

Science Education: Constructing a True View of the Real World?

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Constructivism, we are alarmed to report, is alive, well, and thriving, and doing especially well in a rather unlikely place: namely, science education. Constructivism has acquired the status of “received view,” the doctrine of psychological, epistemological, and/or ontological faith that undergirds much of current pedagogical practice. In the discourse about science education, constructivism is often accepted without argument and without question as the view most appropriate for the science classroom.¹ While there is a strong and growing body of work that clearly, in our view, exposes the deficiencies of constructivism, both as an interpretation of the nature of science and as a basis for science education, constructivism unaccountably persists.² We maintain that both the epistemology and the ontology that attends constructivism, as it is often construed, are seriously flawed. While these flawed positions are most fully and consistently developed in radical forms of constructivism, for example, that of Ernst von Glasersfeld, the more moderate versions of constructivist thought display many of the same defects. The ready acceptance that constructivist views now receive constitutes a serious problem for science educators, and by extension, for all educators. In this essay, therefore, we shall point out some of the conceptual snares that we believe account for the immediate plausibility, and the unmerited popularity, of certain constructivist theses.

Science educators attempt to help students gain a measure of scientific knowledge, as well as a measure of knowledge about the nature of science. To articulate what science is, then, and what knowledge is, is a prerequisite philosophical task, and one that is nowhere near completion. We shall argue that a realism is implicit in scientific practice, and that science is not properly taught when deprived of its basic philosophical groundwork. In the course of teaching science, we may currently be imparting a tolerance for what are actually anti-scientific world-views.

CONFLATIONS, CONFUSIONS, AND CONCEPTUAL CONUNDRUMS IN CONSTRUCTIVISM CONFLATING KNOWLEDGE AND BELIEF

Constructivism has been aptly described as protean in nature, and the various versions are identifiable *as* constructivist only in their sharing of a vague “family resemblance.” The most obvious shared trait is the thesis identified by D.C. Philips, that “human knowledge, and the criteria and methods we use in our inquiries, are all *constructed*.”³ But, what is meant by such a claim? Taken in one sense, the claim is simply true; taken in another sense, it is patently false. This basic constructivist thesis would be true, albeit trivially true, if what we had was an assertion about human beliefs, that is, if the claim were merely that *human* beliefs and the criteria and methods we use in our inquiries are generated by the *action* of human beings. A trivial truth, indeed. But this constructivist thesis is generally explicitly presented as a claim about knowledge. And this is a problem, for “knowledge,” if the term is to be useful, entails things over and above belief; that is, “knowledge” is a fundamentally normative term. We shall adopt the much maligned position that

beliefs, in order to count as knowledge, must not only *be* beliefs but also be *true* beliefs. The criterion of truth is the *sine qua non* for knowledge, that which distinguishes knowledge from belief.

We find in constructivism a pervasive failure to distinguish the concepts of knowledge and belief, and this fundamental error generates many of the paradoxes that mar constructivist thought. Von Glasersfeld, principal proponent of radical constructivism, consistently and intentionally excises truth from his concept of knowledge.⁴ Consequently, when von Glasersfeld speaks of “knowledge,” what he says is often unproblematically true *of belief*, and yet quite untrue of knowledge.⁵ So, if one systematically substitutes the term “belief” for the term “knowledge” in von Glasersfeld’s work, most of the paradoxes dissolve, and there emerges a quite sensible account of human belief. Human beings clearly do “construct” beliefs, in the sense that every belief is the consequence of activity of the human brain/mind, operating in a physical/social/cultural context. But, when we proclaim a belief to be “knowledge,” we state an evaluation of the belief, a judgment that expresses confidence in the *truth* of the belief. The term “knowledge” serves to mark a limited and select set of beliefs, our “A Number One” beliefs.

But, even if this is so, would it not still be fair to note that the designating of certain beliefs *as* “knowledge” is, itself, an activity that human beings *do*, and, given this, would it not follow that knowledge *is* properly said to be “humanly constructed,” the product of human activity? Well, no. The problem is that this seemingly plausible claim fails to highlight the critically important element in the knowledge concept, the *objective criterion* of knowledge, namely, truth.

