



**HAL**  
open science

# Children's understanding of globes as a model of the earth: A problem of contextualizing

Karin Ehrlén

► **To cite this version:**

Karin Ehrlén. Children's understanding of globes as a model of the earth: A problem of contextualizing. *International Journal of Science Education*, 2008, 30 (02), pp.221-238. 10.1080/09500690601185956 . hal-00513335

**HAL Id: hal-00513335**

**<https://hal.science/hal-00513335>**

Submitted on 1 Sep 2010

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



**Children's understanding of globes as a model of the earth:  
A problem of contextualizing**

Journal:	<i>International Journal of Science Education</i>
Manuscript ID:	TSed-2006-0081.R2
Manuscript Type:	Research Paper
Keywords:	qualitative research, conceptual change, alternative conception, primary school, conceptual development
Keywords (user):	conceptual development, models, qualitative research



# Children's understanding of globes as a model of the earth: A problem of contextualizing

## Abstract

Visual representations play an important role in science teaching. The way in which visual representations may help children to acquire scientific concepts is a crucial test in the debate between constructivist and socio-cultural oriented researchers. In this paper, the question is addressed as a problem of how to contextualize conceptions and explanations in cognitive frameworks and visual descriptions in cultural contexts. Eleven children aged six to eight years were interviewed in the presence of a globe. Those children who expressed views of the earth that deviated from the culturally accepted view did not show any difficulties in combining these different ideas with the globe model. The way that this is possible is explained using a model of conceptual development as a process of differentiation between contexts and frameworks. The child must differentiate not only between the earth as an area of flat ground in a common-sense framework and the planet earth in a theoretical framework, but also between these frameworks and the framework of the representation. It is suggested that a differentiation on a meta-level is needed to distinguish which problems and explanations belong to which cognitive framework. In addition, the children must contextualize the visual description of the earth in the globe in a cultural context to discern which mode of representation is used.

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

For Peer Review Only

## Introduction

Visual representations are assumed to contribute to learning, as they are used in traditional textbook and classroom situations and are gaining in importance in computer-based studies. Today, globes are common objects in schools, homes, and public places. Does the fact that children are frequently exposed to models of the planet earth mean that they are also better able to understand the concept of the planet earth? The role of pictures and artefacts in conceptual development is a matter of debate between constructivist and socio-cultural oriented researchers (e.g., Schoultz, Säljö, & Wyndhamn, 2001; Vosniadou, Skopeliti, & Ikospentaki, 2005). In this study, the question is approached as a matter of how children contextualize the concept of the earth in the presence of a globe. The contextualization is considered in relation to both cognitive contexts and the cultural context of the representation.

### *The role of models and pictures*

Models play an important role in scientific explanations and classroom instruction in the sciences; however, research into the use of visual representations in education has shown that pictures do not in themselves necessarily provide students with new information. Instead, learners interpret representations in accordance with their existing knowledge and may give lengthy descriptions of graphic signs without paying any attention to what they represent (Ametller & Pintó, 2002; Colin, Chauvet, & Viennot, 2002; Martínez Peña & Gil Quílez, 2001; Pinto, 2002; Pinto & Ametller, 2002; Stylianidou, Ormerod, & Ogborn, 2002).

Gilbert, Boulter, and Rutherford (1998a, b) called attention to the fact that the use of models in education leads to learners becoming involved in problems concerned not only with an explanation but also with the nature of the model itself. Grosslight, Unger, and Jay (1991) identified three levels of understanding of scientific models. Learners at these levels differ in the way that they understand the relation between the model and reality, as well as how they

1  
2  
3 believe that ideas have influenced the models. At Level 1, models are seen as either toys or  
4  
5 copies of reality. Grosslight and colleagues found that two-thirds of the 7<sup>th</sup> grade pupils in  
6  
7 their study looked upon models in either of these two ways. The remaining 7<sup>th</sup> graders were at  
8  
9 Level 2, where the learner realizes that a model can be constructed with a particular purpose  
10  
11 in mind. Level 3 is the expert's view of models, whereby models are perceived as tools for  
12  
13 developing and testing ideas.  
14  
15

16  
17 The findings of Grosslight et al. can be compared with general findings in terms of  
18  
19 children's understanding of visual representations. Freeman and Parsons (2001) argue that  
20  
21 children develop an intuitive theory of art. Their starting point is that any theory of pictorial  
22  
23 display must consider four factors: the artist, the viewer, the picture, and the world, as well  
24  
25 the relations between these factors. The child first realizes the picture–world relation.  
26  
27  
28 Freeman and Parsons also found that children generally remain unaware of the role of the  
29  
30 artist and the intentions of the producer of a picture until they reach the age of 11 to 14. As  
31  
32 they grow older, they may also become aware of their own role as interpreters of pictures in a  
33  
34 particular historical time and place.  
35  
36  
37

38  
39 To obtain a more varied description of how young children look upon the relation  
40  
41 between a model and the reality it represents, we can use Luquet's (1927/2001) theory  
42  
43 concerning children's drawings. Although Luquet's theory was constructed to understand  
44  
45 children's drawings and not their interpretations of representations, the theory pays  
46  
47 considerable attention to how the child understands the relation between the representation  
48  
49 and reality. Thus, we can expect the theory to be useful when trying to understand how young  
50  
51 children comprehend a model.  
52  
53

54  
55 An important event in children's drawing occurs when the child realizes that the marks  
56  
57 s/he makes on a sheet of paper can be related to the world. When the child realises this, the  
58  
59 problem is then how the world can best be represented. Luquet emphasizes that the child's  
60

1  
2  
3 intention is realistic in that the child tries to represent an object as s/he apprehends it. The  
4  
5 result is often a drawing in which details are depicted in accordance with the importance that  
6  
7 the child ascribes to each part or quality of the object. Luquet provides an example of a 7-  
8  
9 year-old Dutch boy who drew a field of potatoes. He did not depict the plants, which are  
10  
11 above-ground and therefore visible within the field; instead, he drew the potatoes growing  
12  
13 under the ground, which are therefore invisible. This was the approach chosen by the boy to  
14  
15 depict those details that best distinguished a potato field from other types of fields.  
16  
17  
18

19  
20 In making drawings, different ways can be used to achieve realism. Luquet  
21  
22 distinguishes between intellectual realism and visual realism. When a child uses intellectual  
23  
24 realism, s/he tries to depict an object by showing important details of the object, whether or  
25  
26 not the details can be seen. When using visual realism, the child tries to depict an object as  
27  
28 seen from a particular perspective. The latter is the mode of representation used in  
29  
30 photography, linear drawings, and paintings in accordance with the renaissance perspective.  
31  
32 Although visual realism is the usual way of depicting objects, Luquet describes contexts in  
33  
34 which intellectual realism is the preferred method, even among adults. A common example  
35  
36 today is engineering or architectural drawings, where the constructor makes hidden details  
37  
38 visible. Luquet's conclusion is that these two ways of representing should be seen as different  
39  
40 conventions for depicting, not as steps in intellectual development.  
41  
42  
43  
44  
45  
46  
47

