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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.

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

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

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

To obtain a more varied description of how young children look upon the relation between a model and the reality it represents, we can use Luquet's (1927/2001) theory concerning children's drawings. Although Luquet's theory was constructed to understand children's drawings and not their interpretations of representations, the theory pays considerable attention to how the child understands the relation between the representation and reality. Thus, we can expect the theory to be useful when trying to understand how young children comprehend a model.

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

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

In making drawings, different ways can be used to achieve realism. Luquet distinguishes between intellectual realism and visual realism. When a child uses intellectual realism, s/he tries to depict an object by showing important details of the object, whether or not the details can be seen. When using visual realism, the child tries to depict an object as seen from a particular perspective. The latter is the mode of representation used in photography, linear drawings, and paintings in accordance with the renaissance perspective. Although visual realism is the usual way of depicting objects, Luquet describes contexts in which intellectual realism is the preferred method, even among adults. A common example today is engineering or architectural drawings, where the constructor makes hidden details visible. Luquet's conclusion is that these two ways of representing should be seen as different conventions for depicting, not as steps in intellectual development.

Children's understanding of the planet earth

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

the earth; for example, that people live inside a hollow sphere or on the flat top of the earth, or that they live on the ground and that the spherical earth can be seen in the sky. Vosniadou's (1994) view is that these ideas indicate that children have a naïve framework theory with presuppositions that constrain how they understand what they are taught in school; one such example is that 'up' and 'down' are directions in relation to the ground. The naïve framework theory is based on children's interpretations of their own experiences of their physical and cultural surroundings. Vosniadou argues that until children have reinterpreted the presuppositions of their naïve framework theory, they are unable to understand that the earth is a sphere and that 'up' and 'down' are directions toward or away from the centre of the sphere.

From a socio-cultural standpoint, Schoultz, Säljö, and Wyndhamn (2001) and Ivarsson, Schoultz, and Säljö (2002) challenge the idea described above that mental models are constrained by the presuppositions of children's naïve framework theories. Their view is that cognition concerns how people use tools; for example, language and models. Since such tools are integral parts of cognitive processes, Schoultz et al. and Ivarsson et al. studied how children reasoned about elementary astronomical concepts in the presence of a globe and a map. None of the children in the Schoultz et al. study suggested that the earth was flat, hollow, or any of the shapes described in earlier research. Even when only a map was present (Ivarsson, Schoultz, & Säljö, 2002), the children experienced no problems in viewing the earth as a sphere. Schoultz, Ivarsson, and colleagues explain the differences between the findings of the socio-cultural studies and those of Vosniadou and Brewer's (1992) study in terms of the fact that the former used a globe or a map during their interviews. Vosniadou and colleagues (2005) responded with a study in which they first asked the children to make their own representations of the earth in a drawing or using play-dough before interviewing them in the presence of a globe. They found an increase in the number of correct responses from the

children after they were shown the globe, but also a decrease in the overall consistency of the responses. Vosniadou and colleagues maintain that the use of a globe only tests whether the child recognizes scientific information, not whether s/he has understood the information. In a new socio-cultural study of children's understanding of the earth (Ivarsson & Säljö, 2005), the children were interviewed in front of a computer screen that showed a picture of a globe and an aeroplane that could be moved along the surface of the globe. In this situation, the children had greater difficulty in reasoning about gravity and the shape of the earth. The researchers' explanation of this finding is that the children had problems identifying the mode of representation that was relevant in connection with computer programs. They argue that the variation observed in the ways that the children in this study reasoned is related to differences in the children's perception of the graphic representations.

Theoretical background

In the present study, children's understanding of the concept of the earth is regarded as a problem of how to contextualize conceptions and descriptions in the appropriate cognitive or cultural contexts (Halldén, 1999; Halldén et al., 2002). According to this view, conceptual change can be described as occurring when the learner is able to differentiate between frameworks and relate new information or new problems to an adequate framework in a cognitive context (Halldén et al., 2002). Concepts belong to frameworks (Caravita & Halldén, 1994; Halldén, 1991, 1999; Linder, 1993; Tiberghien, 1994; Vosniadou, 1994); the frameworks can be scientific theories, common-sense views (Caravita & Halldén, 1994), or the learner's own 'theories' (Tiberghien, 1994). When contextualizing a concept, it is necessary to differentiate between these different frameworks, since the chosen framework decides which questions and which explanations are possible, as well as which elements become discernable.

