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ABSTRACT

This paper examines the historical roots of critical realism in western thought, highlights the dramatic nature of the shift in thought that the radical constructivists are seeking, and critically considers the relevance of radical constructivism in science teacher education. Radical constructivism is an epistemological philosophy that divorces knowing from any notion that reality is the referent of knowledge. Radical constructivists argue that adopting this view, rather than the realist view, will help teachers improve science instruction. The argument was put forward by Ernst von Glasersfeld at the 1990 annual meeting of the National Association for Research in Science Teaching. However, Glasersfeld's position implies a dramatic shift away from critical realism, which has deep historical roots in western thought and which was critical to the development of modern science. Furthermore, the possible effect of radical constructivism on science teaching must be questioned. Many would argue that there is little reason to think that ontological beliefs are more critical in teacher behavior than social and material factors. Nevertheless, ontological belief is an interesting aspect of culture and could be incorporated into a general discussion of cultural issues during a program of science teacher education. The thorough discussion of ontological issues, however, is probably best left for graduate education.
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EDUCATION RESEARCH WILL NOT PROFIT FROM RADICAL CONSTRUCTIONISM

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Abstract

There are moments when philosophy captures the educator's attention. Such an occasion was the opening night of the 1990 annual meeting of the National Association for Research in Science Teaching. Ernst von Glasersfeld gave a highly stimulating lecture on "radical constructivism." Radical constructivism is an epistemological philosophy that divorces *knowing* from any notion that *reality* is the referent of knowledge. Radical constructivists argue that adopting this view, rather than realist views, will help teachers improve science instruction. This, however, would mean a dramatic shift away from critical realism which has deep historical roots in Western thought, and which arguably was critical for the development of modern science. Furthermore, one must question what effect radical constructivism would actually have on science teaching. Many would argue that there is little reason to think that ontological beliefs are a more critical factor in teacher behavior than social and material factors. Nevertheless, ontological belief is an interesting aspect of culture and could be incorporated into a general discussion of cultural issues during a program of science teacher education. The thorough discussion of ontological issues, however, is probably best left for graduate education.

> The good Dr. Johnson and James Boswell were walking done a London street one day discussing George Berkeley's philosophy of immaterialism. Dr. Johnson, unconvinced by Berkeley's logic, said to Boswell, "I refute it thus!" Upon which he turned and soundly kicked the street curb with his big toe - much to Boswell's amusement!

Along with Boswell, one is amused. Of course, Samuel Johnson's refutation of immaterialism was no philosophical threat to Berkeley. What Johnson did was to present dramatically the wisdom of common folk and everyday, ordinary life. For most people philosophy is an esoteric, arcane discipline with little apparent practical value. Unfortunately, that is not always a wise view. For example, Duschl (1985) argued that for 25 years science curriculum developers ignored concurrent development in the philosophy of science, resulting in impoverished curricula. There are however, moments when philosophy captures the educator's attention. Such an occasion was the opening night of the 1990 annual meeting of the National Association for Research in Science Teaching. Ernst von Glasersfeld gave a highly stimulating lecture on "radical constructivism." Of course, the term *constructivism* is not new to science education researchers. One frequently finds the term in the literature. Good (1991) has recently commented that most science education researchers have boarded the "constructivist express." He asks, "is constructivism the new religion in science education?"

Constructivism refers to a view of learning derived from Piaget's concepts of assimilation and adaptation, a view further developed in Ausubel and Novak's work on meaningful learning. As such, this view of constructivism can be appropriately termed, *pedagogical* constructivism. The gravamen of von Glasersfeld's position, and what is new for many science educators, is the linkage of pedagogical constructivism with radical constructivism. The latter is an epistemological philosophy that divorces *knowing* from any notion that *reality* is the referent of knowledge. And von Glasersfeld does not view this is a recondite philosophy of little practical

import. "[I]t is this *construction* of the individual's subjective reality which ... should be of interest to practitioners and researchers in education and, in particular, to the teachers of science" (1989a, p.122). von Glasersfeld (1989b) emphasizes the critical nature of the linkage between radical constructivism and pedagogical constructivism by asserting that disassociation results, not in pedagogical constructivism, but in *trivial* constructivism. The purpose of this article is first to examine briefly the historical roots of critical realism in Western thought, to highlight the dramatic nature of the shift in thought that the radical constructivists are seeking, and then to critically consider the relevance of radical constructivism in science teacher education.