#### 48 *Children's understanding of the planet earth*

49

50  
51 Research undertaken in recent decades shows that children have difficulty  
52  
53 understanding a scientific astronomical concept of the earth (e.g., Nussbaum, 1979;  
54  
55 Nussbaum & Novak, 1976; Sneider & Pulos, 1983; Vosniadou & Brewer, 1992). The  
56  
57 extensive research of Vosniadou and colleagues (e.g., Vosniadou & Brewer 1992; Vosniadou,  
58  
59 Skopeliti, & Ikospentaki, 2004, 2005) shows that children entertain various misconceptions of  
60

1  
2  
3 the earth; for example, that people live inside a hollow sphere or on the flat top of the earth, or  
4  
5 that they live on the ground and that the spherical earth can be seen in the sky. Vosniadou's  
6  
7 (1994) view is that these ideas indicate that children have a naïve framework theory with  
8  
9 presuppositions that constrain how they understand what they are taught in school; one such  
10  
11 example is that 'up' and 'down' are directions in relation to the ground. The naïve framework  
12  
13 theory is based on children's interpretations of their own experiences of their physical and  
14  
15 cultural surroundings. Vosniadou argues that until children have reinterpreted the  
16  
17 presuppositions of their naïve framework theory, they are unable to understand that the earth  
18  
19 is a sphere and that 'up' and 'down' are directions toward or away from the centre of the  
20  
21 sphere.  
22  
23  
24  
25  
26

27 From a socio-cultural standpoint, Schoultz, Säljö, and Wyndhamn (2001) and  
28  
29 Ivarsson, Schoultz, and Säljö (2002) challenge the idea described above that mental models  
30  
31 are constrained by the presuppositions of children's naïve framework theories. Their view is  
32  
33 that cognition concerns how people use tools; for example, language and models. Since such  
34  
35 tools are integral parts of cognitive processes, Schoultz et al. and Ivarsson et al. studied how  
36  
37 children reasoned about elementary astronomical concepts in the presence of a globe and a  
38  
39 map. None of the children in the Schoultz et al. study suggested that the earth was flat,  
40  
41 hollow, or any of the shapes described in earlier research. Even when only a map was present  
42  
43 (Ivarsson, Schoultz, & Säljö, 2002), the children experienced no problems in viewing the  
44  
45 earth as a sphere. Schoultz, Ivarsson, and colleagues explain the differences between the  
46  
47 findings of the socio-cultural studies and those of Vosniadou and Brewer's (1992) study in  
48  
49 terms of the fact that the former used a globe or a map during their interviews. Vosniadou and  
50  
51 colleagues (2005) responded with a study in which they first asked the children to make their  
52  
53 own representations of the earth in a drawing or using play-dough before interviewing them in  
54  
55 the presence of a globe. They found an increase in the number of correct responses from the  
56  
57  
58  
59  
60



1  
2  
3 children after they were shown the globe, but also a decrease in the overall consistency of the  
4  
5 responses. Vosniadou and colleagues maintain that the use of a globe only tests whether the  
6  
7 child recognizes scientific information, not whether s/he has understood the information. In a  
8  
9 new socio-cultural study of children's understanding of the earth (Ivarsson & Säljö, 2005), the  
10  
11 children were interviewed in front of a computer screen that showed a picture of a globe and  
12  
13 an aeroplane that could be moved along the surface of the globe. In this situation, the children  
14  
15 had greater difficulty in reasoning about gravity and the shape of the earth. The researchers'  
16  
17 explanation of this finding is that the children had problems identifying the mode of  
18  
19 representation that was relevant in connection with computer programs. They argue that the  
20  
21 variation observed in the ways that the children in this study reasoned is related to differences  
22  
23 in the children's perception of the graphic representations.  
24  
25  
26  
27  
28  
29  
30  
31

### 32 *Theoretical background*

33  
34 In the present study, children's understanding of the concept of the earth is regarded as  
35  
36 a problem of how to contextualize conceptions and descriptions in the appropriate cognitive  
37  
38 or cultural contexts (Halldén, 1999; Halldén et al., 2002). According to this view, conceptual  
39  
40 change can be described as occurring when the learner is able to differentiate between  
41  
42 frameworks and relate new information or new problems to an adequate framework in a  
43  
44 cognitive context (Halldén et al., 2002). Concepts belong to frameworks (Caravita & Halldén,  
45  
46 1994; Halldén, 1991, 1999; Linder, 1993; Tiberghien, 1994; Vosniadou, 1994); the  
47  
48 frameworks can be scientific theories, common-sense views (Caravita & Halldén, 1994), or  
49  
50 the learner's own 'theories' (Tiberghien, 1994). When contextualizing a concept, it is  
51  
52 necessary to differentiate between these different frameworks, since the chosen framework  
53  
54 decides which questions and which explanations are possible, as well as which elements  
55  
56 become discernable.  
57  
58  
59  
60

1  
2  
3 Caravita and Halldén (1994) describe three levels in each of the alternative  
4 frameworks of theory or common sense. In a theoretical framework, we can discuss  
5 theoretical, conceptual, and empirical levels. What is counted as data at the empirical level is  
6 decided at the conceptual level. In a common-sense framework, there is a worldview or  
7 ideological level, a conceptual or normative level, and a practical level. What is relevant at the  
8 practical level is decided by conceptions or norms. Tiberghien (1994) describes the  
9 corresponding levels in science as theory, model, and experimental field of reference. It is at  
10 the meta-level of theory or ideology that the frameworks must be considered and compared to  
11 determine which questions and explanations are possible in which framework. Consequently,  
12 the learner is expected to be able to not only differentiate and move between the different  
13 frameworks but also to move between different levels within an individual framework.  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28

29 When the learning process is seen as a problem of differentiating between  
30 frameworks, conceptual development will not entail the child's having to abandon his/her  
31 conception of the earth as flat in favour of a scientific conception. Rather, s/he will use a  
32 conception of the earth as flat in everyday situations and a conception of the planet as  
33 spherical in science classes in the school setting. In this way, learners enlarge their repertoire  
34 of conceptions with a scientific concept of the planet earth (Halldén et al., 2002). Learning  
35 then becomes a matter of expanding one's repertoire of conceptions (Caravita & Halldén,  
36 1994) rather than abandoning one's intuitive concepts for scientific ones, as according to, for  
37 example, the conceptual change model proposed by Strike and Posner (1992).  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49

50 When we want to study children's understanding of a globe, a cultural aspect must  
51 also be taken into account. Halldén (1991, 1999) discusses verbal descriptions in cultural  
52 contexts. It is his view that we should be aware not only of how children contextualize  
53 conceptions in the appropriate cognitive frameworks, but also of how they contextualize  
54 descriptions in different cultural contexts. As verbal descriptions must be contextualized in  
55  
56  
57  
58  
59  
60