So what makes a true belief “true?” John Dewey’s pragmatic correspondence theory of truth, we believe, sheds considerable light. His theory of truth entails that truth must be objective. It is Dewey’s theory that in the inquiry process, observational propositions, which state the existential conditions prior to experimental actions, lead to inferential propositions, which state (possible) meanings of those early conditions. The projected conditions (that is, the meanings) which are specified in these inferential propositions either do (to some degree), or do not, correspond to the existential conditions observed to occur subsequent to the experimental actions.⁶

Figuring out, in practice, which ones of our beliefs satisfy the truth criterion is of course a problem, as every fallibilist acknowledges. We can always be wrong in our judgments. But this fact ought not to be taken as sufficient reason to expunge entirely the element of truth from the concept of knowledge. Why not? Given the difficulty in telling the “true” from the “false,” why *not* simply re-conceptualize knowledge so as to identify knowledge with belief, and in this way eliminate that tricky little bit about “truth”?

Constructivists generally make just this move. Truth is conceptually excised from knowledge, and something we *can* more or less reliably recognize, namely, “viability,” is substituted for it. Grayson Wheatley, a constructivist educator, states the position clearly: We do not find truth but construct viable explanations of our experiences...in constructivism no claim to truth is made. Instead, we consider our

positions viable if they “work.”⁷ Knowledge, then, is construed as sets of beliefs that are viable, in that, being mutually compatible and not actually obstructive of our efforts to act, they persist. And, significantly, nothing is implied as to the truth of the beliefs.

Our contention is that these “surviving beliefs” ought to be considered merely as *candidates* for the status of “knows,” since even the most viable of beliefs can, in fact, be false. We cannot substitute viability for truth in the concept of knowledge unless we are prepared to allow that some false beliefs might *legitimately* count as known. Consider, moreover, that *all* beliefs, while they are being believed, are up to that point viable. So the apparent specification that *only* “viable” beliefs are to be counted as knowledge leaves us precisely where we began, with the simple identification of knowledge and belief.

Wheatley provides an excellent example of the confusions that ensue once truth is excised from knowledge. In the space of one article Wheatley provides us with three different characterizations of knowledge. He asserts, first, that what “constitutes knowledge” is human mental action, thought. “When a person thinks about a tree, it is the action of ‘running through’ their self-built conceptions of trees... which constitutes knowledge.”⁸ On Wheatley’s interpretation, any mental “running through” of conceptions, even when those conceptions are entirely incorrect, is knowledge. If we follow Wheatley, we must abandon the notion that only certain beliefs, that is, true beliefs (which are, moreover, held for good reasons), constitute knowledge.

Next, Wheatley observes that it is persons who know and that they come to know through activity. And we believe this is quite simply correct. But Wheatley does not rest content with this success; he goes on to assert an identity, namely, that “To know is to act.”⁹ And this is, quite simply, wrong. While action, we agree, is essential in the discovery of the truths that constitute a body of knowledge, we cannot simply identify acting and knowing. While it is true that many activities require knowledge for their successful execution, the knowledge required for an activity is a different thing than the activity itself. And, while it is true that inquiry processes are activities, and that knowledge is the *potential* result thereof, nevertheless, even the best of inquiry processes might lead one to accept false beliefs as true. Were we to identify knowledge with the inquiry process, we would have to admit once again that false beliefs might legitimately count as knowledge, and that, in short, there is conceptually no distinction between belief and knowledge.

Taking a third stab, Wheatley claims that knowledge is “actually *constituted* by the language used to express it.”¹⁰ If so, it follows that, whenever language is used, knowledge is *ipso facto* created, whatever the propositional content of that language. Having excised truth from knowledge, it becomes a very simple thing, it seems, to know. One speaks, or acts, or even simply thinks, and one knows. And, since *all* beliefs can potentially be articulated, acted upon, or thought about, we are left with no conceptual distinction between knowledge and belief. And what’s wrong with *this* is that, in the everyday world of action, we most desperately need to distinguish between the two, between beliefs simpliciter, and those beliefs that are true and are held to be so for good reasons. Even when we cannot be sure which is which, we need

the conceptual distinction if we are even to make the effort to find out which is which. And there are good reasons *why* we would want to have true beliefs, rather than false beliefs, upon which to base our actions.