The Insignificance of Reality

According to von Glasersfeld the philosophy of radical constructivism, "discards the notion that knowledge could or should be a representation of an observer-independent world-in-itself and replaces it with the demand that the conceptual constructs we call knowledge be *viable* in the experiential world of the knowing subject" (1989a, p.122). Interpretations of experience are all that one can know. One accepts the validity of interpretations in so far as they are pragmatically viable. The appeal of this position is that it renders moot an historical paradox in Western philosophy, particularly philosophies of realism.

> Radical Constructivism was conceived as an attempt to circumvent the paradox of traditional epistemology that springs from a perennial assumption that is inextricably knitted into Western philosophy: the assumption that knowledge may be called "true" only if it can be considered a more or less accurate *representation* of a world that exists "in itself", prior to and independent of the knower's experience of it. The paradox arises, because the works of philosophers by and large imply, if not explicitly claim, that they embody a path towards Truth and True representations of the world, yet none of them has been able to provide a feasible test for the accuracy of such representations. (von Glasersfeld, 1989b, p.2)

von Glasersfeld summarizes the radical constructivist position by paraphrasing an early 18th Century philosopher, Giambattista Vico:

> God alone can know the *real* world, because He knows how and of what He has created it. In contrast, the human knower can know only what the human knower has constructed. (1989a, p.123)

To say the least, this is an ironic application of the "God of the gaps" argument. The difference is the claim that knowledge of objective reality, i.e., what God alone possesses, is no longer important. What *is* important are the constructions of knowledge and their judged viability.

That objective knowledge about a real world is unobtainable is, of course, an old charge. Mortimer Adler noted that the question of how ideas can actually represent knowledge of an objective reality underlines all the unresolved "riddles and perplexities of later empiricism" (1974, p.X). However, the failure of realism "to provide a feasible test for the accuracy" of representations is hardly a fatal flaw unless one wishes to accept the position that *all* systems of thought are fatally flawed. All systems of thought are founded on first principles of one sort or another, the title of von Glasersfeld (1989b) notwithstanding. As C.S. Lewis argued, "It is simply no use trying to *see through* first principles ... If you see through everything, then everything is transparent. But a wholly transparent world is an invisible world. To *see through* all things is the same as not to see" (1947, p.91). For the critical realist, the fundamental first principle is that reality is knowable.

Confidence in an objectively knowable reality is "inextricably knitted into Western philosophy" (1989b, p.2) as von Glasersfeld rightly observed In ancient Palestine, Moses turned aside to see a burning bush and to ask "why the bush [was] not burned up" (Exodus 3.3). His view of the world was grounded in a concept of creation which implies order and purpose, and

thus the basis for a knowable reality. Much later, voluntaristic theology of Medieval Europe provided a formal expression of this view and marked a significant European departure from the organismic influences of ancient Greece (Glover, 1984).

"And Yet It Moves"

In Greek rationalism an object was thought to be known by ascertaining its *essence*. Perception may lead to essence. Once the essence of an object is known, however, the properties of the object are rationally deducible from its essence, not established by experience. In contrast, voluntaristic theology, as the name implies, does not imbue objects with essence. Without essence an object can only be known by experience (Foster, 1934, 1935, 1936; also see Powell, 1972). In the Judeo-Christian tradition humans have essence because they are living, sentient beings *begotten* by other living, sentient beings. One can observe the characteristics of the mental, social, and material nature of human beings and from this come to some understanding of what humans are like. However, one person comes to knowledge of another individual through a complex, interactive process colloquially referred to as "getting to know" someone. In contrast, a *created* object such as a chair is known solely by it characteristics. The assurance that one can know anything about a chair is warranted by virtue of the chair having been created with order and purpose. Analogously, the West grew up, so to speak, with the idea that reality having been created can also be known by observation. To state it more directly, creation implies purposeful order. The order and purpose of reality warrant the assumption that experience can lead to objective knowledge. In this, one has the basis for natural law which arguably "was an essential condition for the emergence of modern science in Western Europe"