Caravita and Halldén (1994) describe three levels in each of the alternative frameworks of theory or common sense. In a theoretical framework, we can discuss theoretical, conceptual, and empirical levels. What is counted as data at the empirical level is decided at the conceptual level. In a common-sense framework, there is a worldview or ideological level, a conceptual or normative level, and a practical level. What is relevant at the practical level is decided by conceptions or norms. Tiberghien (1994) describes the corresponding levels in science as theory, model, and experimental field of reference. It is at the meta-level of theory or ideology that the frameworks must be considered and compared to determine which questions and explanations are possible in which framework. Consequently, the learner is expected to be able to not only differentiate and move between the different frameworks but also to move between different levels within an individual framework.

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

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

the appropriate speech genres, learning also needs to become socialized into how one speaks within a particular discipline (Halldén, 1999).

The globe is an artefact that increased in popularity during the early sixteenth century because of new geographical discoveries and imperial struggles (Brotton, 1999); the flat map was not thought to be adequate for depicting the new cosmography. From this time, globes have been used both out of geographical and political interests. Different views of the world have been shown on the surface of a globe, and those details of the cosmography that have been considered of interest have varied. The information contained on ordinary globes is transmitted visually; to be interpretable, it must therefore belong to a tradition of visual communication. Following the ideas of Luquet described above, there are different conventions for depiction, and these can be described as different visual languages. Thus, in terms of visual communication, speech genres are comparable to different visual languages. If we extend the view of Halldén from verbal communication to visual communication, a visual description must be contextualized in the appropriate mode of depiction.

Aim of the present study

The aim of the present study is to examine how children contextualize the concept of the earth in the presence of a globe. In cognitive contexts the earth can be understood both in a common-sense framework and in a theoretical scientific framework. Furthermore, as an artefact with visual information, the globe is contextualized in a convention of visual language. To interpret the globe means to contextualize it in a particular technique of depiction. The research question is therefore: how do children differentiate between these frameworks and contexts in an interview conducted in the presence of a globe?

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.

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

Interviews

The interviews were 20 to 30 minutes in duration. The methodological approach employed in the interviews was to focus more on the child's own interests during the discussion than on a predetermined set of questions. This made the interviews more like conversations. Nevertheless, the interviewer had certain aims in mind and posed questions concerning the relationship between the globe and the real earth. Thus, the interviews could be characterized as semi-structured and with the interviewer's aims reflected in the questions posed to the students.

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

which nature outside could be viewed. The wider school situation and culture were also considered in the interpretations.

The utterances were first scrutinized to discern those parts of the dialogue that were relevant in terms of understanding in what cognitive framework the child contextualized the earth and in what mode of depiction s/he contextualized the globe. Utterances that appeared to be informed by intentions that could not be related to these aims were not taken into account when describing the child's knowledge about the earth or the globe. This could be utterances about home or school conditions that gave no information about the child's earlier experience of the earth or globes. Other utterances that were not further considered were those that seemed to be suggested by the interviewer in the interview or by other persons on earlier occasions (cf. Piaget, 1926/1951: suggested conviction) or if the child appeared to be indulging in fantasies (cf. Piaget: romancing). The utterances that were further analysed were judged in relation to the knowledge that was a prerequisite to making the utterance and the apprehension of the situation that was disclosed by the utterance.

Findings

The presentation of the results begins with an overview of the responses of the eleven children interviewed in the study. Here, answers are related to questions without further analysis. This is followed by a presentation of interviews with five children, analysed according to the intentional model. First, we describe the interview with one child who demonstrated a culturally accepted view of the earth, followed by our findings concerning four children whose views of the earth deviated from the culturally accepted notion.

Overview

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

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

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

saying that the earth is round like a ball. A follow-up conversation is necessary to reveal what children mean when they say that the model of the globe is round because the earth is round.

A culturally accepted view of the earth

Mary gives the impression of being well aware of different situations that can be associated with the concept of the earth. The interviewer's first question is if Mary knows what this is, referring to the globe on the table.

Mary: A globe [earth globe].

I: What do you use it for?

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

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

Mary: Because it is round.

I: What is round?

Mary: The earth.

Here the interviewer and the child are talking in the context of the model. In the course of her answers about the countries and the earth, Mary introduces what the model represents. Mary, like several of the other children, states that the use of the globe is to find countries. This appears to be a consequence of earlier experiences of this activity in connection with globes, since on the globe used during the interviews nations are not clearly distinguished. Instead, it could be characterized as a geographical description of the earth.

