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FORUM

Bridging culture with cognition: a commentary on "culturing conceptions: from first principles"

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The purpose of "Culturing conceptions: from first principles" is to consider the problem of conceptual change from the perspective of cultural studies. More specifically, the article uses an interview about a natural phenomenon (the day/night cycle) as a basis from which to criticize what is known as the 'classical approach' to conceptual change, and to derive a set of first principles of a cultural analysis of interviews about science concepts. It is claimed that the cultural approach is 'less presupposing and more parsimonious' than other approaches that assume that conceptions 'are structures inhabiting the human mind.' Roth, Lee and Hwang also wish to draw some implications from this activity for the teaching of science. I will start this short commentary by describing in greater detail the authors' position and will continue by discussing my agreements and disagreements.

The cultural studies position

The first, introductory, part of the article uses a fragment of the interview between 'Mary' and an 'interviewer' in which the former expresses the opinion that the day/night cycle is caused because the sun moves around the earth as the setting for expressing some preliminary thoughts about the communicative intent of an interview in the cultural setting. It is argued that the communication takes place using language, that language is a form of culture, and that the participants are not acting independently of each other but in interaction with each other. It is also noted that Mary is expressing what some science educators would call 'misconceptions' and that these misconceptions are in fact not non-sense, they make perfect sense. "In understanding an utterance as misconception, we recognize and accept it as one possible form of talk; we understand it; and we recognize and accept its cultural (i.e., collective) reality." The conclusion is "that the identification of conceptions as well as misconceptions presupposes the intelligibility of talk in the first instance; this

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intelligibility of 'misconceptions' undermines any attempt to completely 'eradicate/ them by means of instruction."

In the next section entitled "Communicative resources are situationally produced and coordinated in real time," Roth et al. analyze the part of the interview where Mary and the interviewer use their hands to elaborate on the relation between the earth and the sun and in the process create (together and for each other) a demonstrable model of the day/night cycle. Two possible interpretations of this phenomenon are given: 1) that there is a model in the person's mind that drives the production of speech, or, alternatively, 2) that "the production of these communicative resources happens right then and there, in real time." It follows that since we can speak about topics we have never talked or thought about before, we do not need "mental models of something (that) must predate or coincide with talk about this something."

This section ends with the conclusion that it is more parsimonious to assume that participants in conversations, including interviews about conceptions and science classroom talk, say what they say drawing only on language and the available resources, without making references to mental representations and mental models.

The next section, entitled "Borrowed (Mis-)Conceptions For/From the Other" basically repeats the same point. Namely, that Mary uses local resources (such as language and a diagram of a mariner's compass) to construct her answers "right in the here and now of this situation." It is also claimed that Mary's (mis)conception regarding the movement of the sun has its origins in adult talk about sunsets and sunrises: "if there are such things as misconceptions, these are already possible in the language we receive from the other and which we produce for the other."

What is the implication of the above for classroom practice? Rather than having to deduce internal models and cognitive frameworks teachers' only need to deal with students' "ways of talking," to think in terms of the talk the students exhibit in collaboration with them than in terms of the possession of mental models or conceptions. And instruction should focus on assisting students in developing ways of talking that are contextually appropriate.

Points of agreement and the 'reframed' conceptual change approach

I agree with the authors on many of the issues that they raise. It is of course the case that communication takes place using language and other resources which are forms of culture some of which are situationally produced and coordinated in real time. I also agree that misconceptions are indeed not non-sense, that they usually make perfect sense, not only to the individual who utters them but also from the part of the interviewer, and that the purpose of science education is not to 'eradicate' them (see Vosniadou 2006).

When the authors talk about 'conceptual change' they seem to refer to what is known as the 'classical approach' to conceptual change, as presented by Posner and his colleagues (Posner et al. 1982). According to this view, misconceptions in science represent alternative theories which must be replaced by the correct scientific ones. This replacement is seen to be mostly an individual, cognitive, and rational process, which can happen in a short period of time, and which depends on the students' dissatisfaction with his/her existing conceptions. This dissatisfaction is produced mostly through the use of cognitive conflict as an instructional strategy.

