Cult Stud of Sci Educ (2009) 4:705–711
DOI 10.1007/s11422-008-9145-6

FORUM

Socio-scientific reasoning influenced by identities

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Received: 4 July 2008 / Accepted: 11 July 2008 / Published online: 6 September 2008

Abstract Based on the comments by Lopez-Facal and Jiménez-Aleixandre, we consider that the cultural identities within Europe interfere with the question of the re-introduction of the Slovenian bear, generating a kind of "discrimination." When the SAQs under debate run against the students' systems of value, it seems that the closer the connection between the SAQs (socially acute questions) and the territorial and cultural identity, the more deeply the associated systems of values are affected; and the more the evidence is denied, the weaker the socio-scientific reasoning becomes. This result shows the importance of attempting to get the students to clarify the values underlying their socio-scientific reasoning. As Sadler observed, there was no transfer of socio-scientific reasoning on the three questions considered; each SAQ, as they are deeply related to social representations and identity, generated a specific line of reasoning balancing more or less each operation. Among various methods of teaching SAQs—problematizing, genetic, doctrinal and praxeological methods—socio-scientific reasoning may be a complex activity of problematization fostering the development of critical thinking. Confronted with the refusal to analyse the evidence in the case of the bear, and because of the nature of SAQs, we explore the notion of *tangible* proof. We think it relevant to study, together with the students, the processes of investigation used by the actors to establish *or disestablish* tangible proof on SAQs by analysing the intermediary states of the systems of proof, and possibly the "weak signals" which result in calling for the implementation of the precautionary principle.

Keywords Social representation · Identity · Socio-scientific reasoning · Socially acute questions · Socio-scientific issues

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Social representations and identities

Lopez-Facal and Jiménez-Aleixandre focused their analysis on the question of identity. We had explicitly linked the concepts of social representations and identity in the theoretical framework: social representations can be seen to be more an issue of identity than of conception (Astolfi 1999). This is similar to the opinion of Dubar (1991) who states that an understanding of the way identities are constructed requires an internal understanding of the representation. The interpretation put forward by Lopez-Facal and Jiménez-Aleixandre seems perfectly relevant to this analytical framework.

Ramon Lopez-Facal's work on identities has enabled him to develop this issue by focusing specifically on national identities, whereas our interpretation focused essentially on socio-professional representations. We had mentioned the national dimension of identity under the assumption of an unconscious racism when students believe "that Slovenian bears have fundamentally different behaviour, with the implication that this must be genetically based."

Identity is defined by a continuous process of rejection/assimilation—what is the same/different in relation to oneself—in relation to a group, a social category (of age, income, occupation…), also in relation to a community defined by a territory or nation. Students are anti-bear partly because the bears are Slovenian, but they do not highlight the Italian identity of the wolves as being a factor for rejection. This goes along with Ramon Lopez-Facal's interpretation of "a new supra-national identity opposing both sides of the Iron Curtain (which) overlapped with the old (country) identities." The Slovenian bear is foreign, different, he is frightening. The Italian wolf is from "Western Europe": furthermore he is "Latin," he is closely related, he is not to be feared. It is a question of identity differentiation between "Westerner" and "Slav" inside Europe. This identity differentiation highlights, as Ramon Lopez-Facal reminds us, the cultural difficulties encountered in the construction of the European Union which also interfere in these SAQs (socially acute questions). But this differentiation, this "discrimination" is not acknowledgeable, is not politically correct, and remains unconscious, hampering all critical thinking and consideration of contradictory elements.

If we notice, in our case, a supra-national identity, we can imagine a whole series of groups to which one can claim to belong according to the questions analysed: individuals and social groups may feel they belong to the valley, the region, rural areas, the nation, Eastern or Western Europe, Europe, the Western world, the Eastern world, the developing world, the planet. This territorial overlapping may be at the origin of a multi-referential territorial identity: an individual can be defined as being at the same time Pyrenean, French and West European. Students may find it more or less easy to acknowledge this belonging, even to feel it unconsciously. There is a connection between the levels of belonging and the resulting identities. On the question of the bear and the wolf, the students who come from different parts of France and who have all followed land-based training courses felt consciously attached to rural areas and unconsciously to Western Europe.

The Italian wolf is better "assimilated" than the Slovenian bear. Nevertheless, this assimilation is conditional; there must be no form of manipulation, hidden decision making, imposed or secretive governance involved. The wolf must not have been introduced secretly nor the Bern Convention amended as a consequence, without consultation. On the question of climate change these students feel they are citizens of the Western world; they make no mention of the difficulties which may arise in Southern, Eastern or developing countries.