One simple, almost trivial, implication of constructivist excisions of “truth” from knowledge that should be disturbing to science educators and others, is that where there can be no truth of belief, neither can there be any falsity of belief. Incompatible beliefs, which of course, may *all* be false, cannot be evaluated as false, and thence discarded or revised. New beliefs may replace the old, but this is not progress, for the new beliefs are held to be no better than, only different from, the ones they replace. So, creationism, for example, cannot be adjudged false, when there is no such thing as truth. That efforts to incorporate “creation” science into the “regular” science curriculum pose an increasingly serious problem in public education would be hard to doubt — local examples abound, and the current contretemps in Forest City, Iowa is only one of many such cases.¹¹

Constructivist positions can frequently be identified as such by the standard answer to this puzzling conundrum: “Is new knowledge *made*, or is it *discovered*?” Knowledge, constructivists aver, is something that is *made*. Different persons and different cultures, it is said, can and do make different and incompatible knowledges. Science is but a cultural artifact, and we are all “hypnotized” to accept the knowledges (and the correlated realities) our cultures create.¹² This appears to be a startling claim about the world. But it only appears so when one fails to recognize the constructivist’s signature conflation of knowledge and belief. Psychologically, any state of (newly) believing must of course be made by the believer. And, because any new belief must be set into, and develop out of, a context of existing belief, it is clear that the inquirer’s mind, and culture, invariably influences the character of new belief. So, with respect to *belief* construction, it is true: beliefs are “made” in a contingent historical process and both the process and the product could well have been different.

And yet, while a belief is made, its truth must be discovered. The “correspondence” that in Dewey’s epistemology is an essential element in truth is an objective, potentially observable, factual matter; as such, it is there to be discovered. Knowledge, conceived as requiring true belief, is thus necessarily *both* made *and* discovered.

Given the mutual independence of truth and human belief, the constructivist notion that knowledge is made by human choices and activities with few if any constraints set up by an external and objective reality cannot be sustained. *Belief* construction may be “unconstrained,” but constraints on what, conceivably, could come to be *known* arise from the fact that the truth of any belief is *wholly* determined by natural states of affairs.

CONFLATING “REALITY” AND “BELIEFS ABOUT REALITY”

Constructivist discourse often exhibits a failure to consistently distinguish between beliefs *about* the world and the actual things, events, and relations that *constitute* the world. Yet significant differences separate the two. The term “the world” enables us to refer to those states of affairs whose existence is independent

of human beliefs about them, that is, the facts of the matter, or “what is.”¹³ It is the independence of actual states of affairs from human belief that makes the truth of statements about them also independent of human belief. There are, of course, facts of the matter with respect to human states of affairs, for instance, physiological, cognitive, and affective states, as well as desires, intentions, and motivations. There are also facts as to the relations and interactions of human-facts-of-the-matter with other facts. Yet, in all cases, human beliefs do not of themselves affect *other* concurrent states of affairs. They can of course lead to actions that will quite naturally alter the historically developing course of events, thus affecting *future* states of affairs.

Note, though, that facts as to human states of affairs do not constitute the sum total of *all* facts. Unless we carefully maintain the distinction between “the world” and “human beliefs about the world,” we find ourselves unable to refer to the vast collection of “non-human” states of affairs. Moreover, we may even come to believe that such a collection does not exist. Some (though not all) constructivists seem to fall into this conceptual snare. Von Glasersfeld, for example, asserts that because nothing can be encountered except through experience, the term “the world” works merely as a short-hand expression for “what is experienced” and for whatever beliefs happen to become fixed as we attempt to make sense of our experiences. An “experiential world” is what we construct, and we may construct it howsoever we will, unconstrained by anything save our own prior constructions.¹⁴ Moreover, when interacting socially, we “co-construct” our reality through what is called the “social negotiation of meaning.”

