European Journal of Psychology of Education
2009, Vol. XXIV, n° 4, 485-498

Cultural artifact and children's understanding of the shape of the Earth: The case of Moroccan children

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The non-computational brand of cognitivism is based on the premise that performances, including those of children, are generated by mental models or representations, i.e., "internal" resources. The sociocultural approach, on the other hand, regards context, i.e., an "external" resource, as the chief means of elaborating knowledge. The results of empirical research on how Moroccan children develop their understanding of the shape and properties of the Earth highlight some of the limitations not only of the representationalist paradigm but also of the more "radical" socioculturalist approach. They show that, while the sociocultural context does indeed play a vital role in the development of understanding, the latter in turn helps to increase children's autonomy of mind.

Introduction

In their introduction to a special issue of *Human Development* on sociocultural or "situated" approaches to cognitive development, Giyoo Hatano and James Wertsch (2001) state that, until relatively recently, most research on cognition was focused on "symbol manipulation within the individual, ignoring the surrounding sociocultural context" (p. 77). According to these authors, a person's mind, together with the way he or she develops and functions, is determined mainly by his or her interactions with other individuals, as well as by the use of cultural artifacts in the

The authors would like to thank Mouna El Baldi, Abdelali El Boujidi, Ibrahim Himdate, Ilham Naciri and Driss Rafie, all students at the Dhar el Mahraz Faculty of Arts and Human Sciences of Fès University, for their active help in gathering the data.

course of everyday activities. It is the concept of "participation" in these activities that defines the relationship between the environment and individual cognitive development (Rogoff, 2003).

This participation can give rise to many different forms of cognitive development, according to the nature of the individual and the context. However, although the sociocultural approach acknowledges the complexity of the "brain-mind-environment" interactions brought to light by contemporary cognitive science, it has tended to concentrate on the postulate that "mind develops by incorporating the community's shared artifacts accumulated over generations" (Hatano & Wertsch, 2001, p. 78), despite the risk of a strictly linear conception of causality [*context* ⇒ *individual*]. The aim of the present paper was to use the example of a study conducted in the astronomy domain to demonstrate that the sometimes exaggerated focus on just the causal aspects of the contexts of cognitive development can mask the importance of autonomy of mind and its ability to "fashion" the context [*individual* ⇒ *context*].

Cognition and mental models

The same issue of *Human Development* features a critique by Jan Schoultz, Roger Säljö, and Jan Wyndhamn (2001) of two studies conducted by Stella Vosniadou and William Brewer (1992, 1994). These authors investigated the way children acquire concepts relating to astronomy, in particular the Earth's shape, gravity and the day/night cycle. This can be regarded as a very specific domain, in that it involves particularly counterintuitive knowledge which can only be gained from culture and the media, and not from innate knowledge in other domains or from sensible experience of reality. Stella Vosniadou's research (1994), involving American, Samoan, Greek and Indian children, was carried out from an evolutionist, cognitivist standpoint. The idea was that a combination of questionnaires and representations produced by the children (drawings, Plasticine shapes) during research interviews would allow the psychologist to gain "direct" knowledge of the mental constructions subtending the behaviours they observed. Results attested to the difficulty young children experience in conceiving of the Earth as an astronomical object and to the development of erroneous conceptions that are resistant to change. The latter can be ascribed to the existence of innate competences generated by direct experience and relating to the specific domain of properties of the physical world (Baillargeon, 2002; Carey, Spelke, 1994). As children gradually take on board information disseminated by their culture and through the media, so their conception of the Earth's shape slowly changes. This process takes the form of a "staircase", moving up through three main types of cognitively coherent mental models (bottom to top, Figure 1):

- A naïve / intuitive conception (rectangular or circular flat Earth models);
- A synthetic conception (both flat and spherical models of the Earth: double Earth, hollow Earth (a) and (b), flattened Earth);
- An accepted / scientific conception (spherical model of the Earth).