It seems that the closer the connection between the SAQs and the territorial and cultural identity, the more deeply the associated systems of values are affected; and the greater the

rejection of discordant positions, the more the evidence is denied. This explains why these students prove to be capable of acute analysis, of questioning their preconceptions on the global issue of climate change; whereas on the issue of the bear, their socio-professional and territorial identity affect their social representations of the Slovenian bear and obstruct their socio-scientific reasoning. In both the cases of the wolf and the bear, we must remember the role of these animals in numerous tales and legends in order to appreciate the heavy symbolism linked to these animals, symbolism which is not confined to a particular territory even though this feature seems to be decisive in the reasoning about the bears. On the issue of the wolf, it is the socio-professional origin which has the greatest impact: the wolf is practically French, at least Latin; the reasoning is more open-minded. We do not observe the same rejection in the case of the Spanish bears that cross the Pyrenees.

In other words, this interaction of territorial and cultural identity with socio-professional identity should be taken into account when analysing local SAQs in class, especially those concerning environmental issues or linked to sustainable development. The high social "vivacity" of the issue may obstruct or distort the reasoning and thus block access to the scientific dimension of the question. The SAQs should be selected according to this axiological and emotional distance. It is perhaps more appropriate to begin with local SAQs which do not go against the students' system of values, so relying on context to encourage motivation and cognition, before moving progressively on to local SAQs which challenge their system of values.

Another comparative study that goes into the perception of the risks involved in GMOs (genetically modified organisms) is currently being carried out using this same group of students on the Ecology, Agronomy, Territory and Society (EATS) degree course and another group of students at the ENFA (a public institution involved in land-based higher education and research) who are following a degree course in Plant Biotechnology. We have observed a degree of variability within the EATS group on this rather more global question. In this case it is their socio-professional origins linked to their former studies which are expressed more clearly. Those students having previously followed a course in Animal or Plant Production with a technical economic bias find GMOs of greater interest than those students who have followed a course in Environment Protection and Management and who have a wider perception of the risks involved in the use of GMOs. The reasoning of the former group is similar to that of the students studying Plant Biotechnology. From a sociological perspective, at least in the Western world, society attaches several symbolic values to rural areas and the countryside including ecological and identity values Hervieu and Viard (1996). This confirms the view that the decisive socio-affective features of the handling of an SAQ vary according to the nature of the issue being considered by one and the same population.

It seems interesting to dwell a little further on what Lopez-Facal and Jiménez-Aleix-andre describe as the unconscious projection of the national identities of the bears and the wolves: the characteristics of these animals are not "scientific" characteristics (species, diet, sex…) but are linked to their origins. According to Lopez-Facal and Jiménez-Aleixandre's line of reasoning, the relation to the animal (to a greater or lesser extent foreign) is based on a psycho-social and psychoanalytical explanation. Can the identity prevent the "assimilation" of the Slovenian bear and the Italian wolf? In the end, is it a question of ethnic assimilation? The dimension of identity is no doubt stronger when it concerns the potential "integration" of animals. The symbolic association of certain characteristics is not exclusive to animals: this phenomenon explains, for example, the rejection of and the preferences for certain foods, the symbolic qualities of food being presumed to be assimilated by the eater: one assimilates and becomes what one eats, one

becomes for example as strong "as an ox." Of course this symbolic association varies from culture to culture. Food is initially defined in terms of culture and identity before being defined on a nutritional level (Poulain 2002). Setting the "scientific scene" of a subject is a form of distancing from reality in the same way that a scene set at the theatre, the cinema or museum is a cultural fabrication; in the case of science, a logical rationale is supposed to create a distance from the symbolic characteristics. The examples of the bear and the wolf demonstrate the return or resistance of the unconscious and the symbolic—and this even more so in the contextualisation of knowledge. Whatever science says, the bear, as defined by the scientist, is not the same animal as the reintroduced bear regardless of his origin or the location chosen for his resettlement. There are two conflicting representations of the animal. Scientific teaching attempts to give more weight to one of them; but the students' representations are so focused and far-removed that it is difficult to get them to interact.

Science builds a relation to the environment which may be in synergy with or in opposition to social, economic or cultural relations; the SAQs' modality for problematizing is a clue how to set up this confrontation.

