in the activities, concerning the adventures of a seaman. The narration of stories and the design of activities around a specific scenario may arouse children's interest and make them involve in the process (Fleer, 1997). The first activity consisted of the narration of the seaman's story: he decided to make a long travel by travelling always in the same direction and finally succeeded to return back home. The children are initially urged to express their ideas about the way he succeeded to return home. Afterwards the children used a geomorphologic universal map in order to follow the seaman's route (starting from Spain and traveling to the west) and find the answer to the question. Figuring out how to find an answer or a solution to a problem challenges children's thinking and also fosters children to discover new concepts and apply new strategies (Thornton, 1995). As the activity proceeded, when they reach the end of the map the educator asked "*What will happen if he continues his trip in this direction?*" After children had expressed their ideas the educator introduced a relief globe and asked the children to observe and try to find out similarities and differences between the two representations of earth. They spotted the point at the end of the map on the globe and the seaman's route is followed both on the map and on the globe (Figure 1).

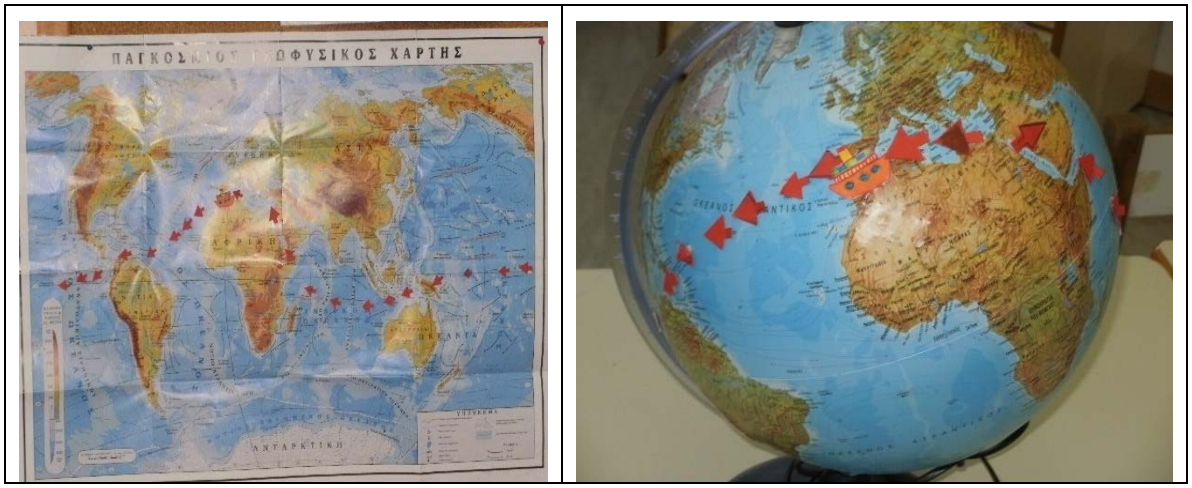

Figure 1 : *Children followed the route on the map and on the globe presented by the educator placing little arrows indicating the direction*

The teaching approach was collaborative, placing emphasis on social interaction during the activities through discussions and sharing meanings. Group discussions are key elements in the kindergarten's everyday practice and provide the children with more opportunities to express their ideas. Peers can help children revise their ideas by challenging their views and focusing the attention on information that they would not consider otherwise. "*There are many ways that peers can influence knowledge acquisition and revision. First, their influence may be at the motivational or affective level, increasing each other's willingness to attempt difficult tasks and reducing frustration when the work becomes too challenging. Second, peers may observe and imitate the behaviors and strategies of others. Third, a more expert peer might tutor a novice. Fourth, peers can engage in lively discussions and negotiations that may result in mutually shared and potentially higher levels of understanding"* (Azmitia, 1996, p. 134).

Results

We proposed a series of activities during which children used two-dimensional and three-dimensional tools of representation of earth (the map and the globe). All of the children were familiar with the map and the globe (they had a map or a globe in the school or at home). These activities were incorporated in the kindergarten's daily program involving small or large groups of children in a dynamic process of discussion. Before and after the instructional approach children were asked to make a drawing of earth (Figure 2).

***Figure 2** : Drawings of earth before (left) and after (right) the implementation of the instructional activities. Discussing his drawing with the educator the child responded that "earth is like a city" before his participation in the activities and "like a circle" afterwards (written comments). In order to clarify the two-dimensional representation in his drawing (after) he selected a sphere among the solid geometric shapes*

The majority of the children drew a "round" earth but since two-dimensional drawings don't allow the children to present their ideas of the earth's shape (flat or solid), solid geometric shapes were used by the educators in order to clarify their representation (Kampeza, 2006). In addition, the terms "round" and "sphere" are not used in a stable and explicit way among preschoolers. After their participation in the activities fewer children drew "flat" representations of the earth while the majority of the children moved to the "sphere" category (Table 1).

Earth's shape	Before	After
Sphere	16	58
Disk	15	9
Flat	30	4
Other	12	2

***Table 1** : Results of analysis of children's drawings of the earth*

We present below some extracts of conversation among children and the educator where the use of the map and the globe serve as a context of discussion that facilitates children's understanding of the earth's shape.