I: And the earth, what is that?

Mary: A planet.

I: Well. Can you see the earth?

Mary: Yes, you can, if you look at the ground.

Here the conversation about what the globe represents has changed to a cognitive context related to the earth. The question 'Can you see the earth?' seems to make Mary switch from the astronomical framework of the earth as a planet to the common-sense framework of the earth as the nearby surroundings. The interviewer then tries to make Mary relate the different contexts of the earth that have been discussed thus far in the interview; namely, the model, the planet, and the ground.

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

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

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

Mary: Yes, but when you look from above, or when you look at the globe, then it's round. But it looks like it's flat when you look outside.

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

Mary: Mm.

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

Mary: You can go by plane or a space rocket.

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

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

who live down under. Mary replies that they keep standing and when the interviewer asks how they can do that, she replies that this is because of 'the power of attraction, maybe'. Later in the interview the topic of the inside of the earth arises, and when the interviewer asks what it looks like inside the earth, Mary replies 'lava'.

Mary does not appear to have any problem here in finding relevant frameworks for her explanations. When the interviewer asks why people in Argentina do not fall off the earth and what is inside the earth, Mary's explanations are formulated within scientific frameworks. She is also able to relate these scientific frameworks of the planet earth to the situation and explain how she is able to see the earth. In addition, she seems to be well acquainted with how an object can function as a representation of something else. This can be concluded from her explanations of what the globe can be used for, the reason for its shape, and what it represents. This knowledge concerns the cultural contexts of the globe as a visual representation. Her description of the use of the globe to look for countries seems to refer to nations, and it could be argued that this is not the main purpose of this particular globe with its geographical description of the earth; however, the Swedish word 'land' is commonly used to refer to nation, country, and land. Accordingly, the distinction may not be obvious to the children. This is in addition to the fact that the children may have experienced the activity of looking for countries on a globe. Most accurately, they could be described as categorizing the globe as a representation of the earth, but not discerning all of the information about the earth that is provided by the globe.

Alternative views of the earth

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

(earth) globe, and that you use it to see where of all the countries are located. Later on the interviewer asks her what it looks like inside the earth.

Jill: It is…hum…sea.

I: Is there sea inside the earth?

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

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

Jill: Yes…Wait!... Inside?

I: Yes.

Jill: I don't think so.

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

Jill: Not exactly inside.

I: Where are they then?

Jill: Outside.

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

As the conversation continues, Jill tells the interviewer that she has not seen the real earth, but since she has already said that Stockholm is on the globe, the interviewer asks her why we cannot see the real earth if we live on it.

Jill: You can see it, but…

I: What do you see?

Jill: You see…what's all around.

I: For example? Can you see it now?

Jill: No, not all of it.

I: What can you see then?

Jill: I can see…eh…the sky.

Even if both the interviewer and Jill are talking about what the globe represents, the interviewer talks about the earth in a commonsense framework (to make Jill understand how she is able to see the earth), while Jill at first, when she says that she has not seen the real earth, probably talks about the earth in the astronomical framework of the planet. When Jill says that she can see 'what's all around', she, too, seems to talk in a common-sense framework. At first her response 'not all of it' may seem to reveal some awareness of the relationship between the earth in the nearby surroundings and the framework of the earth in space, but these utterances might also be related to what she can see of 'what's all around' through the window. The latter interpretation would explain why she says that she can see 'the sky'; the sky might have constituted the main part of her view through the window. Although Jill appears to start with an alternative view of the earth, namely that people live inside the globe (cf. Nussbaum, 1985; Vosniadou & Brewer, 1992), the present globe and the conversation with the interviewer seems to make her move towards a more culturally accepted idea.

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

of her utterances is an explanation in the context of the representation. Further on in the interview, the interviewer asks her what is inside the earth, to which she replies that there are bushes, trees, and such things.

> I: […] And people, where are they then?
>
> Caroline: They are inside too. They are, you could say, a little bit on, and inside.
>
> I: On and inside?
>
> Caroline: Mm.
>
> I: Can they be both on and inside?
>
> Caroline: I think so. Since you can see the sun, and the trees and the bushes are where you are and they are inside and we are on and inside.