(Powell, 1972, p.5). Moses turned aside fully expecting that his observations of the burning bush would help him to understand the phenomenon.

It is important to note that the concept of creation, and its reputation as an important concept in the history of Western ideas, has suffered considerable damage as the result of unfortunate 20th Century disputes concerning the teaching of evolution. Historically, the concept of creation has provided the West with an ontological understanding of what the world is really like. At times it has also been used simplistically to provide a mechanistic understanding of how the world came to its present condition. The latter (e.g., *creation science*) has long been discredited. The former remains a powerful aspect of Western thought though its religious foundation has been weakened (Templeton, 1982).

Radical constructivists have a different view. They argue that radical constructivism can be traced to Copernicus which in effect contradicts the above discussion (von Glasersfeld, 1989b, p.3). As evidence, radical constructivists quote Andreas Osiander's preface in the original publication of *De Revolutionibus*. Osiander wrote that the repercussions of Copernicus' work should not be feared because the works of astronomers are not to be regarded as truth, but only efficient calculating devices. Given the revolutionary nature of the shift from geocentrism to heliocentrism, Osiander's caveat was a political necessity. However, in the reading of Copernicus quite a different view is evident:

> Any apparent motion of the firmament is the result, not of the firmament itself moving, but of the Earth's motion. The Earth, together with the material elements lying around it, goes through a complete rotation on its axis each day, while the firmament and highest heaven remain unaltered. (*De Revolutionibus*, quoted in Toulmin & Goodfield, 1961, p.172)

Copernicus was aware that the Ptolemaic system was consistent with numerical data. However, he also believed, "despite everything else, the truth about the Heavens *could* be discovered by rational investigation" (Toulmin & Goodfield, 1961, p.178). Viability of a theory was simply not good enough for Copernicus. Furthermore, there is no reason to think that Galileo accepted Osiander's political position on *De Revolutionibus*. Hodson wrote, "it was precisely because Galileo took a *realist* interpretation of Copernican theory, and set about solving the problems it created, that progress was made" (1982b, p.23). And one final consideration. Galileo's under-the-breath response to a coerced recantation was, "and yet it moves." If Galileo had been a radical constructivist, he never would have gone to trial (see Wallace, 1986).

Dürer Vs Kandinsky

Despite the centrality of objective knowledge in the Western world view, what is called knowledge about the world changes. The realist recognizes that knowledge at any given time approximates reality and that the quest for accuracy is endless. The realist understands that an individual constructs knowledge of reality from sense perceptions which are subject to many influences. The realist is not naive, but critical. Knowledge of reality is not like a photograph, but more like representational art. In a Dürer painting, for example:

> there is little of sensuous beauty; but the rude, stark outlines of life itself, the literal-minded dwelling on the last detail of the imaginative vision, the intense seriousness of the preoccupation with the furniture of practical life, whether in the creased strength of those faces of his merchant friends - "I think the more exact and like a man a picture is the better the work," he said ... (Randall, 1940, p.127)

Representational art and photographs are not easily confused. The vicissitude of knowledge is widely recognized. Nevertheless, the goal is exactitude, albeit elusive.