We agree, readily, that a necessary condition of a thing’s being known is that it be experienced, even if indirectly; that is, there must be some way in which a thing/event impinges upon a human being’s consciousness, if it is to be (humanly) noted, wondered at, explained. But it is important to note that all real thing/events potentially do so impinge, for every event occurs in an unbounded interactive web of real connections, a web which includes human states of affairs.

Moreover, the facts that constitute the real world contribute to, and so constrain, the development, and the continuance, of human beliefs. Von Glasersfeld claims, however, that there are no such constraints.¹⁵ In fact, he claims that the activities that result in belief provide no clue at all to objective states of affairs. He writes that “the structure of the behavior of living organisms can never serve as a basis for conclusions concerning an ‘objective’ world, that is, a world as it might be prior to experience.”¹⁶

But because the interactions that result in human belief are themselves real and connected in objective ways with all else that is real, human behaviors, experiences, and personal events of interaction do serve as excellent bases for conclusions about the objective world. The conclusions that we reach about the world are, of course, also part of the objective world, and hence contribute in determining the character of future interactions. And these future interactive events constitute the means of retrospectively evaluating the beliefs involved in their production. Our beliefs about reality, generated in real and objective interactions, are tested in future, ongoing, real

and objective interactions. True beliefs tend to pass such tests, while false beliefs tend not to. As we become more sophisticated in designing and controlling the tests to which we submit beliefs, we become more adept at distinguishing the true from the false. And in this way, knowledge of the objective world is reached.

Von Glasersfeld sets out another conundrum that arises from his repudiation of the possibility of knowledge of objective reality. He asks how it is that we experience a “relatively stable and reliable world, in spite of the fact that we are unable to ascribe stability, regularity, or any other perceived property to an objective reality.”¹⁷ His answer, one that is common among constructivists, is that “intelligence operates...to construct a relatively *regular* world out of the flow of its experience.”¹⁸ The nature of the regularities that are perceived is determined entirely by the nature of the cognitive organism and by its order-producing cognitive operations. Any apparent order is merely a humanly created product that is imposed on the inchoate unstructured flow of experience. Order is not really “out there,” and thus cannot be discovered.¹⁹ Von Glasersfeld explains,

the experiencing consciousness creates *structure* in the flow of its experience; and this structure is what conscious cognitive organisms experience as “reality” — and since this reality is created almost entirely without the experiencer’s awareness of his or her creative activity, it comes to appear as given by an independently “existing” world.²⁰

Wheatley takes a similar stand, rejecting the realist view that the world “contain[s] information or patterns existing prior to the organizing activity of the person.”²¹ Knowledge acquisition, on this view, can never be a matter of becoming aware of, and formally articulating, real patterns and real relations.

Why are these constructivist theses, which at worst harken back to a Berkeleyan idealism, and at best require a deep skepticism about the possibility of knowledge as true and justified belief, so plausible, in a world so filled with evidence of the exact opposite? Our conjecture is this: it is very easy to fall into the epistemological and ontological snares that abound in the postmodern world, and so to come to believe, without very much thought, that realism is naïve, that truth is *passé*, and that knowledge about objective states of affairs is (known to be) mere delusion. In the absence of a “truth” that relates in some way to a “real world,” the concept of knowledge must collapse into that of belief. And, once it is “belief” of which we speak, the constructivist positions really are true. They are not, however, true of knowledge. And it is with the development of knowledge that educators, especially science educators, are, or ought to be, concerned.

REALISM AS THE APPROPRIATE PHILOSOPHICAL BASIS FOR SCIENCE EDUCATION.

To the extent that educators, in their practice, incorporate and convey the problematic constructivist theses discussed herein, we believe that, to that very extent, they are actually undermining the scientific literacy of their students. The constructivist ontological and epistemological positions pervading science education must be challenged, for there is clear evidence that scientists, in the practice of science, implicitly adopt a set of realist positions. The fundamental proposition on the table, when science is being done is, “this is the way the world really is/works.”