Earlier, Caroline showed the interviewer that the sun is situated a short distance from the globe, i.e., that the sun is outside the globe, by indicating with her hand. She says that people are 'on and inside'. When Caroline says that people are inside the globe, this is in line with the conception that people live on a disc within a sphere located in space, as described in many studies of children's conceptions of the earth (e.g., Vosniadou & Brewer, 1992). When she says that people are 'on' the earth, this can be related to how she has shown that people walk on the surface of the globe and that the sun is situated outside the globe. These latter explanations are close to a culturally accepted view. Caroline makes these explanations with the help of the representation. When Caroline maintains that the sun is situated outside the earth, this can be a description of what she has seen in pictures or models on previous occasions. When she tries to combine this information, which may have been in an astronomical context, with her experience of the earth nearby in a common-sense context, she appears to end up with two conceptions. Her conception of the earth as a place that people

live ‘on’ can be combined with an interpretation of the globe as made in what Luquet (1927/2001) called a visually realistic mode of depiction. Her conception of the earth as a place that people are inside, but that can also be shown to walk on the countries shown on the surface of the globe model, should be connected to a mode of depiction that Luquet called intellectually realistic. In this convention, important characteristics can be shown on the surface even if they are not visible.

Another girl, Margaret, says that the object on the table is a globe and that it is used to look for countries. She finds Sweden with some help, and then the interviewer asks her if it looks like that in Sweden. After some hesitation she says that Sweden is not that small. The interviewer then asks if there is a real earth that is not as small as this one, to which she replies no. The interviewer’s next question is what Sweden looks like in reality, to which Margaret responds by pointing out the window. She says that she does not know why the globe is round. When the interviewer asks her if she knows what the earth is, Margaret replies again that she doesn’t know, and that she only knows that she lives ‘on earth’. In Swedish, as in English, the expression ‘on earth’ may mean something like ‘in the world’ without a clear indication of position. It seems to be this meaning that is alluded to by Margaret, while Caroline, above, who makes her assertion about the preposition ‘on’ in isolation, appears to talk about a certain position in relation to the earth.

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

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

that are the keys to colour symbols on the globe. The interviewer asks her if the globe otherwise looks like the earth.

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

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

Margaret: It's inside.

I: Yes?

Margaret: Yes.

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

Margaret: Inside.

I: What does it look like inside?

Margaret: Like this.

I: In what way like this?

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

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

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

I: In all other?

Margaret: Countries.

I: In all other countries. But it looks like that inside. But you say people are inside. Can they come out then?

Margaret: No.

I: Is there no one who has been outside?

Margaret: Yes, in space.

Here Margaret tells more about how she understands the mode of depiction in the globe. The squares that are the keys to colour symbols are not found on the real earth. Further, she

believes that the countries depicted on the surface of the globe are inside the real globe. Most of what Margaret is talking about can be related either to the earth nearby or to the model. However, what she says about 'inside' and an outside 'space' indicates that she has some knowledge of an astronomical concept of the planet, although her knowledge of this context does not appear to be differentiated and related to her knowledge of the common-sense knowledge of the earth nearby. Her idea of the earth seems to be consistent with earlier descriptions by Nussbaum (1985) and Vosniadou and Brewer (1992), where some children believe that people live inside a hollow sphere.

How then is Margaret able to combine her alternative conception of the earth with the globe as a model of the culturally accepted view of the earth? This can be described as a problem of contextualizing the description of the earth in the globe in a relevant visual language. When the countries are shown on the surface of a globe, this is intended to be what Luquet (1927/2001) calls a visually realistic mode of representation. This means that the countries are in fact situated on the surface of the real globe. Margaret, however, seems to have contextualized the description in what Luquet calls an intellectually realistic mode of depiction, where that which is considered a relevant characteristic can be depicted on the spherical model even if it is situated inside and is impossible to see. To Margaret, countries may be a relevant characteristic of the earth.

Another girl interviewed in the class, Jane, says that she does not know if the earth looks like the globe because she has never seen it. Shortly thereafter, she switches perspective and says that she is seeing the earth at that very moment and that everything in the room and outside the window is the earth. After talking about this for a while, the interviewer asks about the globe again.

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

Jane: A statue of the earth.

I: A statue of the earth?

Jane: Yes, which is fastened here.

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

Jane: I don't know.

I: You don't know.

Jane: You see, I've never been outside the earth.