This research is now the object of fierce criticism. Michael Siegal, George Butterworth and Peter Newcombe (2004), for instance, have demonstrated that the combination of an open questionnaire and two-dimensional representations (drawing) used by Stella Vosniadou and Brewer (1992, 1994) "underestimates" children's "real " performance levels, compared with a forced-choice questionnaire combined with three-dimensional modelling (Plasticine shapes) (see also Panagiotaki, Nobes, & Banerjee, 2006a). Furthermore, these authors have shown that children's knowledge is not as coherent as it might seem, and is accumulated in a rather "fragmented" fashion. According to them, the coherence of mental models is actually "manufactured" by the researcher and the theory of innate or early knowledge exerting an influence is simply invalid (see also Panagiotaki, Nobes, & Baneriee, 2006b). Stella Vosniadou, Irini Skoneliti, and Kalliopi Ikospentaki (2004) retort that in actual fact, it is the "fragmentation" of knowledge that is induced by the researcher's method, thus masking the "reality" of the cognitive coherence of the mental models. Wherever the truth lies, as with the many other scientific and religious entities that cannot be observed by children (microbes,

waves, dragons, witches, God, etc.), their understanding of the spherical shape of the Earth is mainly gained from other people's utterances and/or the media (Harris & Koenig, 2006).

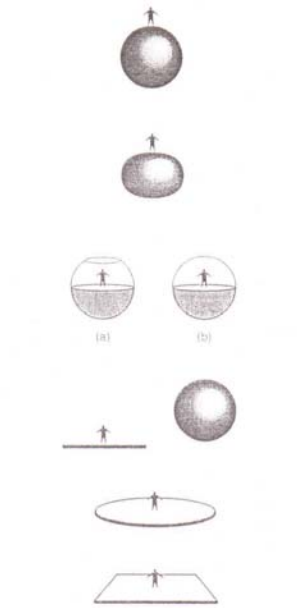

Figure 1. Mental models of the Earth (taken from Vosniadou & Brewer, 1992, p. 549)

Situated cognition and artifacts

Moving to a different register of criticism, Jan Schoultz et al. (2001) counter the cognitivist or "internalist" conception adopted by Stella Vosniadou and Brewer (1992, 1994) with an "externalist" or sociocultural one. "Instead of viewing understanding as the overt expression of underlying mental models, children's responses in interview studies should be regarded as situated and as dependent on the tools available as resources for reasoning" (p. 103). Inspired by phenomenology, this research perspective questions the idea that the mind "manufactures" "internal" representations of the world, i.e., mental models that are independent entities which we can analyze. It regards people's "external" expressions of the way they experience reality as the only route to their consciousness, albeit an indirect one. The paradigm chosen by Jan Schoultz et al. (2001) then takes on a twofold aspect. "First, it reflects an interest in the research interview as a concrete discursive practice. In particular, our interest has been one of studying in some detail how children are positioned in a communicative sense in such interactions in which they dialogue with an adult. Second, our interest is focused on issues of the relationship between reasoning and artifacts, i.e., how people rely on socioculturally meaningful artifacts when thinking" (p. 105).

To encourage the children to reason about the Earth, Schoultz et al. (2001) used a globe as a resource during the interaction, describing it as a "relevant" cultural artifact compared with drawings and Plasticine models. Its relevance derives from the close correspondence between it (a model) and the Earth (the reality it represents), and this relationship is borne out by the fact that in scientific culture, it is used as a "prosthetic device for thinking" (Schoultz et al., 2001, p. 115). The globe was placed in front of the child and the experimenter. The ensuing interview was semi-directive, based on the Piagetian clinical method (Piaget, 1947). Twenty-five Swedish children took part in the experiment, with a mean age of 6½ years (grade 1), 7½ years (grade 2) and 10½ years (grade 5). The procedure consisted of an open questionnaire about the globe and what it represented (questions set out in detail below). Results (Table 1) were very different from those reported by Stella Vosniadou. "With the globe as a concrete

point of reference for the interaction, we find that all children can identify the globe and they know that it is a representation of the Earth. They find it completely natural that people can live in the southern hemisphere without falling off" (Schoultz et al., 2001, p. 113). Only two out of the twenty-five children displayed any uncertainty as to the Earth's spherical shape.