The realism we have in mind is a modest thing, such as that set out by William Newton-Smith, in *The Ontology of Science*. Modest realism is

simply the extension of the stance of CSR [Common Sense Realism] to all scientific discourse. Truth is at stake in science, and we have on occasion good reasons to believe in the truth or likely truth or likely approximation to the truth of some scientific claims. Consequently, we (sometimes) have reason to believe in the existence of those theoretical entities which would have to exist were our reasonable beliefs to be true.²²

But, what of quantum physics? one might ask. Is this not the scientific advance that proves once and for all the futility of science as a means of learning what's "out there?" Here is the beauty of the modest realism we endorse: It is not incompatible with an equally modest instrumentalism.²³ That is, it is possible, *on occasion*, to decline to aver the actual existence of the theoretical entities employed, and this may be the most appropriate tack in some areas, at some times. Thus, as Geoffrey Hellman puts this, "one can view our best micro-physics as 'purely instrumental' without in any sense embracing an instrumentalist view of science."²⁴

What, if any, is the social significance of these abstruse epistemological and ontological issues? That is, does any of this matter? We believe that the social ramifications of philosophical issues such as these are serious. Underlying philosophical beliefs, even when only vaguely articulated, do influence judgments and subsequent actions. And these actions alter the world, for better or worse. As science teachers, we avoid quite a bit of personal and political discomfiture, and so do ourselves a service, if we allow via the adoption of constructivist rhetoric that, for example, Darwinian evolutionary theory is just "one way of making meaning," no better and no worse than any other. But we do our students a grave disservice. Evolutionary biologists understand themselves to be describing real events and real relations, and condensing the information acquired, as much as possible, into the form of scientific laws and general principles that state real regularities in nature. Competing theories about the particulars quite naturally emerge and may co-exist for some time. But, the principal "selection pressure" on these theories, that leads to the survival of some and not others, *insofar as science is being done*, is the requirement that a theory produce objective predictive success.²⁵ And it is true theories, those that formulate real regularities among real things/events, that are most likely to produce such success.

Science is, and should be taught as, a "privileged" form of knowledge — since science, as Lewis Wolpert points out, "provides the most reliable means of understanding how the world works."²⁶ The position in science with respect to constructivism is simple: Wolpert continues that "[a]lthough social processes play a role in science, scientists change theories because the new ones provide a better correspondence with reality; because, like Darwin's theory of evolution, they provide a better explanation of the world."²⁷ To claim to teach science, while simultaneously avowing that there are "other ways of knowing" equal to, or perhaps better than, the scientific "way" is to pervert the teaching of science. Similarly, to assert misguidedly that the content of scientific knowledge might well be other than it is, had scientific inquiry been subject to different cultural pressures, is to give a false account of the nature and practice of science. Although problems might well have been differently prioritized, the knowledge that could be discovered *must* be the same. This will sound odd to those who have identified knowledge with belief. But

a fully developed terranean biology, without DNA, for example, simply is not a possibility. "Descent with modification," for another example, is a fact in speciation, and no terranean biology is or could be complete without its recognition.

To close, Derrick Hodson, a constructivist educator, asserts, and we heartily agree, that "a proper understanding of science and the scientific enterprise is a key component of critical scientific literacy."²⁸ We believe, however, that to accomplish this goal requires that science be presented with its philosophical roots attached, that is, with a modest realist ontology, and with an epistemology to match. This formulation is one in which knowledge requires truth, and truth requires correspondence, in the Deweyan sense, with an objective reality. To fail in this is to undermine the very science that we purport to teach.

1. Examples of works that assume constructivism are readily found in *Science Education* 83, no. 6 (1999), see articles by Chin-Chung Tsai, Alfredo Bezzi, Derek Hodson in the *International Journal of Science Education* 21, no. 7 (1999); see Cross and Price, and Cajas.