Here Jane gives a different explanation than the one she gave earlier in the interview of why she does not know if the earth looks like the globe. Her first explanation is that she has never seen the earth and the second is that she has never been outside the earth. This difference must be looked upon in relation to the idea that she seems to have suddenly realised that she is able to see the earth in the room where the interview takes place. What Jane is talking about here can be interpreted as talking about the earth in three different contexts. One context is the model of the earth, which she calls 'a statue of the earth'. A second context is the earth as seen from space, as a planet. This is the context that she is referring to when she first says that she does not know if the earth looks like the globe because she has never seen it; she repeats this assertion, this time providing the explanation that she has never been outside the earth. The third context is the earth that we can see all around us. Jane is talking about the earth in this context when she says that she is seeing the earth during the interview and that everything in the room and outside the window is the earth. When she says that she has 'never been outside the earth', she indicates that she is unable to relate these three contexts in a culturally accepted way, and that her conception of the earth seems to be in line with the alternative model of the hollow sphere described by Nussbaum (1985) and Vosniadou and Brewer (1992).

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

study, however, indicate that the globe could help children become aware that there exists another framework of the earth in addition to that of the nearby surroundings. This is illustrated by Jill and Caroline in the present study, who at the start of the interviews maintained that people were inside the earth but readjusted this view during the interview and said that people were either outside or both inside and on the earth. This is compatible with Vosniadou et al. (2005), who found an increase in the number of correct responses when the children were interviewed in the presence of a globe, although the responses were less consistent.

We can discern certain characteristics of the role of a globe when the children tried to contextualize the concept of earth. The globe seemed to constitute a separate context in this process alongside the common-sense framework of the flat ground and the scientific framework of the planet. In addition to the problem of how the concept of earth can be contextualized in cognitive frameworks, the globe must be interpreted in a cultural context of visual languages. This means that to be able to profit by the information found on a globe, the learner must contextualize the globe in the appropriate visual speech genre or mode of representation. This is in line with how Ivarsson et al. (2005) describe the differences in the way the children in their study reasoned in front of a picture of the earth on a computer screen as differences in the children's perception of the graphical representations.

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

knowledge of the conventions for depicting in a scientific area, s/he may be able to extract information from a model. Therefore, the ability to contextualize a visual description of a concept in the proper visual language may facilitate understanding of the corresponding scientific concept.

By regarding the 'conceptual change' problem (Strike & Posner, 1992) as a problem of contextualization as opposed to the constructivist view of change and the socio-cultural view concerning the use of tools, it seems possible to detect how contexts other than the scientific and common-sense frameworks are involved in the process of conceptual development. When in the present study we used a visual representation within this framework, we found indications of the sources of both the failings and the possible advantages of the use of such tools. Failings may arise when explanations are contextualized in the context of the representation rather than in the context of the referent. In the views of Grosslight, Unger, and Jay (1991) and Freeman and Parsons (2001), the development of an understanding of visual representation appears to imply the adding to or replacing of earlier ideas. Here, it is suggested that the process could be described as a continuous differentiation between contexts and an understanding of what context explanations belong in. Since not only cognitive frameworks but also (e.g.,) visual representations could be considered in the search for the appropriate context of an explanation, the meta-level on which possible contexts are judged should be extended. Where Tiberghien (1994) compared scientific theories to learner's theories and Caravita and Halldén (1994) compared different theories to common-sense world views, it is here recommended that cultural factors, such as the mode of depiction, should also be related to scientific theories on a meta-level. Otherwise, an alternative conception may be supported by an alternative interpretation of the mode of depiction in a visual representation.

Conclusion and implications

In this study, the potential of a globe in providing children with the culturally accepted concept of the earth was investigated as a problem of contextualizing. The children were described as contextualizing the concept of earth in a conceptual framework, whether a common-sense framework or a theoretical scientific framework. The children were also described to contextualize their interpretation of the globe in a visual language. This contextualizing was compared to Luquet's (1927/2001) notions of visually realistic depictions, where the depicted object is shown as it can be seen from one perspective, and intellectually realistic depictions, where what is understood as the most important characteristics of the object is shown. It was demonstrated how an alternative interpretation of the mode of depiction in the globe could support an alternative conception of the earth.

The implications of the above results for science teaching could be that when artefacts are used as models there may be a need not only for teaching the scientific theory but also for teaching the conventions for depiction in this scientific context. Moreover, caution is advised when pupils accept models, since this may be because an unintended interpretation of the mode of depiction in the model may support an alternative conception.

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