Table 1

Swedish children's performances (taken from Schoultz et al., 2001, p. 114)

	6½ years *N*=8	7½ years *N*=8	10½ years *N*=9	Total
Can recognize different countries on the globe	100%	100%	100%	100%
Conceives of the Earth as a sphere	84%	100%	89%	92%
Conceives that it is possible to live anywhere on the Earth without falling off	100%	100%	100%	100%
Uses some sort of gravity-related concept	38%	75%	89%	77%

The conclusion reached by Jan Schoultz et al. (2001) was nonetheless rather surprising. The authors wrote that "a simple explanation would be that Swedish children are much more well-informed than those of other countries where these studies have been carried out. However, there is no reason to assume that this is the case (though we cannot disprove this idea)" (p. 114). The Swedish children's "good" understanding therefore relied essentially on the social context and on the use of a particular artifact, which immediately "gave shape" to their cultural and personal resources [*context* ⇒ *individual*]. Does this mean that we have to refute the autonomy of individual constructions [*individual* ⇒ *context*] in order to justify the sociocultural or "situated" approach to cognition? To answer this question, we conducted a study using the same procedure, but this time in Morocco. To quote a comment made many years ago by Jean Piaget (1966), "the kind of psychology we develop in our social environments, characterized by a certain culture, a certain language, etc., remains conjectural as long as comparative extensive and systematic research is not available" (p. 12).

Experiment

Population

The sample was made up of 225 Moroccan children attending five different primary schools in the Fès and Mekhnès region. Fifteen pupils were randomly selected from each school for each of the three age groups we studied, making a total of seventy-five children in each age group, with equal numbers of boys and girls. The mean age of the first group of children (grade 1) was 6 years and 5 months, that of the second group (grade 2) 7 years and 7 months, and that of the third group (grade 5) 10 years and 9 months.

Procedure

We used the same procedure as Jan Schoultz et al. (2001), conducting a semi-directive interview featuring a globe and based on twelve predefined questions (see description of questions below). The children were questioned individually at school. The interviews were recorded, then transcribed. The language used during these interviews was the Moroccan dialect used in the Fès region, rather than standard Arabic. This dialect is the language of everyday communication, and although standard Arabic is the language used by teachers and in the media, it is chiefly learned at school and younger children are therefore less proficient in it.

Descriptive analysis

Q1. What is it?

When they were shown the artifact, more than 70% of the Moroccan children identified it frequently as "a globe", rarely as "a map". This means that the children were relatively familiar with the Moroccan dialect word كرة أرضية that designates this particular object. Correct knowledge of this word increased with the level of schooling. While nearly 55% of 1st-graders were already familiar with the word for "globe", this figure rose to 63% for 2nd-graders and 88% for 5th-graders. The frequency of the other forms of responses gradually fell as the level of schooling increased. Only in grade 5 did the vast majority of children appear to know how to designate the cultural artifact (i.e., the globe) correctly.

Q2. Does it look like the Earth?

This was a key question, as it probed the children's understanding that this particular cultural artifact (i.e., the globe) is a scale model of a real-life object (i.e., the Earth) which cannot be seen directly in its entirety. As we know, a model is not reality: it only (re)presents it. Overall, only 36% of the children answered "yes" to this question *and* justified their responses. Just under 20% also answered "yes", but failed to explain why the globe resembled the Earth. As for the children who gave negative responses and who justified them, they numbered 30%. Those who simply said "no", without any further explanation, represented 6% of the cohort. This result demonstrates that although the Moroccan children were relatively familiar with the name of the artifact (Q1), they were far less familiar with its function (Q2).

An examination of the arguments they used to justify their responses revealed that their positive responses were mainly made on the basis of identity. In other words, the globe "is" like the Earth "is". Identity of shape and even colour cropped up most frequently, and/or identity of what is found there. Examples of some of the responses supplied by the three different age groups are given below:

- "This [the globe] is round. The Earth is round, too, even if people don't feel it" (grade 1).
- This [the globe] has the sea and the Earth has the sea, too. This is round and so is the Earth" (grade 2).
- "It [the globe] resembles the Earth because of the deserts, the countries and the cities. It resembles it in every way" (grade 5).