2. For example, Michael Matthews, ed., *Constructivism in Science Education: A Philosophical Examination* (Kluwer: Dordrecht, 1998); Matthews, *Science Teaching: The Role of History and Philosophy of Science* (New York: Routledge, 1994); Matthews, "Old Wine in New Bottles: A Problem with Constructivist Epistemology," in *Philosophy of Education* 1992, ed. H.A. Alexander (Urbana, IL: Philosophy of Education Society, 1993), 303-11; D.C. Phillips, "The Good, the Bad, and the Ugly: The Many Faces of Constructivism," *Educational Researcher* 24, no. 7 (1995); Phillips, "On Castigating Constructivists," in Alexander, *Philosophy of Education* 1992, 312-15.

The critique of constructivism we are advancing, here and in future essays, introduces a Deweyan-pragmatic perspective that is ontologically realist and requires, epistemologically, a correspondence theory of truth. It is often thought that Deweyan pragmatism presages, and hence is consistent with and supportive of, various constructivist theses. We intend to disinter and revitalize the Deweyan positions that actually link the "scientific philosopher" to the practices of science.

3. Phillips, "The Good, the Bad, and the Ugly," 5.

4. Ernst von Glasersfeld, "An Introduction to Radical Constructivism," in *The Invented Reality*, ed. Paul Watzlawick (New York: W.W. Norton and Company, 1984), 17-40.

5. "Knowledge," traditionally, being defined as "justified true belief."

6. John Dewey, "Propositions, Warranted Assertibility and Truth" in *Dewey and His Critics*, 265-82. Originally published in the *Journal of Philosophy* 38, no. 7 (27 March 1941).

7. H. Grayson Wheatley, "Constructivist Perspectives on Science and Mathematics Learning," *Science Education* 75, no. 1 (1991): 10, 11.

8. Wheatley, "Constructivist Perspectives on Science and Mathematics Learning," 10.

9. *Ibid.*

10. *Ibid.*, 11.

11. "ICLU...Considers Creationism Lawsuit," *The Defender: Newsletter of the Iowa Civil Liberties Union* 27, no. 1 (Jan-March, 2000).

12. See, for instance, W. Harmon, "The Postmodern Heresy: Consciousness as Causal," in *The Reenchantment of Science*, ed. R. Griffen (Albany: State University of New York Press, 1988), 121.

13. Or, as one prefers, the "universe," or the "cosmos."

14. Von Glasersfeld, "An Introduction to Radical Constructivism," 29-30.

15. Von Glasersfeld is not alone in adopting these "radical" theses; see also: Larochelle and Bednarz; Morf; Confrey; and Fleury, in *Constructivism and Education*, ed. Marie Larochelle, Nadine Bednarz, and Jim Garrison (Cambridge: Cambridge University Press, 1998).

16. Von Glasersfeld, "An Introduction to Radical Constructivism," 23.

17. Ibid., 29.
18. Ibid., 32.
19. Some less-than-radical constructivists may allow that the order *is* “there,” but is inaccessible to human beings, and hence we must still ourselves be creating whatever order we erroneously believe we find.
20. Von Glasersfeld, “An Introduction to Radical Constructivism,” 38.
21. Wheatley, “Constructivist Perspectives on Science and Mathematics Learning,” 12.
22. William Newton-Smith, “Modest Realism,” in *The Ontology of Science*, ed. John Worrell (Dartmouth: Aldershot, 1994), 243.
23. In the non-Deweyan sense.
24. Geoffrey Hellman, “Realist Principles,” in Worrell, *The Ontology of Science*, 229.
25. Murray Gell-Mann, *The Quark and the Jaguar: Adventures in the Simple and the Complex* (W.H. Freeman Company: New York, 1994), 80.
26. Lewis Wolpert, *The Unnatural Nature of Science: Why Science Does Not Make (Common) Sense* (Cambridge: Harvard University Press, 1992), 100-1.
27. Ibid., 100 and 103.
28. Hodson, “Going Beyond Cultural Pluralism: Science Education for Sociopolitical Action,” *Science Education* 83 (1999): 784.