1  
2  
3 the appropriate speech genres, learning also needs to become socialized into how one speaks  
4  
5 within a particular discipline (Halldén, 1999).  
6  
7

8 The globe is an artefact that increased in popularity during the early sixteenth century  
9  
10 because of new geographical discoveries and imperial struggles (Brotton, 1999); the flat map  
11  
12 was not thought to be adequate for depicting the new cosmography. From this time, globes  
13  
14 have been used both out of geographical and political interests. Different views of the world  
15  
16 have been shown on the surface of a globe, and those details of the cosmography that have  
17  
18 been considered of interest have varied. The information contained on ordinary globes is  
19  
20 transmitted visually; to be interpretable, it must therefore belong to a tradition of visual  
21  
22 communication. Following the ideas of Luquet described above, there are different  
23  
24 conventions for depiction, and these can be described as different visual languages. Thus, in  
25  
26 terms of visual communication, speech genres are comparable to different visual languages. If  
27  
28 we extend the view of Halldén from verbal communication to visual communication, a visual  
29  
30 description must be contextualized in the appropriate mode of depiction.  
31  
32  
33  
34  
35  
36  
37  
38

### 39 *Aim of the present study*

40  
41 The aim of the present study is to examine how children contextualize the concept of  
42  
43 the earth in the presence of a globe. In cognitive contexts the earth can be understood both in  
44  
45 a common-sense framework and in a theoretical scientific framework. Furthermore, as an  
46  
47 artefact with visual information, the globe is contextualized in a convention of visual  
48  
49 language. To interpret the globe means to contextualize it in a particular technique of  
50  
51 depiction. The research question is therefore: how do children differentiate between these  
52  
53 frameworks and contexts in an interview conducted in the presence of a globe?  
54  
55  
56  
57  
58  
59

### 60 **Method**

### *Participants*

The participants were selected from an age group within which earlier studies had shown many examples of deviation from the culturally accepted view of the earth (Nussbaum, 1985; Vosniadou & Brewer, 1992). The participants were pupils in the first grade at a school in Stockholm, Sweden, and were from working- or middle-class backgrounds. One of them (Liza) had recently immigrated to Sweden. In the first meeting with the class, the researcher presented the study and told the children that they would be asked to take part in an interview about a model and that the interviews would be tape-recorded. They were not told that the interviews would be about a globe. During this first meeting, a short interview about a picture was conducted in front of the class, using a volunteer from the class, as an example of the interview to be conducted at a later date. The children listened together to the recording of the interview, after which they were asked if they wished to participate in the study. To be allowed to participate, they had to obtain the written consent of their informed parents. Eight girls and three boys, aged between six and eight, were interviewed after this procedure. These eleven children represented approximately half of the pupils in the class, and they seemed to be well motivated to participate in the study.

The teacher told the researcher that she had not yet introduced the subject of the earth to the children; however, the children had probably met the subject in earlier pre-school classes. Two of the children made explicit references to this: one boy said that he had done 'research' about space in a pre-school class, and Liza said that in her introductory class for immigrant children they were provided with a small globe to find their countries of origin.

### *Materials*

A globe was present during the entire duration of the interviews. The globe was 30 cm in diameter and could be lit from within, although this only occurred in one of the interviews.

1  
2  
3 In this case it was a boy who, on his own initiative, connected the cord and switched it on to  
4 try to find colours that he observed on a globe at home. During the other interviews the cord  
5 was disconnected and the globe was unlit. The globe was fastened in a stand, with a leaning  
6 axis on which it could spin; the North Pole was slightly below the highest point. On the globe,  
7 the names of geographical elements were printed and the colours of land areas showed  
8 different kinds of vegetation; for example, light yellow for farmland, dark yellow for  
9 savannahs, and green for pine forests. Land level and sea depth were discernable from colour  
10 changes. Although the names of countries were given, nations were not depicted by different  
11 colours, as is commonly found on globes with a political description of the world. This globe  
12 belonged to the school and was taken from a cupboard to be used by the interviewer. It can be  
13 described as an ordinary school globe used in Sweden, although it had not yet been introduced  
14 to this particular class. Between the interviews, which were conducted over several days, the  
15 globe was kept in the interview room, where the children could also spend time after lessons.  
16 Two of the children, Mary and Liza, told the interviewer that they had found the globe in this  
17 room the day before they were interviewed and that they had tried to find Sweden, although  
18 without success.

### 43 *Interviews*

45 The interviews were 20 to 30 minutes in duration. The methodological approach  
46 employed in the interviews was to focus more on the child's own interests during the  
47 discussion than on a predetermined set of questions. This made the interviews more like  
48 conversations. Nevertheless, the interviewer had certain aims in mind and posed questions  
49 concerning the relationship between the globe and the real earth. Thus, the interviews could  
50 be characterized as semi-structured and with the interviewer's aims reflected in the questions  
51 posed to the students.  
52  
53  
54  
55  
56  
57  
58  
59  
60

*Analysis*

The interview is both a physical setting and a social and cultural situation. From the child's actions in this situation, it is possible to make inferences about the child's knowledge as well as the child's apprehension of the situation. The child's utterances, looked upon as actions, do not in themselves always reveal the child's ideas about the earth; they might equally reveal the child's ideas about how to behave during an interview or during a conversation with an adult. To categorize utterances as actions implies that the speaker's intention is implicit in the utterance and that this is acknowledged by the listener. In the examination of this material, intentional analysis was employed (Halldén, 1999; Halldén, Haglund, & Strömdahl, 2005; Ryve, 2006). This model of analysis takes into account people's intentions with their utterances. With reference to a person's intentions in a specific situation, it is possible to interpret her/his utterances as specific acts; acts are always situated. By regarding what is uttered as acts, it is possible to consider not only the cognitive ideas of the talking parties, but also their views about the social and cultural constraints of the situation. In this way, it is thought to be possible to draw conclusions about a person's knowledge. The utterances in themselves do not reveal the person's thinking; instead, they must be viewed as part of a situation where certain rules for talking and behaving interact with the person's knowledge and intentions (Halldén, 1999; Halldén, Haglund, & Strömdahl, 2005; Ryve, 2006).