Some children, while expressing the shared identity of the globe and the Earth, also mentioned the physical differences. The Earth and the globe might be "identical", but they were not *absolutely* "identical".

- "They both resemble a ball, except that the Earth doesn't have writing on it and this one [the globe] has a lot of writing on it" (grade 1).
- "The Earth doesn't rest on a stand. It's suspended in space" (grade 2).
- "It [the globe] resembles it 100%, but you can tell them apart by their volumes. This [the globe] is small. The Earth is very big" (grade 5).

As far as the negative responses are concerned, the main argument was the opposite of the previous one. For these children, there was no shared identity between the two objects. The globe "is not" like the Earth "is". Once again shape, but also colour, was the most frequently mentioned characteristic. A less frequent argument involved the divine nature of the Earth's origins.

- "The Earth is rectangular and this [the globe] is round" (grade 1).
- "The Earth is white and brown and this [the globe] is blue" (grade 1).
- "Because it was made by a human being. The real Earth was created by God" (grade 2).
- "The Earth we live on is bigger than this [the globe]. We can't make the Earth go round like we can with this. And the Earth is flat" (grade 5).

To conclude, an analysis of the justifications of the responses revealed that many of the children regarded the globe and the Earth as two quite separate objects, mainly due to their different physical characteristics (shape, colour, size). Others, who knew that what is on Earth (countries, cities, oceans, etc.) can also be seen on the globe, took the view that the two objects were identical, especially with regard to their physical characteristics (shape, colour). However, these identical features did not prevent some of them from pointing out that they were two physically different objects. In both cases, children rarely explicitly stated that one was the "model" of the other. This analysis allowed us to distinguish between two levels of conceptualization:

– a level where the comparison of these two objects only highlights physical differences;
– a level where this comparison involves two contradictory types of knowledge about them: identity as to what one can find there and a number of physical differences.

Compared with the previous question (Q1), there was an even greater contrast between the first two levels of schooling and the third one (grade 5). While only 11% of children in grade 1 and 28% of children in grade 2 replied "yes, the globe looks like the Earth" and went on to justify their responses, more than 65% did so in grade 5. As a corollary, the frequency of all the other forms of response fell as the level of schooling rose. Similarly, while 45% of children in the first two levels provided negative responses, only 18% did so in the third level.

Q3. Can you find Morocco?

Overall, more than 62% of children claimed to know where Morocco was on the globe, but only half of them (31%) were actually able to point to it. The difference between the first two levels of schooling and grade 5, which had already been observed in the responses to the first two questions (Q1 and Q2) was even more marked here. While no children at all in grade 1 and only 17% in grade 2 claimed to know where Morocco was and were able to point to it correctly, more than 80% were capable of doing so in grade 5. Both negative responses and positive responses given by children who were subsequently unable to locate Morocco on the globe were extremely frequent in the first two levels, but virtually absent in grade 5. In conclusion, the responses to these first three questions highlighted a notable difference between the first two levels of schooling (children aged 6½ and 7½ years) and the third one (children aged 10½ years).

Q4. Do you know any other countries?

The results for this question were broadly similar to those for the previous question (Q3). The correct responses, i.e., those where the children claimed to know other countries apart from Morocco and were actually able to point to them on the globe, were relatively infrequent in the first two levels of schooling (9% and 23% respectively), but formed an overwhelming majority in the third one (93%).

Q5-6-7. What are the green/blue/brown areas?

For these three questions, results show that the frequency of correct responses underwent a clear increase with age. While the blue areas (water, sea) were fairly well identified (29% in grade 1, 48% in grade 2, 91% in grade 5), the green (trees, forests) and brown ones (mountains) were far less so (1.5% and 4% in grade 1, 48% and 40% in grade 5).

Q8. Can people live all over the Earth?

Overall, 65% of children answered that people can live anywhere on the Earth. The frequency of the "yes" response gradually increased, from 50% in grade 1 and 56% in grade 2 to 88% in grade 5.