Over the years practically all of the above mentioned tenets of the classical conceptual change approach have been subjected to serious criticisms. Most notable among those have been the criticisms coming from the sociocultural perspective, that conceptual change is not only an internal cognitive process but one that happens in broader situational, cultural, and educational contexts and is assisted by the use of the relevant cultural tools and artifacts (e.g., Saljo 1999). Other researchers have pointed out that conceptual change does not involve the sudden restructuring of an alternative view but that it is a long and gradual process that proceeds through small modifications in a complex system, that misconceptions are not always well formed and/or resistant to change, and that cognitive conflict is not a successful instructional strategy for producing conceptual change (e.g., Smith et al. 1993). It has also been argued that science learning should not be seen as involving the replacement of 'incorrect' with 'correct' conceptions, but rather in terms of cultivating the learners' abilities to take different points of view and understand when different conceptions are appropriate depending on the context of use (e.g., Pozo et al. 1999).

These criticisms have led to a 'reframed' approach to the problem of conceptual change. In this reframed approach, the emphasis is not on misconceptions as unitary, faulty conceptions, but on knowledge acquisition as a complex and intricate process that proceeds through various kinds of modifications. A distinction is made between naïve explanations of natural phenomena, based on everyday experience in the context of lay culture and scientific explanations. It is argued that scientific explanations are difficult for learners to understand because they are the product of a long historical development of science characterized by radical theory changes which have restructured our representations of the physical world and which violate fundamental principles of naïve physics (Vosniadou et al. 2007).

In this reframed approach, many misconceptions are seen to result often from students' attempts to synthesize the new, scientific information, with existing beliefs based on naïve physics. This is why we call them 'synthetic models'. Synthetic models are not stable, alternative theories, but dynamic, situated, and constantly changing representations that adapt to contextual variables and/or to the learners' developing knowledge.

This position is a constructivist position. It can explain how new information is built on existing knowledge structures and provides a comprehensive theoretical framework within which meaningful and detailed predictions can be made about the learning process that can guide instructional interventions. It also considers that teaching for conceptual change cannot be achieved through cognitive means alone but requires extensive socio-cultural support, as it takes as its primary unit of analysis not the individual student, but the individual participating in rich socio-cultural activities, without, however, denying that knowledge can be acquired and stored in memory in some form (Vosniadou 2006). Finally, conceptual change is considered not as the replacement of an incorrect naïve theory with a correct one, but rather, as an opening up of the conceptual space through increased metaconceptual awareness and epistemological sophistication, creating the possibility of entertaining different perspectives and different points of view.

The role of mental representations

From the perspective of this, reframed, conceptual change approach, our disagreement with the position advanced in this paper centers mostly around the attempt to 'eradicate' mental representations. The authors appeal to issues of parsimony when they argue against the assumption that speakers form mental representations of the world which are used to guide their verbal communication. However, their proposal that the participants in a conversation rely only on language and available resources to communicate is without explanatory power. Language is nothing but a symbolic system that derives its power from the fact that it refers to objects and their relations in the world. It is our shared representations of the world that allow us to communicate about entities that are not perceptually present.

The authors argue that the intelligibility of misconceptions depends solely on the fact that it is a form of talk. However, the intelligibility of Mary's conception that the movement of the sun causes the day/night cycle, does not spring from the language used, or at least not only from the language used. If Mary had said that the day/night happens because Venus turns around the earth, or that living creatures on Venus cause night, we would find that her utterances made no sense, even though we would have no difficulty understanding the specific words used.

Misconceptions make sense because they express (usually through the use of language) explanations of phenomena which are probable in the context of our experiential and cultural knowledge, despite the fact that they may differ from currently accepted science. In particular, Mary's conception that movement of the sun around the earth causes the day/night cycle, is a perfectly good explanation of the phenomenon, in view of Mary's everyday experience in the context of lay culture.