The interviews were audio-recorded and transcribed by the interviewer shortly after they took place. This material, together with notes about what happened during or in connection with the interviews, was analysed by the interviewer. In this way, the utterances and other actions were considered in relation to the physical situation during the interviews. The physical situation consisted, among other things, of the globe and a window through

1  
2  
3 which nature outside could be viewed. The wider school situation and culture were also  
4  
5 considered in the interpretations.  
6  
7

8 The utterances were first scrutinized to discern those parts of the dialogue that were  
9  
10 relevant in terms of understanding in what cognitive framework the child contextualized the  
11  
12 earth and in what mode of depiction s/he contextualized the globe. Utterances that appeared to  
13  
14 be informed by intentions that could not be related to these aims were not taken into account  
15  
16 when describing the child's knowledge about the earth or the globe. This could be utterances  
17  
18 about home or school conditions that gave no information about the child's earlier experience  
19  
20 of the earth or globes. Other utterances that were not further considered were those that  
21  
22 seemed to be suggested by the interviewer in the interview or by other persons on earlier  
23  
24 occasions (cf. Piaget, 1926/1951: suggested conviction) or if the child appeared to be  
25  
26 indulging in fantasies (cf. Piaget: romancing). The utterances that were further analysed were  
27  
28 judged in relation to the knowledge that was a prerequisite to making the utterance and the  
29  
30 apprehension of the situation that was disclosed by the utterance.  
31  
32  
33  
34  
35  
36  
37  
38

### 39 Findings

40  
41 The presentation of the results begins with an overview of the responses of the eleven  
42  
43 children interviewed in the study. Here, answers are related to questions without further  
44  
45 analysis. This is followed by a presentation of interviews with five children, analysed  
46  
47 according to the intentional model. First, we describe the interview with one child who  
48  
49 demonstrated a culturally accepted view of the earth, followed by our findings concerning  
50  
51 four children whose views of the earth deviated from the culturally accepted notion.  
52  
53  
54  
55  
56

### 57 Overview

58  
59  
60

1  
2  
3 Since the interviews resembled ordinary conversations, not all of the children were  
4 asked exactly the same questions, although several questions were put to all of them. When  
5 confronted with the globe and asked 'What is this?', nine of the eleven children replied that it  
6 was a terrestrial globe (in Swedish, the word for earth is usually combined with the word for  
7 globe, '*jordglob*'). One child (Liza) said that it was a map; another child did not name it but  
8 said that she had seen one of them before and she knew that it was used to show countries.  
9 These responses indicate that for the children in the study the globe was a well-known  
10 artefact. The girl (Liza) who called the globe in front of her a map did not seem to regard the  
11 earth as a spherical planet. When the interviewer asked why she thought the globe was round  
12 in shape, she replied that it was to enable the viewer to locate countries. She hesitated when  
13 the interviewer asked if she thought the earth looked like the round model or if it was flat, but  
14 finally appeared to decide that it was flat.

15  
16  
17 The children gave clear suggestions for the use of a globe. In response to the question,  
18 'What do you use it for?', ten of them replied that you use it to look for countries, or they  
19 demonstrated this response by looking for particular countries themselves. One child, in  
20 addition to saying that one could look for countries on the globe, said it was a lamp; another  
21 child replied only that you use it as a lamp—this girl had a globe in her home that was used as  
22 a lamp. When the interviewer asked her why it was round, she replied that she did not know.

23  
24  
25 Of the nine children who were asked, 'Why is it round?', five replied that it was round  
26 because the earth is round, one replied that it was round because it was made like that, one  
27 replied that it was round to make it possible to find countries, and two replied that they did not  
28 know. Even though five of the children replied that the model was round because the earth is  
29 round, we still cannot be certain of what they meant by this. Nussbaum (1985) pointed out  
30 that of the children in his study who were attributed a flat-earth concept, all of them began by



1  
2  
3 saying that the earth is round like a ball. A follow-up conversation is necessary to reveal what  
4  
5 children mean when they say that the model of the globe is round because the earth is round.  
6  
7  
8  
9

10 *A culturally accepted view of the earth*  
11

12 Mary gives the impression of being well aware of different situations that can be  
13 associated with the concept of the earth. The interviewer's first question is if Mary knows  
14 what this is, referring to the globe on the table.  
15  
16  
17  
18  
19  
20  
21

22 Mary: A globe [earth globe].  
23

24 I: What do you use it for?  
25

26 Mary: You can look at other countries and what countries there are.  
27  
28

29 I: Well. Why does it look round like this?  
30

31 Mary: Because it is round.  
32  
33

34 I: What is round?  
35

36 Mary: The earth.  
37  
38  
39  
40

41 Here the interviewer and the child are talking in the context of the model. In the course of her  
42 answers about the countries and the earth, Mary introduces what the model represents. Mary,  
43 like several of the other children, states that the use of the globe is to find countries. This  
44 appears to be a consequence of earlier experiences of this activity in connection with globes,  
45 since on the globe used during the interviews nations are not clearly distinguished. Instead, it  
46 could be characterized as a geographical description of the earth.  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56

57 I: And the earth, what is that?  
58

59 Mary: A planet.  
60

1  
2  
3 I: Well. Can you see the earth?  
4

5  
6 Mary: Yes, you can, if you look at the ground.  
7  
8  
9

10 Here the conversation about what the globe represents has changed to a cognitive context  
11 related to the earth. The question ‘Can you see the earth?’ seems to make Mary switch from  
12 the astronomical framework of the earth as a planet to the common-sense framework of the  
13 earth as the nearby surroundings. The interviewer then tries to make Mary relate the different  
14 contexts of the earth that have been discussed thus far in the interview; namely, the model, the  
15 planet, and the ground.  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26

27 I: But if we look outside, it looks flat. Why is that?  
28

29 Mary: Because it looks like that when you are on it.  
30

31 I: When you are on it, it looks flat?  
32

33 Mary: Yes, but when you look from above, or when you look at the globe, then it’s  
34 round. But it looks like it’s flat when you look outside.  
35  
36  
37

38 I: But you said, if you look from above.  
39

40 Mary: Mm.  
41

42 I: For example, what can you do to look from above?  
43  
44

45 Mary: You can go by plane or a space rocket.  
46  
47  
48  
49

50 From this extract it is reasonable to conclude that Mary relates the globe, the planet it  
51 represents, and the ground, in a culturally accepted way.  
52

53  
54  
55 Later in the interview Mary and the interviewer talk about living in other countries.  
56  
57 Mary says she knows a person who has lived in Argentina. She looks up Argentina on the  
58 globe and the interviewer comments that it is down below and asks what happens to people  
59  
60

1  
2  
3 who live down under. Mary replies that they keep standing and when the interviewer asks  
4  
5 how they can do that, she replies that this is because of 'the power of attraction, maybe'. Later  
6  
7 in the interview the topic of the inside of the earth arises, and when the interviewer asks what  
8  
9 it looks like inside the earth, Mary replies 'lava'.  
10  
11