Q9. Can people live in Argentina?

A large majority of the Moroccan children responded positively to the question about being able to live in Argentina. Argentina lies in the southern hemisphere, at the bottom of the globe compared with Morocco, and this may seem "peculiar" to some people. Unlike the previous questions, this one elicited very few pauses or "don't know" responses (8% in all). In other words, the children had no hesitation in answering this question. Lastly, although it was already very frequent in the first level (65%), the correct "yes" response increased in frequency with the level of schooling, reaching 83% in the third level (grade 5).

Q10. Can people live in Australia?

As far as Australia, another southern hemisphere country, is concerned, the results were very similar to those for the question about Argentina. Overall, 73% of children answered that it was possible to live there. Yet again, the already high frequency of correct responses in grade 1 (63%) underwent a steady increase (69% in grade 2 and 88% in grade 5).

Q11. Isn't it peculiar, living in Australia?

As Australia is "at the bottom" compared with Morocco, which is located "at the top" of the globe, living there "upside down" could seem peculiar to some people, and nearly 40% of all the children did indeed think that that was the case. Only 47% of them thought that it was not peculiar. Thus, while 73% of children said that it was possible to live in Australia in response to the previous question (Q10), far fewer of them were prepared to say that it was not peculiar, when they were posed the following question (Q11). The level of schooling had a clear effect on the frequency of the answer, "no, living in Australia isn't at all peculiar". Only 36% of children in grade 1 and 37% in grade 2 gave this answer, but 68% of 5th-graders did.

Q12. Don't people fall off?

First of all, it is important to note that this question was asked in its negative form, unlike the question posed by Jan Schoultz et al. (2001). In the Moroccan dialect, a "yes" response to this question signifies "yes, they do fall off", whereas a "no" response signifies "no, they don't fall off". This final question was particularly important, as it assessed the children's knowledge of a property of the Earth as an astronomical object rather than as a physical one. The Earth, of course, has neither "top" nor "bottom", and people can live "anywhere" on its surface. Results showed that only a very few children (11%) evoked some sort of gravity-related concept to explain why people living in Australia "don't fall off" (see following examples):

– "God put gravity there so that nobody would stay up in the sky. Birds are in the sky because they have wings" (grade 1).
– "Because the Earth sticks to us. It makes everything fall towards it" (grade 2).
– "Gravity stops them. It's like a magnet that attracts them" (grade 5).

Other children also answered that people "don't fall off" (19%), but adduced reasons denoting an erroneous model of the Earth. The most frequent argument was that people don't fall of the Earth because it is flat.

– "God stops them" (grade 1).
– "Because it [the Earth] is in the shape of a ball and that's not how it is in reality" (grade 2).
– "They won't fall off because they're humans like us, even if they have different religions from ours" (grade 5).

Lastly, positive and therefore incorrect responses were fairly frequent overall (55%). The most common argument involved the fact that it is impossible to live "down under" without "falling off".

- "Because the Earth is on a slant and if they go to live there, they'll fall off" (grade 1).
- "If they don't want to fall off, they have to live inside the Earth" (grade 1).
- "Because they can't live upside-down, with their feet in the air" (grade 2).
- "They'll fall off here [showing the bottom] and die" (grade 5).
- "Because this area isn't at the top, above this [pointing to the Equator]" (grade 5).
- "Because they're not Muslims like us" (grade 5).

These incorrect positive responses were characteristic of the children in the first two levels, with a frequency of approximately 70%. At these two levels, approximately 20% of children gave negative responses, but these were justified by an incorrect model of the Earth. There was practically no mention of gravity at these two levels. 5th-graders appeared to have a monopoly on correct responses associated with a more or less approximate idea of gravity, though even then they remained relatively infrequent (27%).