In fact, given that most probably Mary and the interviewer do not see the sun, the earth, and 'night' at the time of the interview, we make the assumption that they, like the rest of us, can bring to mind the sun and the earth, create a mental model, and use it to derive from it possible explanations of the phenomenon of the day/night cycle. Mary continuously makes reference to such an implied model which the interviewer understands and which they both use throughout the interview. The creation of the mental model is a cognitive resource that allows us to use perceptual information creatively for the purpose of explanation.

But this cannot be possible, Roth et al. argue, because communication is produced in real time and because we can speak about topics we have never talked or thought about before. We do not need mental models or something that must predate our talk. Roth et al. seem to think that mental models are static and must predate our talk. But this is not the case. Mental models can be situationally produced and coordinated in real time to deal with the demands of the situation. They can predate our talk or follow it. We can create a mental model and run it in our mind to derive new information and new explanations which are based on perceptual knowledge and which are not readily conceptually available.

In our previous work in observational astronomy, we have argued that in many cases the nature and sequence of children's responses to our questions about the shape of the earth and the day/night cycle, "suggested some model construction taking place while answering the questions in the process of the interview" (Vosniadou and Brewer 1992, p. 576). There is plenty of evidence that something similar is happening with Mary in the present interview. The presence and use of mental models does not have to be assumed. It is exhibited in students' drawings and their constructions of models during the interview.

Roth et al. think that mental models are not only assumed but also superfluous. They appeal to issues of parsimony to justify their arguments regarding the uselessness of mental models. But mental models are not useless. As mentioned earlier, they provide the necessary link between language and perception. Shared mental representations allow us to communicate about things that are not immediately present; they bridge language with the world that it represents. Linguistic communication cannot be the sole basis for explanation in science. If that were the case there would be no reason to conduct experiments.

Furthermore, humans' ability to form mental representations of the environment can be used as the basis for deriving new, conceptual, knowledge from perception, beyond that which the individual can already express linguistically. Greeno (1988) argues that models "behave similarly to the objects in the situations that are represented, so that operations on the objects in the model have effects like those of corresponding operations in the situations. Mental models of this kind incorporate features of the situation that can go beyond the knowledge that the individual can state in propositions or other explicit forms, and that the representations of situations formed as mental models can be constrained by principles that are either known or considered as hypotheses."

As humans, not only can we form mental models of the physical environment, we can also use these models as a basis for the creation of various cultural artifacts. Sociocultural approaches to learning emphasize the importance of cultural artifacts and their role as cognitive facilitators. But they do not explain how human culture created these artifacts in the first place. Model-based reasoning is the key to understanding how humans construct the rich cultural environments that mediate our social and intellectual life. A globe as a cultural artifact is nothing more than a reified mental model of the earth viewed from a certain perspective.

Many researchers are now arguing for a distributed cognitive system that can generate internal representations of the environment when necessary, but can also use salient resources in the environment, such as cultural artifacts, in a non-reductive way (e.g., Vosniadou 2006). In such a distributed cognitive system, mental models play an important role. Individuals can form mental models not only of their everyday, physical experiences but also of the cultural artifacts they use. As Hutchins (1995) points out, "we can be instructed to behave in a particular way. Responding to instructions in this way can be viewed simply as responding to some environmental event. We can also remember such an instruction and tell ourselves what to do. We have in this way internalized the instruction."

Cultural artifacts like maps and globes can be internalized and used in instrumental ways in revising representations based on everyday experience. Our studies of children's reasoning in astronomy provide important although preliminary information about how individuals can construct mental representations that are neither copies of external reality nor copies of external artifacts, but creative synthetic combinations of both (Vosniadou et al. 2005). This suggests that the cognitive system is flexible and capable of utilizing a variety of external and internal representations to adapt to the needs of the situation.

It would not help science instruction to prevent educators from teaching children how to use mental modeling for conceptual change in science. Mental models can play an important role in conceptual change because they can form the basis on which new information can enter the cognitive system in ways that can modify what we already know. They can be used by children and by scientists to conduct thought experiments and simulations that can help them see the differences between alternative explanations of phenomena and to test the implications of principles or theories (Nersessian (in press); Clement, (in press)). And they can form the background on which teachers can sustain students' interest in participating in extensive science discussion and in developing contextually appropriate ways of talking.

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