12  
13 Mary does not appear to have any problem here in finding relevant frameworks for her  
14  
15 explanations. When the interviewer asks why people in Argentina do not fall off the earth and  
16  
17 what is inside the earth, Mary's explanations are formulated within scientific frameworks. She  
18  
19 is also able to relate these scientific frameworks of the planet earth to the situation and explain  
20  
21 how she is able to see the earth. In addition, she seems to be well acquainted with how an  
22  
23 object can function as a representation of something else. This can be concluded from her  
24  
25 explanations of what the globe can be used for, the reason for its shape, and what it  
26  
27 represents. This knowledge concerns the cultural contexts of the globe as a visual  
28  
29 representation. Her description of the use of the globe to look for countries seems to refer to  
30  
31 nations, and it could be argued that this is not the main purpose of this particular globe with  
32  
33 its geographical description of the earth; however, the Swedish word 'land' is commonly used  
34  
35 to refer to nation, country, and land. Accordingly, the distinction may not be obvious to the  
36  
37 children. This is in addition to the fact that the children may have experienced the activity of  
38  
39 looking for countries on a globe. Most accurately, they could be described as categorizing the  
40  
41 globe as a representation of the earth, but not discerning all of the information about the earth  
42  
43 that is provided by the globe.  
44  
45  
46  
47  
48  
49  
50  
51  
52

### 53 *Alternative views of the earth*

54

55  
56 Some children had more problems than Mary in differentiating between the common-  
57  
58 sense framework of the earth nearby and the astronomical framework of the earth. This can be  
59  
60 illustrated by Jill's comments concerning 'inside' and 'outside'. Jill says that the model is a

1  
2  
3 (earth) globe, and that you use it to see where of all the countries are located. Later on the  
4  
5 interviewer asks her what it looks like inside the earth.  
6  
7  
8  
9

10 Jill: It is...hum...sea.

11  
12 I: Is there sea inside the earth?

13  
14 Jill: Yes. And there is ground you can walk on, too.

15  
16 I: There is ground you can walk on. Are there people inside?

17  
18 Jill: Yes... Wait!... Inside?

19  
20 I: Yes.

21  
22 Jill: I don't think so.

23  
24 I: You don't think there are any people?

25  
26 Jill: Not exactly inside.

27  
28 I: Where are they then?

29  
30 Jill: Outside.  
31  
32  
33  
34  
35  
36  
37

38 Jill initially says that the ground and people are inside the earth, but changes her mind to  
39  
40 people being outside. These comments are concerned with the differentiation of the  
41  
42 commonsense framework of the earth nearby and the astronomical framework of the planet. It  
43  
44 is possible that the present globe helps her in this process.  
45  
46  
47

48 As the conversation continues, Jill tells the interviewer that she has not seen the real  
49  
50 earth, but since she has already said that Stockholm is on the globe, the interviewer asks her  
51  
52 why we cannot see the real earth if we live on it.  
53  
54  
55  
56

57 Jill: You can see it, but...

58  
59 I: What do you see?  
60

1  
2  
3 Jill: You see...what's all around.  
4

5 I: For example? Can you see it now?  
6  
7

8 Jill: No, not all of it.  
9

10 I: What can you see then?  
11

12 Jill: I can see...eh...the sky.  
13  
14

15  
16  
17 Even if both the interviewer and Jill are talking about what the globe represents, the  
18 interviewer talks about the earth in a commonsense framework (to make Jill understand how  
19 she is able to see the earth), while Jill at first, when she says that she has not seen the real  
20 earth, probably talks about the earth in the astronomical framework of the planet. When Jill  
21 says that she can see 'what's all around', she, too, seems to talk in a common-sense  
22 framework. At first her response 'not all of it' may seem to reveal some awareness of the  
23 relationship between the earth in the nearby surroundings and the framework of the earth in  
24 space, but these utterances might also be related to what she can see of 'what's all around'  
25 through the window. The latter interpretation would explain why she says that she can see  
26 'the sky'; the sky might have constituted the main part of her view through the window.  
27 Although Jill appears to start with an alternative view of the earth, namely that people live  
28 inside the globe (cf. Nussbaum, 1985; Vosniadou & Brewer, 1992), the present globe and the  
29 conversation with the interviewer seems to make her move towards a more culturally accepted  
30 idea.  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49

50 Caroline explains to the interviewer during her interview: 'I mean we walk there, on  
51 those countries'. While saying this, Caroline points to land areas on the globe in front of her.  
52 This explanation can be described as being in the commonsense framework of the earth  
53 nearby in that 'we walk' is referring to an activity on the earth nearby. Moreover, 'on those  
54 countries' is referring to the representation, since this is what she is pointing at; thus, this part  
55  
56  
57  
58  
59  
60

1  
2  
3 of her utterances is an explanation in the context of the representation. Further on in the  
4  
5 interview, the interviewer asks her what is inside the earth, to which she replies that there are  
6  
7 bushes, trees, and such things.  
8  
9

10  
11  
12 I: [...] And people, where are they then?  
13

14  
15 Caroline: They are inside too. They are, you could say, a little bit on, and inside.  
16

17  
18 I: On and inside?  
19

20  
21 Caroline: Mm.  
22

23  
24 I: Can they be both on and inside?  
25

26  
27 Caroline: I think so. Since you can see the sun, and the trees and the bushes are where  
28  
29 you are and they are inside and we are on and inside.  
30  
31

32  
33 Earlier, Caroline showed the interviewer that the sun is situated a short distance from the  
34  
35 globe, i.e., that the sun is outside the globe, by indicating with her hand. She says that people  
36  
37 are 'on and inside'. When Caroline says that people are inside the globe, this is in line with  
38  
39 the conception that people live on a disc within a sphere located in space, as described in  
40  
41 many studies of children's conceptions of the earth (e.g., Vosniadou & Brewer, 1992). When  
42  
43 she says that people are 'on' the earth, this can be related to how she has shown that people  
44  
45 walk on the surface of the globe and that the sun is situated outside the globe. These latter  
46  
47 explanations are close to a culturally accepted view. Caroline makes these explanations with  
48  
49 the help of the representation. When Caroline maintains that the sun is situated outside the  
50  
51 earth, this can be a description of what she has seen in pictures or models on previous  
52  
53 occasions. When she tries to combine this information, which may have been in an  
54  
55 astronomical context, with her experience of the earth nearby in a common-sense context, she  
56  
57 appears to end up with two conceptions. Her conception of the earth as a place that people  
58  
59  
60

1  
2  
3 live 'on' can be combined with an interpretation of the globe as made in what Luquet  
4  
5 (1927/2001) called a visually realistic mode of depiction. Her conception of the earth as a  
6  
7 place that people are inside, but that can also be shown to walk on the countries shown on the  
8  
9 surface of the globe model, should be connected to a mode of depiction that Luquet called  
10  
11 intellectually realistic. In this convention, important characteristics can be shown on the  
12  
13 surface even if they are not visible.  
14  
15

16  
17 Another girl, Margaret, says that the object on the table is a globe and that it is used to  
18  
19 look for countries. She finds Sweden with some help, and then the interviewer asks her if it  
20  
21 looks like that in Sweden. After some hesitation she says that Sweden is not that small. The  
22  
23 interviewer then asks if there is a real earth that is not as small as this one, to which she  
24  
25 replies no. The interviewer's next question is what Sweden looks like in reality, to which  
26  
27 Margaret responds by pointing out the window. She says that she does not know why the  
28  
29 globe is round. When the interviewer asks her if she knows what the earth is, Margaret replies  
30  
31 again that she doesn't know, and that she only knows that she lives 'on earth'. In Swedish, as  
32  
33 in English, the expression 'on earth' may mean something like 'in the world' without a clear  
34  
35 indication of position. It seems to be this meaning that is alluded to by Margaret, while  
36  
37 Caroline, above, who makes her assertion about the preposition 'on' in isolation, appears to  
38  
39 talk about a certain position in relation to the earth.  
40  
41  
42  
43  
44