Inferential analyses

In order to compare the results for the Swedish children and the Moroccan children, we created four categories of responses (Table 1). There were clearly substantial differences not only between the Swedish and Moroccan sociocultural contexts but also between the ways in which the research interviews proceeded, making it impossible to compare the results from this point of view. According to Patricia Greenfield (1997), there is a clear methodological difference between cultural psychology and the psychometric or experimental approach, in that the latter requires the methods used in different cultures to be formally equivalent. This assumes, for instance, that a questionnaire designed for one cultural group can be adapted for use with another cultural group. The cultural approach, on the other hand, takes the view that experimenters must communicate with the subjects of a given culture in a mode that is usual and appropriate for that culture, whilst "participating" in everyday activities. The issue of whether the "questionnaire" is "open" or "forced-choice" is therefore not necessarily relevant. Accordingly, comparisons can be made at the conceptual and theoretical levels of the elaboration of scientific knowledge, but not at the strictly empirical level of methods and behaviours, even if these are brought about by equivalent procedures. Thus, in the present study, the comparison of results for the Swedish and Moroccan children was restricted to a conceptual level of analysis.

Recognizing countries on the globe. The first category of responses corresponded to the subjects' ability to recognize countries on the globe. This concerned the answers to questions Q3 and Q4. A response was deemed to be correct if a child knew not only where Morocco was on the globe (Q3) but also where other countries were, and was able to point to them (Q4). In all other instances, the response was incorrect. Results suggested that none of the children in grade 1 correctly recognized two or more countries on the globe. Similarly, only a very few (5 out of 75; i.e., 6.7%) were able to do so in grade 2. This ability, however, appeared to have been acquired by grade 5, where 77% of children were able to do so. The differences in frequency between the three groups were statistically significant (χ^2=136.64; DOF=2; p<.001).

Conceiving of the Earth as a sphere. The second category of responses concerned the conception of the Earth as a sphere. These were the responses to questions Q1 and Q2. If a child said that the artifact shown him or her was a globe or a map (Q1) and if he or she went on to say that the Earth resembled this artifact (Q2), the response was deemed to be correct. In all other instances, it was incorrect. Children appeared to acquire the ability to conceive of the Earth as a sphere earlier than knowledge of different countries. In grade 1, no fewer than

22.7% of children produced correct responses, while this figure rose to 33.3% in grade 2 and 76% in grade 5. Once again, the differences in frequency between the three groups were statistically significant (χ^2=48.485; DOF=2; p<.001).

Conceiving that people can live "down under". The third category of responses related to the conception of being able to live anywhere on the Earth, and more particularly on the "underside" without falling off. It comprised responses to the two questions about Australia (Q10 and Q11), which lies in the southern hemisphere and is therefore "at the bottom", compared with Morocco. A response was deemed to be correct if the child asserted that it was possible to live in Australia (Q10) and that it was not peculiar (Q11). Living on the "underside" of the Earth, when the latter is represented by a globe, may seem counterintuitive, and indeed only 27% of children in grade 1 and 28% of children in grade 2 conceived that it was possible. 63% of 5th-graders, however, asserted not only that it was possible to live there but also that it was not "peculiar". The differences in frequency between the three groups were once again statistically significant (χ^2=26.24; DOF=2; p<.001).

Evoking some sort of gravity-related concept. The fourth and last category concerned the children's more or less approximate understanding of gravity, as an explanation for the fact that people do not fall off the Earth if they live "down under". It corresponded to answers to the last question (Q12). A response was deemed to be correct if the child evoked anything approaching a concept of gravity and incorrect in all other instances. This last category of knowledge was clearly less well understood by the Moroccan children. Just one child out of 75 (1.3%) in grade 1 and 3 out of 75 (4%) in grade 2 were capable of evoking some sort of gravity-related concept, and this figure only rose to 20 out of 75 (27%) in grade 5. The differences in frequency between the three groups were statistically significant (χ^2=30.504; DOF=2; p<.001).

Intra-cultural comparison

The previous nominal variable was then considered as a numerical variable. Correct responses were converted into a score of 1 point, while incorrect responses were scored 0. The former were "expected" responses, in that they corresponded to the scientific model of the Earth, while the latter were incorrect responses in relation to this same model. Each child was given a score of between 0 and 4, by adding up the scores for the four previous response categories (Figure 2).