To go still further, this unconscious reasoning, fuelled by symbolism and the notion of identity, illustrates the difficult but necessary integration of SAQs into teaching, and the importance of attempting to get the students to clarify the values underlying their reasoning. In this study, territorial, cultural, political and socio-professional identities combine to play a part in the stance taken by the students on local SAQs; they contribute to the construction of social representations on the subject of the bear and the wolf—whereas on the question of climate change, the much broader and emotionally detached identity of "Western citizen" expresses itself. Is it this difference that makes the same group of students capable of taking other evidence into account, and of identifying the evolution of their initial conceptions?

Use of socio-scientific reasoning

It is true that we have not used socio-scientific reasoning in the same way as Sadler et al. Our intention was not to identify the performance levels of the different "aspects" of the students' socio-scientific reasoning. First and foremost we used this reasoning from an educational point of view, building on it and illustrating it with the students on the subject of GMOs. This explains, as we have already indicated, that although the account taken of the uncertainties and risks is integrated into the aspect "complexity," we have chosen to distinguish it. Our idea was to make the reasoning with the students as explicit as possible. Therefore, rather than evaluate their performance in terms of, for example values, we fostered their clarification of the values underlying their reasoning. It is true that there was no transfer of socio-scientific reasoning; each SAQ generated a line of reasoning balancing more or less each operation (we will come back to this term later on) which could integrate supplementary operations such as the analysis of governance. In the end, of course, if the contextualisation on authentic, local SAQs does not *necessarily* limit learning and the students' capacity for critical reasoning (the example of Jiménez-Aleixandre's research into the work of Galician students on the oil slick proves this), it all depends on the local question raised: if it conflicts with the students' system of values, it will become a barrier to evaluating the evidence. It is therefore advisable to identify an appropriate affective and axiological "distance" in order to foster the students' reasoning—even if this means a very progressive analysis of the issues so as to encourage the students to carefully consider the ideologies, dominant values, scientific and social data linked to these SAQs.

The question of the use of socio-scientific reasoning refers back to the objective of qualifying a mode of thinking, or even acting when faced with a given situation, in our case with an SAQ. Socio-scientific reasoning is a promising path. We have considered that socio-scientific reasoning is a complex activity of problematization which could be the subject of a training course. The different "aspects" of socio-scientific reasoning have been described using the term "operation", not in reference to Piaget, but in reference to Vergnaud's (1994) operational invariants. According to the latter, such schemes enable us to describe the organising elements of thought. They are characterised by goals and anticipations, rules-of-action, operational invariants and inference possibilities. They can be learnt. According to Vergnaud, conceptualisation of the action or of the decision occurs from the moment there is an intention, mobilisation of knowledge or of models and the association of a practice. This conceptualisation model does not depend solely on knowledge but integrates the individuals' own values into the way in which they construct solutions.

We have considered that socio-scientific reasoning involves a certain number of operational invariants: *recognizing the inherent complexity of the issue studied, examining the issue from multiple perspectives, appreciating that the issue is subject to ongoing inquiry and exhibiting scepticism when presented potentially with biased information*. To make the training course explicit, we included *identifying the risks and uncertainties*; and to render students' thinking more critical, *the identification of the values underlying their reasoning*. At the end of the study, it seems appropriate to complete this reasoning by considering *the research and evaluation of the knowledge produced by non-academic producers of knowledge* (professional groups, associations, consumers…), and *the analysis of the modes of governance*. However, if this reasoning consists of different operational invariants, it does not constitute a scheme in Vergnaud's sense, because the intentionality of those attempting to answer a SAQ, is not unique.

Problematization, identity, socio-scientific reasoning, evidence

We based the work carried out together with the students on a *problematizing* method founded on socio-scientific reasoning with the intention of fostering the development of their critical thinking, rather than using a *genetic* method based on the construction (by different producers of knowledge) of disputed knowledge on SAQs. Ours is a *doctrinal* method based on the adherence to ethical, political or economic principals, in other words a *praxeological* method seeking to foster attitudes, involvement in action. But in the case of the reintroduction of the "Slovenian" bears we minimised the importance of the students' identity assimilation with the anti-bear shepherds which made all forms of distancing and acknowledgement of evidence impossible. On the subject of SAQs, evidence is still further called into question, the proof is not considered *tangible* because controversy is at the heart of the SAQs.