45  
46 What Margaret says about the earth here can be related to the earth in a common-sense  
47  
48 context: she knows that she lives on earth and that Sweden looks like what you can see  
49  
50 outside the window. She also knows that Sweden can be found on the globe, but the only  
51  
52 description about the mode of depiction in the globe she has given so far is that Sweden is not  
53  
54 as small as it is depicted on the globe.  
55  
56

57  
58 When the interviewer later asks her about the likeness between the globe and the earth,  
59  
60 Margaret says that they are almost the same but that the earth does not have the little squares

1  
2  
3 that are the keys to colour symbols on the globe. The interviewer asks her if the globe  
4  
5 otherwise looks like the earth.  
6

7  
8 Margaret: Yes. [She points at the surface of the globe] But this is inside.  
9

10 I: You are pointing on the outside, on that country there.  
11

12 Margaret: It's inside.  
13

14 I: Yes?  
15

16 Margaret: Yes.  
17

18 I: It is inside. And people then, where are they?  
19

20 Margaret: Inside.  
21

22 I: What does it look like inside?  
23

24 Margaret: Like this.  
25

26 I: In what way like this?  
27

28 Margaret: Like this. [She indicates out of the window with her hand]  
29

30 I: You're pointing out of the window. Do you mean, like where we are?  
31

32 Margaret: I don't know what it looks like in all other...  
33

34 I: In all other?  
35

36 Margaret: Countries.  
37

38 I: In all other countries. But it looks like that inside. But you say people are inside.  
39

40 Can they come out then?  
41

42 Margaret: No.  
43

44 I: Is there no one who has been outside?  
45

46 Margaret: Yes, in space.  
47  
48  
49  
50  
51  
52

53 Here Margaret tells more about how she understands the mode of depiction in the globe. The  
54 squares that are the keys to colour symbols are not found on the real earth. Further, she  
55  
56  
57  
58  
59  
60



1  
2  
3 believes that the countries depicted on the surface of the globe are inside the real globe. Most  
4  
5 of what Margaret is talking about can be related either to the earth nearby or to the model.  
6  
7  
8 However, what she says about 'inside' and an outside 'space' indicates that she has some  
9  
10 knowledge of an astronomical concept of the planet, although her knowledge of this context  
11  
12 does not appear to be differentiated and related to her knowledge of the common-sense  
13  
14 knowledge of the earth nearby. Her idea of the earth seems to be consistent with earlier  
15  
16 descriptions by Nussbaum (1985) and Vosniadou and Brewer (1992), where some children  
17  
18 believe that people live inside a hollow sphere.  
19  
20  
21

22 How then is Margaret able to combine her alternative conception of the earth with the  
23  
24 globe as a model of the culturally accepted view of the earth? This can be described as a  
25  
26 problem of contextualizing the description of the earth in the globe in a relevant visual  
27  
28 language. When the countries are shown on the surface of a globe, this is intended to be what  
29  
30 Luquet (1927/2001) calls a visually realistic mode of representation. This means that the  
31  
32 countries are in fact situated on the surface of the real globe. Margaret, however, seems to  
33  
34 have contextualized the description in what Luquet calls an intellectually realistic mode of  
35  
36 depiction, where that which is considered a relevant characteristic can be depicted on the  
37  
38 spherical model even if it is situated inside and is impossible to see. To Margaret, countries  
39  
40 may be a relevant characteristic of the earth.  
41  
42  
43  
44

45 Another girl interviewed in the class, Jane, says that she does not know if the earth  
46  
47 looks like the globe because she has never seen it. Shortly thereafter, she switches perspective  
48  
49 and says that she is seeing the earth at that very moment and that everything in the room and  
50  
51 outside the window is the earth. After talking about this for a while, the interviewer asks  
52  
53 about the globe again.  
54  
55  
56  
57  
58  
59  
60

I: But this, what we have on the table, what is that then?

1  
2  
3 Jane: A statue of the earth.  
4

5  
6 I: A statue of the earth?  
7

8 Jane: Yes, which is fastened here.  
9

10 I: Which is fastened here. But does the earth look like this?  
11

12 Jane: I don't know.  
13

14  
15 I: You don't know.  
16

17 Jane: You see, I've never been outside the earth.  
18  
19  
20  
21

22 Here Jane gives a different explanation than the one she gave earlier in the interview of why  
23 she does not know if the earth looks like the globe. Her first explanation is that she has never  
24 seen the earth and the second is that she has never been outside the earth. This difference must  
25 be looked upon in relation to the idea that she seems to have suddenly realised that she is able  
26 to see the earth in the room where the interview takes place. What Jane is talking about here  
27 can be interpreted as talking about the earth in three different contexts. One context is the  
28 model of the earth, which she calls 'a statue of the earth'. A second context is the earth as  
29 seen from space, as a planet. This is the context that she is referring to when she first says that  
30 she does not know if the earth looks like the globe because she has never seen it; she repeats  
31 this assertion, this time providing the explanation that she has never been outside the earth.  
32  
33 The third context is the earth that we can see all around us. Jane is talking about the earth in  
34 this context when she says that she is seeing the earth during the interview and that everything  
35 in the room and outside the window is the earth. When she says that she has 'never been  
36 outside the earth', she indicates that she is unable to relate these three contexts in a culturally  
37 accepted way, and that her conception of the earth seems to be in line with the alternative  
38 model of the hollow sphere described by Nussbaum (1985) and Vosniadou and Brewer  
39 (1992).  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## Discussion

The children were able to contextualize the concept of earth in a common-sense framework, but several of them had difficulty in contextualizing the concept in a scientific framework. What role then did the presence of the globe play in their attempts to contextualize the concept of earth in a scientific framework? The four children presented here who expressed notions of the earth that deviated from the culturally accepted view in the presence of the globe indicate that the globe is not an easy tool to use in conveying the scientific concept. This is in line with previous research showing that visual representations do not always give students access to that which is being represented (Ametller & Pintó, 2002; Colin, Chauvet, & Viennot, 2002; Martínez Peña & Gil Quílez, 2001; Pinto, 2002; Pinto & Ametller, 2002; Stylianidou, Ormerod, & Ogborn, 2002; Vosniadou et al., 2005). Here it is argued that this can be explained by the fact that there exists more than one mode of depiction and that children may have problems in contextualizing a picture or model in the appropriate visual language. These problems may be the consequences of children holding a different view on realistic depiction compared to adults (Luquet, 1927/2001). If children attach to what Luquet called an intellectually realistic mode of depiction, where details or qualities are depicted in accordance with the importance that they are attributed, they may think it suitable to depict countries on the surface of a globe model even if the countries are believed to be situated inside the real globe. This was clearly demonstrated in the present study by Margaret, who pointed at the surface of the globe and said 'this is inside'.