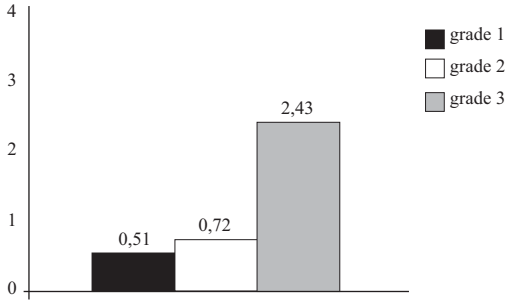

Figure 2. Mean scores out of 4 in the four response categories according to level of schooling

An analysis of variance (ANOVA) confirmed that, overall, there was a significant difference between the mean scores for the three different levels of schooling [F(2;222)=131.506; p<.001]. However, the children in the first two levels (grade 1: m=0.51; σ=0.601 – grade 2: m=0.72; σ=0.727) had broadly similar mean performances and, with scores below 1 out of 4, had obviously not yet acquired the scientific model of the Earth. An analysis of variance confirmed

that there was no statistically significant difference between mean performances at these two levels [$F(1;148)=3.835$; $p>.05$].

The children in the third level ($m=2.43$; $\sigma=1.002$) displayed a far better mean performance. A score above 2 out of 4 suggested that they had mastered the scientific model to a considerable extent. An analysis of variance confirmed that the difference between the mean scores was statistically significant for the two specific comparisons: "grade 1 *vs.* grade 5" [$F(1;148)=138,24$; $p>.001$] and "grade 2 *vs.* grade 5" [$F(1;148)=109,227$; $p>.001$]. The children's gender and the schools they attended had no significant effect on their mean scores.

Cross-cultural comparison

All the preceding results are summed up in the following table (Table 2). This shows that there was a clear difference between the two first levels of schooling and the third one. Not until they had reached this level did children gain a proper understanding about the Earth. The notion of gravity appeared to be the most difficult one to master. This was also the case of the Swedish children, albeit to a lesser extent (Table 1).

Table 2

Moroccan children's performances

	6½ years *N*=75	7½ years *N*=75	10½ years *N*=75	Total
Can recognize different countries on the globe	0%	7%	77%	28%
Conceives of the Earth as a sphere	23%	33%	76%	44%
Conceives that it is possible to live anywhere on the Earth without falling off	27%	28%	63%	39%
Uses some sort of gravity-related concept	1%	4%	27%	11%

The Moroccan results nonetheless differed radically from those recorded for the Swedish children, in that the performances of the former were noticeably less "good" than those of the latter. In the Discussion, we look at how this finding can be interpreted, but we can already assert that presenting a culturally-relevant artifact, in this case a globe, is not enough to spur children into reasoning correctly about the Earth.

Discussion

While the knowledge "of the globe as a representation of the Earth appears obvious to the [Swedish] children" as early as 6½ years (Schoultz et al., 2001, p. 110), this is visibly not the case for Moroccan children. It would appear that most of them only acquire this understanding at around 10½ years, which corresponds to the age at which astronomy is taught in Morocco. A similar study of French children revealed a clear difference between the knowledge of children in the first year of primary school (6½ years) and those in the third year of primary school (8½ years), showing that in France, this knowledge is mainly acquired at around 8½ years (Frappart, 2006; Frappart, Frède, & Troadec, 2008). This, too, corresponds to the level of schooling at which astronomy is taught in France. Accordingly, contrary to the conclusion reached by Jan Schoultz et al. (2001) and cited in the Introduction, Swedish children do indeed appear to be "informed" differently from those in other countries.

While the choice of an appropriate communication situation and the introduction of a culturally-relevant artifact may be necessary, they are not enough to trigger the emergence of "correct" knowledge. Stella Vosniadou, Irini Skopeliti, and Kalliopi Ikospentaki (2005) recently criticized the analysis proposed by Jan Schoultz et al. (2001), showing that the coherence of a mental model of the Earth that Greek school-age children had supposedly constructed while

producing a drawing and/or a Plasticine shape, was "disturbed" by the presentation of a globe, as the latter was not consistent with this previously activated mental model. They went on to claim that the results can only be explained by a theory postulating the existence of prior "internal" representations and concluded that when scientific concepts are being taught, instead of just presenting the cultural artifact, teachers need to explain how it is used, taking children's prior knowledge into account. This conclusion offers an entirely satisfactory explanation of the Moroccan children's results.