***Class 3**. Child 1: He reaches the end…(of the map). C2: He could not go forwards any more… C3: He sunk!! Educator: We said that he succeeded to return home. C1: He can't go out of the map so he can't continue the trip. C2 He went backwards… E: But he didn't change his direction…we have to find out what happened… The educator introduces the globe and after some time spent in familiarization to the globe the children put little arrows on the globe following the route they had on the map* (Figure 1). *E: So, where is he now? (a child locates the place on both the map and the globe). C4: This sea continues…they come close… (educator puts the two sides of the map together). E: So did he go backwards? All Children: No. E: He followed the same direction …how did he managed to return home? C4: He went around. E: Around where? C4: Around the sea. C5: Around the earth. E: So, because the earth is spherical he managed to go all around earth and return home. C5: What about us? E: Can we go around earth? Let's find Greece (on the map and globe)…can we do the same using an airplane? C (together): Yes. E: Using a car? C5: No, because there is the sea. C6: We can put it on a boat. C5: Yes.*

It is evident that the use both of the map and the globe constituted a context of discussion where different ideas were expressed but at the same time there was an effort to establish a joint definition of the situation. It was really crucial that the "restrictions" of the problem were reminded (the hero did return home, he didn't change direction) in order to emphasize that unless children begin to think in terms of a spherical earth the answers are not corresponding to the scenario. So, they can realize that one can go around earth traveling at the same direction only if earth is a sphere. Furthermore, children incorporated the hero's experience into their own point of view and displayed their interest to imagine themselves traveling around the globe.

***Class 1**. Educator: Can you think of any similarities or differences between the map and the globe? Child 1: These two are not alike because the globe is a sphere and the map is parallelogram. C2: Let's make the map look as a ball. E: Why do you think that? C2: To make it "sphere" (he means like the globe). E: Ok, how about we wrap the map around the globe and see if whatever is represented on the map is on the globe too. This is America on the map…can you locate it on the globe? Children: Yes. [….] After finding the route of the seaman on the map and on the globe putting little arrows to show the way (Figure 1). C1: He went all around… C3: How can this happen? His home (he means Spain- the departure point) is on the back! C1: He went round and round and found his home. C4: The globe is similar to the map. E: Is it the same? C4: No, the globe is plastic and the map is paper. C 5: They "show" the same things (he means land, sea, mountains, etc). E: That is? C4: The earth. C5: But the earth is not like the globe but is like the map because we are not "spherical" (he means what we experience). C4: … they show the same. C5: We go outside and we are like the map not "spherical" […]. E: Why do you think that? C5: We would fall off…we would fall off if it was spherical.*

In this extract we observe how children are dealing with the "trick" of finding similarities and differences between the two representation tools in an attempt to elaborate the idea of the earth's shape through the complementary use of the map and the globe. Children picked up the difference concerning the shape and the

similarities concerning what is represented leads one child to propose "*Let's make the map look as a ball*". It seems that the geomorphologic characteristics help children think that they have two "images" of the earth in front of them and that one can go around earth traveling at the same direction only if earth is a sphere. In fact, one of the children takes the initiative to explain how this is possible answering to another child's question. In addition, in this kind of interaction children feel free to express their ideas or disagreement, such as the "flat" conception of the earth derived from everyday experience, as shown above.

Discussion

In the proposed instruction we provided an educational framework that would help children aged 4-6 years old to approach the spherical shape of the earth through a scenario that would facilitate children make sense of the question posed in order to effectively seek an answer. The activities were oriented at constructing characteristics of a precursor model concerning the earth's shape that children will be able to apply systematically in relevant situations. Children, as described above, were not engaged in an abstract discussion concerning the earth's shape, but they confronted a problem based on a specific story. In this perspective the development of learning skills is encouraged because children can move from a "theoretical" plane to a "practical" one and doing so they can make a connection between ideas that seem abstract ("the earth is spherical") and the world of everyday personal experience ("how can I go around the world"). The use of the map and the globe incorporated in a specific scenario enabled children to express ideas that constituted a common context of communication, a context that was flexible enough to permit free expression of children's beliefs as well as instruction to take place. Allowing children time to think and wander about a specific topic may reveal the way their thinking is evolving and will help educators realize that children may hold multiple views at one particular point in time.

Another interesting point in this pilot study was the way the educators facilitated children to present their views of the world they live in and to reflect on these often conflicting ideas. Educators have a very demanding role to fulfill in designing and evaluating activities especially in the domain of science education. They have to look for the right "teachable moments" to introduce new ideas or pose questions that will help children progress. The precursor model framework takes into consideration children's conceptions and places them under elaboration during the teaching intervention. For example, in our case, it was crucial to use the map and the globe in a way that could help children realize that they both represent earth (seas, oceans, land) and at the same time establish the necessary conditions to help children discard beliefs based on appearance. It is worth mentioning that none of the children provided an answer based on the spherical earth's shape before the use of the globe in the activity, although all of them were familiar with a globe.

Group discussions allow the educator to trace children's ideas about the related issues, handle difficulties that the children are facing and utilize the curiosity of children to construct meaning. All the above provide additional useful information about the ways of communication preferred by children or the aspects of the subject that interest them more that can reinforce the potential for cognitive development and foster learning. The educator can exploit the additional information when designing learning activities that will be meaningful for the children and will contribute to the deepening of the comprehension of the subjects at issue. Our research on activities that would foster the development of precursor models in children's thinking focuses on the design of tasks that would enable children to use materials that are easy to handle (drawings and play-dough) and various means of representation (such as photographs or images from Google-earth) that can facilitate communication among the members of the group.

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