Furthermore, the children's identification of countries on the globe was not sufficient for all of them to accept that people live all over the surface of the globe. This finding differs from Schoultz et al. (2001)'s finding where the children did not appear to have any difficulty understanding the scientific concept in the presence of a globe. The findings in the present

1  
2  
3 study, however, indicate that the globe could help children become aware that there exists  
4  
5 another framework of the earth in addition to that of the nearby surroundings. This is  
6  
7 illustrated by Jill and Caroline in the present study, who at the start of the interviews  
8  
9 maintained that people were inside the earth but readjusted this view during the interview and  
10  
11 said that people were either outside or both inside and on the earth. This is compatible with  
12  
13 Vosniadou et al. (2005), who found an increase in the number of correct responses when the  
14  
15 children were interviewed in the presence of a globe, although the responses were less  
16  
17 consistent.  
18  
19  
20  
21

22 We can discern certain characteristics of the role of a globe when the children tried to  
23  
24 contextualize the concept of earth. The globe seemed to constitute a separate context in this  
25  
26 process alongside the common-sense framework of the flat ground and the scientific  
27  
28 framework of the planet. In addition to the problem of how the concept of earth can be  
29  
30 contextualized in cognitive frameworks, the globe must be interpreted in a cultural context of  
31  
32 visual languages. This means that to be able to profit by the information found on a globe, the  
33  
34 learner must contextualize the globe in the appropriate visual speech genre or mode of  
35  
36 representation. This is in line with how Ivarsson et al. (2005) describe the differences in the  
37  
38 way the children in their study reasoned in front of a picture of the earth on a computer screen  
39  
40 as differences in the children's perception of the graphical representations.  
41  
42  
43  
44

45 Halldén (1999) suggests that contextualization in a cultural context of speech genres  
46  
47 may supply learners with vaguely apprehended higher-order conceptions; this could be the  
48  
49 solution to the learning paradox of how it is possible to learn something completely new  
50  
51 although one does not know how to pose relevant questions. Halldén describes the ability to  
52  
53 contextualize in a cultural context as learning how to express oneself in the language of the  
54  
55 genre, for example, to recognize a story belonging to a specific scientific discipline. Here, it is  
56  
57 suggested that this is what we can also expect from visual representations. If an individual has  
58  
59  
60

1  
2  
3 knowledge of the conventions for depicting in a scientific area, s/he may be able to extract  
4  
5 information from a model. Therefore, the ability to contextualize a visual description of a  
6  
7 concept in the proper visual language may facilitate understanding of the corresponding  
8  
9 scientific concept.  
10

11  
12 By regarding the ‘conceptual change’ problem (Strike & Posner, 1992) as a problem  
13  
14 of contextualization as opposed to the constructivist view of change and the socio-cultural  
15  
16 view concerning the use of tools, it **seems** possible to detect how contexts other than the  
17  
18 scientific and common-sense frameworks are involved in the process of conceptual  
19  
20 development. When in the present study we used a visual representation within this  
21  
22 framework, we found indications of the sources of both the failings and the possible  
23  
24 advantages of the use of such tools. Failings may arise when explanations are contextualized  
25  
26 in the context of the representation rather than in the context of the referent. In the views of  
27  
28 Grosslight, Unger, and Jay (1991) and Freeman and Parsons (2001), the development of an  
29  
30 understanding of visual representation appears to imply the adding to or replacing of earlier  
31  
32 ideas. Here, **it is suggested that the process could be** described as a continuous differentiation  
33  
34 between contexts and an understanding of what context explanations belong in. Since not only  
35  
36 cognitive frameworks but also (e.g.,) visual representations **could** be considered in the search  
37  
38 for the appropriate context of an explanation, the meta-level on which possible contexts are  
39  
40 judged **should** be extended. Where Tiberghien (1994) compared scientific theories to learner’s  
41  
42 theories and Caravita and Halldén (1994) compared different theories to common-sense world  
43  
44 views, it is here **recommended** that cultural factors, such as the mode of depiction, **should** also  
45  
46 be related to scientific theories on a meta-level. Otherwise, an alternative conception may be  
47  
48 supported by an alternative interpretation of the mode of depiction in a visual representation.  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

### **Conclusion and implications**

1  
2  
3 In this study, the potential of a globe in providing children with the culturally accepted  
4  
5 concept of the earth was investigated as a problem of contextualizing. The children were  
6  
7 described as contextualizing the concept of earth in a conceptual framework, whether a  
8  
9 common-sense framework or a theoretical scientific framework. The children were also  
10  
11 described to contextualize their interpretation of the globe in a visual language. This  
12  
13 contextualizing was compared to Luquet's (1927/2001) notions of visually realistic  
14  
15 depictions, where the depicted object is shown as it can be seen from one perspective, and  
16  
17 intellectually realistic depictions, where what is understood as the most important  
18  
19 characteristics of the object is shown. It was demonstrated how an alternative interpretation of  
20  
21 the mode of depiction in the globe could support an alternative conception of the earth.  
22  
23  
24  
25  
26

27 The implications of the above results for science teaching could be that when artefacts  
28  
29 are used as models there may be a need not only for teaching the scientific theory but also for  
30  
31 teaching the conventions for depiction in this scientific context. Moreover, caution is advised  
32  
33 when pupils accept models, since this may be because an unintended interpretation of the  
34  
35 mode of depiction in the model may support an alternative conception.  
36  
37  
38  
39  
40  
41  
42

#### 43 **References**

- 44  
45  
46 Ametller, J., & Pinto, R. (2002). Students' reading of innovative images of energy at  
47  
48 secondary school level. International Journal of Science Education, 24 (3), 285-312.  
49  
50  
51 Brotton, J. (1999). Terrestrial globalism: mapping the globe in early modern Europe. In D.  
52  
53 Cosgrove (Ed.), Mappings (pp. 71-89). London, Reaktion Books.  
54  
55  
56 Caravita, S., & Halldén, O. (1994). Re-framing the problem of conceptual change. Learning  
57  
58 and Instruction, 4, 89-111.  
59  
60