Nonetheless, we believe that the debate now needs to move on to the ontological status of mental representations. It is simplistic to set the cognitivist conception of mind, which places the emphasis on the "internal" processing of symbolic information, against the sociocultural approach, which underscores the former's failure to take the "external" context into account (Hatano & Wertsch, 2001). The computational approach is currently in deadlock (Fodor, 2003), and by borrowing her notion of mental models from Philip Johnson-Laird (1993), Stella Vosniadou has clearly distanced herself from that particular current of opinion. She has, however, adopted a representationalist perspective, which itself has come in for criticism recently. There are thus several competing hypotheses about the ontology of mind. According to Francisco Varela (1989b), beyond the cognitivist approach lie connectionism, which has no need of "symbol-based calculations", and enaction, where "the endogenous and the exogenous mutually define each other in the course of a lengthy history" (p. 117), and where there is no need of "mental representations". To this list, we can add Gerald Edelman's neural Darwinism (2004), which refutes both computation and representation.

We can therefore concur with Jan Schoultz et al. (2001) over the "dubious ontological status" (p. 109) of the "internal" cognitive structures postulated by Stella Vosniadou – in this case, mental models, without necessarily rejecting the hypothesis of children's autonomy of mind, or "self-regulation" (Piaget, 1992) or then again "autopoiesis" (Varela, 1989a). It is this that enables us to explain the differences we observed between the Swedish and Moroccan children without having to invoke either an "external" sociocultural deficit or an "internal" cognitive skill deficit. Children's immediate assimilation, in the Piagetian sense of the word, of the globe also depends on the current status of their "internal" organization. Indeed, this is the hypothesis that Stella Vosniadou (2007) now defends. She advocates going beyond the apparent antagonism between the cognitive and situated perspectives, and now supports a constructivist approach, which takes as its unit of analysis the individual interacting with the world via a diversity of symbolic structures – both "internal" ones (mental models) and "external" ones (cultural artifacts). The author infers a number of consequences for the teaching of science in schools. In line with the historical-cultural or "externalist" perspective, the author asserts that learning must take place in contexts that resemble those of everyday life. In line with the cognitive or "internalist" perspective, she argues that as scientific concepts often appear to be counterintuitive and to conflict with prior naïve knowledge, they must be presented not as facts but rather as answers to questions or in response to a lack of understanding. Lastly, the author adds that learning should be regarded as the act of an autonomous individual an aspect which does not appear to be taken into account in the two previous perspectives. Teachers should therefore take care to instil in learners a thirst for knowledge and a metaconceptual and intentional awareness which allows them to revise their naïve beliefs. Having put the predictions of these two competing perspectives to the test (Frappart, Frède, & Troadec, 2008) we, too, defend the epistemological attitude. Meanwhile, in view of its radicalism, the "contextualist" or "externalist" hypothesis defended by Jan Schoultz et al. (2001) in their sociocultural approach brings a risk of returning to empiricism.

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Le cognitivisme, lorsqu'il n'est pas computationnel, met l'accent sur des modèles mentaux – ressource "interne" – comme étant à l'origine de performances, par exemple, chez l'enfant. Le socioculturalisme met, en revanche, l'accent sur le contexte – ressource "externe" – comme moyen principal d'élaboration des connaissances. Les résultats d'une recherche relative au développement de la conception de la forme et des propriétés de la Terre, réalisée au Maroc, permettent de discuter des limites du cognitivisme représentationaliste, mais aussi de l'approche socioculturaliste "radicale". Il en ressort que si le contexte socioculturel est essentiel au développement des connaissances, ce développement contribue conjointement à l'accroissement de l'autonomie de l'esprit des enfants.

Key words: Cognitivism, Cultural artifact, Morocco, Sociocultural approach, Shape of the Earth.

Received: November 2006

Revision received: May 2008

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