School Science: Is it Science?

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Many school science curricula impose scientists’ science on school science with the assumption that such translation creates the same possibility for students of science as for scientists. Recent complex interpretations of learning problematize such notions by considering learning as emergent simultaneously at different levels of complex interactions—a function of the history of the structure at that particular level of organization. So, how can school science be considered science? And is such a question relevant?

Much of formal school science is shaped by ongoing debates of what science knowing is of value in the classroom. School science has tended to be defined in terms of the standards and activities of research scientists—and in particular of empiricist scientists. Scientific knowledge, be it imported into school science as knowledge product, processes of science, “pupil as a scientist” or as the nature of science is done so under the auspices that it must be introduced as a truth statement of how we may “find out” about the world. This is what I shall refer to as the imposed ethic as it locates the realm of science beyond the classroom, beyond all access of students to engage in science.

Thus, ontological considerations of science are mirrored in and become part of the discourse on science education, in the debates between “making sense” of the world and ‘finding out” about the world. Realist/anti-realist claims to science (Chalmers, 1999; Maturana, 1991) underlie the debate between constructivist and non-constructivist learning theories and pedagogies in science education, locating the knower in two different non-coterminous realms (Mathews, 1998; von Glasersfeld, 1998).

The observer in science

In a discussion of scientific knowing, the underlying issue is to distinguish
scientific knowing from other kinds of knowing.

...the problem of demarcation is more than a question of classifying theories in order to be able to call them either “scientific” or “metaphysical.” Indeed, it provides an access to some of the most fundamental problems of the theory of knowledge, and thus of philosophy (p. 162, 1983, Popper).

Popper’s struggles with attempting to go beyond the observer to distinguish an objective recoverable “universum,”—one fixed reality that exceeds the individuality of the process of observation (Maturana, 2000)—by proposing that failure to do so falls prey to the same problem in failing to address the observer who distinguishes experiences that claim any theory false. Lakatosian frameworks of a hard core of a research programme surrounded by a falsifiable protective belt, while acknowledging the evolutionary aspects of knowing, succumbs to the problem Popper faces. This persistent issue of the presence of the observer is only problematic for the recovery of a “universum.” For continued discussion of the issue it is worthwhile to consider not that it is a problem, but how it is.

“As observers we generally take the observer for granted and, by accepting his (sic) universality by implication, ascribe many of the invariant features of our descriptions that depend on the standard observer to a reality that is ontologically objective and independent of us” (p. 29, 1978, Maturana).

The recognition that it is we, humans, who do science and attempt to either “find out” about the world (from a realist stance) or “make sense” of the world then restructures any empirical and rational claims to science. Any claims to knowledge can only refer to the observer-making-observation, and cannot be separated from the observer (Maturana, 2000). The knower and the known are woven together in the fabric of human cognition.

Science and cognition: distinctions

Is science similar to all human cognizing? In what ways is it different? When it comes to how this distinction may be made, there have been many different interpretations of what the “Natures of Science” that scientists live are (Lederman, 1999; Brickhouse, 1990; Abd-El Khalick, 1998). If one claims to acknowledge the observer, as I have done here, it can be seen as stating the obvious, especially in light of those scientists involved in the different arenas of science arising with their knowing and different consensual[1] domains (Chalmers, 1999).

One concept that is extremely useful for interpreting this distinction is Maturana’s (2000) notion of interobjectivity, which brings forth the object
as a product of recurrent coordinations of actions\textsuperscript{[2]} within a domain. He posits that in the continuous coordinations of actions that take place in the praxis of living, observers arise as objects with the distinguished object, in distinction, masking those coordinations of actions that brought them forth. Science in itself can be distinguished as such, masking the consensual coordinations of actions that brought it forth as an object. This is evident in the widespread efforts to recover those processes of science that the scientific community engages in as the features of what is science.

Then what is it that is different of science in comparison to other human cognizing? As a scientist in the biological field, Maturana makes science distinct from his other experiences as a domain that arises in the compulsive explaining of experiences in generative reformulations that are validated in the scientific community, bringing himself forth as an observer in the act (Maturana, 1991). While he runs the risk of falling back on delineating a truth statement about a common “nature of science,” his statements are distinctions that he makes of the scientific knowledge objects that arise in the collective. That explanations need to be validated by other observers (scientists) for them to be scientific, is prevalent in many other explicit and implicit references to the communal nature of scientific knowing acts (McGuire & Tuchanska, 2000, Chalmers, 1999).

Science as a cognitive domain in which the observer as an individual is implicated in a knowing that is collective, must go beyond the representational views of cognition such as mentalism and behaviourism (Davis and Sumara, 2002). Among constructivist discourses, the individual constructivist (usually referred to as the Piagetian) view only highlights the individual making sense of the world, while the social constructivist (arising from the Vygotskian) view focuses on how the social context constructs the individual. Both constructivist theories have exclusive concerns, the former foregrounding the individual and the latter, the web of relations in which the individual is embedded; yet both focus on how the individual learns, as the individual interacts with his or her environment, perturbing and being perturbed by the environment, and reconstituting its structure and that of the environment in the domain of coupling, simultaneously (Davis, Sumara and Luce-Kapler).

Recent ecological views of cognition (Maturana & Varela, 1987; Capra, 2002) shed a different light on cognition, and consider knowing as arising with two different types of autonomous unities, the individual and the collective, nested in different levels of complexity (Davis, Sumara and Luce-Kapler, 2000). As such the knower (be it individual or collective) and the known co-emerge together through recursive structural coupling of the unities to the environment in which it is immersed.