According to Chateauraynaud (2004), proof can be considered tangible if it resists "the perpetual instrumental and argumentative variations to which the actors, endowed with diverging representations and interests, submit it" (p. 168). All the terms used in this definition are important. In epistemology and sociology of science we are familiar with the importance of instrumentation and argumentation when certifying proof; the idea of *tangible* proof also calls for perceptual action. Social representations are also called upon, in other words the common identity of the individuals in relation to social groups. Each group is characterised by the assimilation of the dominant system of values. Subjects of the group

adopt the dominant ideology. Making decisions in relation to the dominant system can have far-reaching consequences; schools must play a role in this decision making. Recent "issues" or "crises," such as climate change, have led to the creation of temporary procedures, linked to the gradual nature of tangibility. The precautionary principle causes an inversion of the old logical order between proof and action. In this configuration, it is a question of identifying the "weak signals", the tangibility of which is still uncertain (Chateauraynaud 2003).

It may, however, take many years for certain environmental phenomena to become tangible. There is no automatic resolution for uncertainties. "Thus, at one end of the continuum we have the pole of enigmas for which even the most robust of instruments has not been able to establish definite proof; at the other extremity, there is proof which has been deliberately withheld until a future date" (Chateauraynaud 2004, p. 170). To illustrate the processes by which the actors perceive the solidity of facts and statements, Chateauraynaud (2004) gives the details of three cases: the case of the "sniffer planes" describes the setting up of a scam which led to the final proof of a hoax; the major "unforeseen" incident which almost happened in 1999 when water from the Gironde river flooded the Blayais nuclear power plant and jeopardised a long-term calculation, bearing with it the proof of an incomplete security system; the investigations into the death of bees which introduced the paradigm of precaution despite the absence of tangible proof. The author remarks that precautionary measures may also destroy evidence that a catastrophe was well and truly in gestation. There is a huge gap between the experience acquired by beekeepers in contact with their bees and the laboratory space where scientists carry out their tests. In this case, we observe the development of a collective vigilance which situates the probative activity within a continual process of negotiation. The battle of wills and the series of arguments between the beekeepers' Union, Bayer the agrochemical firm, associations, politicians…constantly delay the closure of the file.

Chateraurayaud identifies five important moments which occur during the processes of investigation for the purpose of establishing proof: the emergence of an interrogation, of a doubt or an uncertainty; the arrival of clues, traces, witness accounts about the organisation by those involved in the investigation of a network of conceptual connections and cross-checks; the cross-checking of expectations and arguments held by the plurality of actors; and finally, the act of closure and of public validation allowing the confirmation or revision of shared evidence. Intermediary states of the system of proof appear along with linguistic markers which reveal these successive states: "not the least scrap of evidence," "simple presumption," "the initial elements of the investigation point towards," "subject to verification, we can say," "it seems certain that," "in the absence of evidence to the contrary."

Chateauraynaud (2004) questions the importance of belief which would appear to be contrary to proof: "But, how can we dissociate belief and proof when, to establish proof, we rely on statements, and on witness accounts made by people who are necessarily convinced?" (p. 180). Can we presume that the statements reflect sincere belief and are not sophisms designed to mislead or obstruct the debate, something which is not to be excluded with SAQs? Chateauraynaud's point of view goes beyond the usual barriers of scientific activity.

Risk assessments by the scientific community do not correlate with those of the lay citizen. Scientists concentrate on their pocket of certainty when they produce knowledge, which is really only a series of the most valid hypotheses, *until proven otherwise*. Whereas, when assessing risk, it is important to examine the domains of ignorance. "The 'absence of any evidence' of risk is not the same thing as the 'evidence of absence'" (ESRC 1999).

Research in sociology demonstrates that the public at large has a more complex perception of risk than the experts. Experts assess the probability of an adverse event and measure the resulting consequences in quantitative terms, using the following formula:

$$\text{Risk (consequences/unit of time)} = \text{probability (event/unit of time)} \times \text{consequences (consequences/event)}.$$

The layman integrates more qualitative criteria into his definition of risk: he is more interested in the nature of the consequences than in their probability (Marris 1999). The assessment of risk varies, for instance, depending on whether the risk is imposed or voluntary, whether or not the repercussions will impact future generations….

We think it relevant to study the processes of investigation, with the students, in order to establish proof concerning past or contemporary SAQs by analysing the intermediary states of the systems of proof, the "weak signals" which lead the actors to call for the implementation of the precautionary principle, and the linguistic markers which reveal these successive states in the discussion about SAQs. This approach could foster an axiological distancing favourable to critical rationality.

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