- 1  
2  
3 Colin, P., Chauvet, F., & Viennot, L. (2002). Reading images in optics: students' difficulties  
4 and teachers' views. International Journal of Science Education. 24 (3), 313-332.  
5  
6  
7  
8 Freeman, H. N., & Parsons, M. J. (2001). Children's intuitive understandings of pictures. In  
9  
10 Torff, B., & Sternberg, R. J. (Eds.), *Understanding and teaching the intuitive mind:*  
11  
12 *Student and teacher learning* (pp. 73-91). Mahwah, New Jersey and London:  
13  
14 Lawrence Erlbaum Associates.  
15  
16  
17 Gilbert, J. K., Boulter, C., & Rutherford, M. (1998a). Models in explanation, Part 1: Horses  
18  
19 for courses? International Journal of Science Education, 20 (1), 83-97.  
20  
21  
22 Gilbert, J. K., Boulter, C., & Rutherford, M. (1998b). Models in explanation, Part 2: Whose  
23  
24 voice? Whose ears? International Journal of Science Education, 20 (2), 187-203.  
25  
26  
27 Grosslight, L., Unger, C., & Jay, E. (1991). Understanding models and their use in science:  
28  
29 Conceptions of middle and high school students and experts. Journal of Research in  
30  
31 Science Teaching, 28 (9), 799-822.  
32  
33  
34 Halldén, O. (1991, August). Conceptual change, conceptual rigidity. Paper presented at the  
35  
36 Earli Conference in Turku, Finland.  
37  
38  
39 Halldén, O. (1999). Conceptual change and contextualisation. In W. Schnotz, M. Carratero, &  
40  
41 S. Vosniadou (Eds.), *New perspectives on conceptual change* (pp. 137-148).  
42  
43 Amsterdam: Pergamon, Elsevier.  
44  
45  
46 Halldén, O., Haglund, L., & Strömdahl, H. (2005, April). On the interpretation of interview  
47  
48 and observational data. Intentional analysis. Paper presented at the 86<sup>th</sup> Meeting of  
49  
50 American Educational Research Association in Montreal, Canada.  
51  
52  
53 Halldén, O., Petersson, G., Scheja, M., Ehrlén, K., Haglund, L., Österlind, K., & Stenlund, A.  
54  
55 (2002). Situating the question of conceptual change. In Limon, M., & Mason, L.  
56  
57 (Eds.), *Reconsidering conceptual change: Issues in theory and practice* (pp. 137-148).  
58  
59 Dordrecht, The Netherlands: Kluwer Academic Publishers.  
60

- 1  
2  
3 Ivarsson, J., & Säljö, R. (2005). Seeing through the screen: Human reasoning and the  
4  
5 development of representational technologies. In P. Gärdenfors, & P. Johansson  
6  
7 (Eds.), *Cognition, education and communication technology* (pp. 203-222). Hillsdale,  
8  
9 NJ: Erlbaum.
- 10  
11  
12 Ivarsson, J., Schoultz, J., & Säljö, R. (2002). Map reading versus mind reading. Revisiting  
13  
14 children's understanding of the shape of the earth. In M. Limón, & L. Mason (Eds.),  
15  
16 *Reconsidering conceptual change: Issues in theory and practice* (pp. 77-99).  
17  
18 Dordrecht, The Netherlands: Kluwer Academic Publishers.
- 19  
20  
21  
22 Luquet, G. H. (1927/2001). Children's drawings. (Le dessin enfantin) Translated with an  
23  
24 introduction and notes by Alan Costall. London: Free Association Books.
- 25  
26  
27 Linder, C. J. (1993). A challenge to conceptual change. Science Education, 77, 293-300.
- 28  
29  
30 Martínez Peña, B., & Gil Quílez, M. J. (2001). The importance of images in astronomy  
31  
32 education. International Journal of Science Education, 23 (11), 1125-1135.
- 33  
34 Nussbaum, J. (1979). Children's conceptions of the Earth as a cosmic body: A cross age  
35  
36 study. Science Education, 63, 83-93.
- 37  
38  
39 Nussbaum, J. (1985). The earth as a cosmic body. In Driver, R., Guesne, E., & Tiberghien, A.  
40  
41 (Eds.), *Children's ideas in science* (pp. 170-192). Milton Keynes and Philadelphia:  
42  
43 Open University Press.
- 44  
45  
46 Nussbaum, J., & Novak, J. (1976). An assessment of children's concepts of the Earth utilizing  
47  
48 structured interviews. Science Education, 60, 535-550.
- 49  
50  
51 Piaget, J. (1951). The child's conception of the world. London: Routledge and Kegan Paul.  
52  
53 (Original work published 1926)
- 54  
55  
56 Pintó, R. (2002). Introduction to the science teacher training in an information society  
57  
58 (STTIS) project. International Journal of Science Education, 24 (3), 227-234.
- 59  
60



- 1  
2  
3 Pintó, R., & Ametller, J. (2002). Students' difficulties in reading images. Comparing results  
4  
5 from four national research groups. International Journal of Science Education, 24 (3),  
6  
7 333-341.  
8  
9
- 10 Ryve, A. (2006). Making explicit the analysis of students' mathematical discourses –  
11  
12 Revisiting a newly developed methodological framework. Educational Studies in  
13  
14 Mathematics, 62 (2), 191-209.  
15  
16
- 17 Schoultz, J., Säljö, R., & Wyndhamn, J. (2001). Heavenly talk: Discourse, artifacts, and  
18  
19 children's understanding of elementary astronomy. Human Development, 44, 103-  
20  
21 118.  
22  
23
- 24 Sneider, C., & Pulos, S. (1983). Children's cosmographies: Understanding the Earth's shape  
25  
26 and gravity. Science Education, 67, 205-221.  
27  
28
- 29 Strike, K. A., & Posner, G. J. (1992). A revisionist theory of conceptual change. In R. A.  
30  
31 Duschl, & R. J. Hamilton (Eds.), Philosophy of science, cognitive psychology, and  
32  
33 educational theory and practice (pp. 147-176). Albany: State University of New York  
34  
35 Press.  
36  
37
- 38 Stylianidou, F., Ormerod, F., & Ogborn, J. (2002). Analysis of science textbook pictures  
39  
40 about energy and pupils' readings of them. International Journal of Science Education,  
41  
42 24 (3), 257-283.  
43  
44
- 45 Tiberghien, A. (1994). Modeling as a basis for analyzing teaching – learning situations.  
46  
47 Learning and Instruction, 4, 71-87.  
48  
49
- 50 Vosniadou, S. (1994). Capturing and modeling the process of conceptual change. Learning  
51  
52 and Instruction, 4 (1), 45-69.  
53  
54
- 55 Vosniadou, S., & Brewer, W. J., (1992). Mental models of the Earth: A study of conceptual  
56  
57 change in childhood. Cognitive Psychology, 24, 535-585.  
58  
59  
60

1  
2  
3 Vosniadou, S., Skopeliti, I., & Ikospentaki, K. (2004). Modes of knowing and ways of  
4 reasoning in elementary astronomy. Cognitive Development, 19, 203-222.  
5  
6

7  
8 Vosniadou, S., Skopeliti, I., & Ikospentaki, K. (2005). Reconsidering the role of artefacts in  
9 reasoning: Children's understanding of the globe as a model of the earth. Learning and  
10 Instruction, 15, 333-351.  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

For Peer Review Only