Science as a way of recursive knowing in which different observers who
make distinctions feed on other distinctions made by other observers, thus bringing forth a collective communal practice arising from the mutual structural couplings of the agents between and within local scientific communities of knowing (McGuire & Tucháska, 2000). Such mutual structural couplings thus contribute to the conjoint knowing that emerges, as opposed to being brought forth by any one individual.

When science is viewed through the lens of complex interpretations of cognition with nested levels of the individual and collective cognizing agents, such historical and socially situated interpretations of scientific knowing render problematic the objectification of the knowing that arises within (science). Hence teaching a body of knowledge as objective while subscribing to constructivist learning theories is contradictory due to mutually exclusive structures. This point is particularly relevant in proposing that scientific knowing in collectives may be considered process as opposed to product (von Foerster, 1981).

The world brought forth collectively by scientists in living is one of collective significance (Simmt, 2000), of explanation that allows these and other observers who are part of this collective (of consensual life) to cope in their living, to continue their living in and with science. What is of added significance in the development of collectives is that as they arise as a unity from bottom-up interactions that are proscriptive, no one individual controls the group and yet every agent in the group implicitly adheres to the rules that prevent the collapse of the collective like the emergence of cities, or ant colonies (Johnson, 2001). The criterion of validation that the explanations submit to are not a top down, but a bottom up emergent criterion that arises out of the actions of the individual scientists, flexible and emergent. Since the structure of a collective is determined through its history of interactions, which make certain consequent interactions possible, the ontogenic changes that occur at the level of the collective are a feature of the natural drift it experiences, of being viable, in the autopoietic regeneration of itself (Maturana & Varela, 1987).

Yet scientific knowing that is evident at the level of the project of science and the project of science education differ by the level of imposition on the collective. Given that scientists and other groups in the communities that contribute to the emergence of scientific knowing such as funding agencies, or social activists (Roth & Lee, 2002) are a collective of a particular nature, qualitatively different to that of the individual and collective unities that arise within the classroom. The question arises as to what kind of scientific knowing may be occasioned in the classroom and what a science curriculum may look like.

**School science: is it science?**

One of the distinctions that can be made between school science from
‘mainstream’ science is evident in its reference to scientists’ science. When school science is dictated to by scientists’ science, both the mandated and lived curriculum impose the scientific ethic on the student while in the domain of the scientist, it is lived. Many science curricula impose the scientific knowing that may be occasioned at school level on individuals and collectives while knowledge imported into school curricula is a product of a different collective and a different dynamics. The curriculum is determined by the knowledge product of scientists’ collective knowing acts. Teaching becomes telling, or not telling as the case may be, but with the intention to lead the students to a known answer (Davis and Sumara, 2002). School science in the domain of the student is inaccessible to the student. Students’ coordinations of actions in their operational coherences arise in a different domain to that of the imposed science. Additionally, if a biological explanation of cognition based on structural determinism were embraced, scientists’ science would become a parallel domain for students, similar to realist conceptions of science based on correspondence to an observer independent reality.

Yet once scientists’ science is identified as arising within the human cognitive domain, nested in both individual and collective cognition, with no objectively superior claims to reality, as explanations of experiences, arising as a world of significance for those agents in the collective, school science may then be invited to this domain in consideration of individual and collective nested levels of learning that can arise in the classroom simultaneously (Davis and Simmt, 2003). The challenge for school science has been to simultaneously acknowledge the history of preparation of students for participation in science that is part of its historical structure, while recognizing school science as located in a different domain, in the living praxis of students. This recognition is evident in the ‘Science for all’ chant prevalent in most school science curricula that succumbs to importing scientific knowledge as product and process in living. Once school science recognizes science as a collective cognitive process, then it can ensure that it caters for both by locating school science in the living praxis of students, expanding the space of the possible by creating environments within school science such that scientists’ science is within the possible. The challenge is to expand the space of the possible (Davis, in press).

One way of doing this can be through creating conditions for collective scientific knowing in classrooms (Davis and Simmt, 2003). Students’ collective generative explanations for their experiences and the need for a specific criterion of validation that validates these explanations for the acceptance of such explanations can be the object of scientific investigation so that it can reveal itself as one that is emergent and brought forth with the collective. The criteria of validation brought forth is one of the ways of establishing sameness in the science classroom, as a redundant
systemic quality (Davis & Simmt, 2003) that allows scientific knowing to emerge in the collective, by allowing a space of overlap and commonality among students such that their interactions are consensual. The emergent criterion is then open to be examined in itself as arising within the collective and the basis of validation.

In this way, the science that is enacted in schools becomes an initiation into the community of scientists and students come to see science as a way of coping with experience in the praxis of living. The lived ethic of science becomes one of possibility as opposed to one of exclusion. The space of the possible then becomes larger for school science.

References:


Lederman, N. G. (1999). Teachers' Understanding of the Nature of Science and Classroom Practice: Factors That Facilitate or Impede the


[1] Consensuality takes place in the coherent transformation of behaviour of two or more
organisms as they live together, and occurs as an unintended result of that living together
[2] flow of responsive interactions between two or more living beings as they live
together
[3] how a living system appears to observers as coherent with its circumstances of living
(Maturana, 2000)
[4] Used to refer to the manner in which complex agents respond when perturbed. The
manner of the response is determined by the agent’s structure, not by the perturbation.
That is, a complex agent’s response is dependent on, but not determined by environmental
influences

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