The radical constructivist having grown tired of the quest to know reality declares reality unimportant. It is only the construction, in and of itself, that is important. To carry further the artistic metaphor, radically constructed knowledge is a form of *modernism* similar to modern art:

> Modernism ... denies the primacy of an outside reality, as given. It seeks either to rearrange that reality, or to retreat to the self's interior, to private experience as the source of its concerns and aesthetic preoccupations ... There is an emphasis on the self as touchstone of understanding and on the activity of the knower rather than the character of the object as the source of knowledge ... Thus one discerns the intentions of modern painting ... to break up ordered space ... to bridge the distance between object and spectator, to "thrust" itself on the viewer and establish itself immediately by impact. (Bell, 1976, p.110,112)

As with a Wassily Kandinsky painting, there is no intention to represent the natural world. The value of the art is in its impact. The value of radically constructed knowledge is in its *viability*. One does not worry that knowledge match reality, only that knowledge allow the useful prediction of experience, its impact. But when it does so predict, what metaphysic does viability reinforce? The eminent physicist Cecil Frank Powell noted, "all our experience of the development of science suggests that there is indeed an order in nature which we can discover..." (1972, p.5). I am inclined to think that viability reinforces the estimation that knowledge is approaching reality, and in fact undermines radical constructivism.

In sum, the argument here is that a knowable, objective reality is a key feature of the historical Western world view, and one that was crucial for the birth and nurture of modern science. In 1991, a radical constructivist will do science because the power of experimental science has been previously established in the years since Galileo. One has cause to doubt that in an earlier age radical constructivism would have motivated the exploration of something that had no known potential. Furthermore, even if one were now to adopt radical constructivism the viability test that it offers may actually undermine the first principles of radical constructivism,

rather then support them. Perhaps one should say, the success of science undermines radical constructivism for all but those who have an *a priori* commitment to radical constructivism. In fact, I would go so far as to say, the real issue at hand is *a priori* commitments to different ontological positions. Westerners have for centuries lived with the difficulties of realism. The question is thus, why would one choose to make an *a priori* commitment to radical constructivism?

Linking Ontology and Pedagogy

The radical constructivist may well respond that whether or not radical constructivism could give birth and nurture to a young science is irrelevant since science is in fact established. They may also cite the increasing attention that philosophers of science have given to subjectivist views of knowledge. These views range from the moderate position taken by Kuhn in *The Structure of Scientific Revolutions* to the extremism of Feyerabend's *Against Method.* More to the point of the above question, however, radical constructivists argue that their position promotes better teaching and thus better learning. To bolster this assertion the radical constructivists point to research such as Clement (1987) and Briscoe et al. (1990).

Pedagogical constructivism rejects the idea that an identity exists between knowledge within and knowledge without. For example, we may agree that at the end of a lesson a student has successfully gained knowledge about plants, but is there an identity between the student's knowledge (knowledge within) and the knowledge the teacher presented in the instructional process (knowledge without)? Pedagogical constructivism says no. Learning is not the relatively simple process of *transplanting* knowledge from the teacher or textbook to the student. Rather, learning is an interpretive process. Learning occurs when a person under the influence of

experience (in this example teaching) constructs personal knowledge that makes the experience meaningful. In the tradition of pragmatism, this learning is subsequently validated or invalidated by further experience. This view of learning suggests the use of instructional procedures that foster higher order cognitive thinking as exemplified in Clement (1987).

The unique position of radical constructivists is that ontology and pedagogy are vitally linked. Radical constructivists maintain that constructivist teaching will increase with teacher acceptance of radical constructivist ontology. Figure #1 is a graphic portrayal of the radical-pedagogical constructivist linkage. The four spheres represent ontology, epistemology, psychology, and pedagogy. The radical constructivists discount the first sphere as unknowable. They collapse or link the second and third spheres with the equation, *knowledge=knowing*; and they assert that this equation logically leads to a particular view of pedagogy. The linkage argument is: If I understand that reality is inherently unknowable, then I also will understand that what I know is a construction and the only meaningful reality. It is only logical that methods of instruction should facilitate the personal construction of meaning and stress higher order cognition. Radical constructivists also maintain that the alternative to this view is *naive realism*: If I understand that the world is real and knowable, then I also will understand that knowledge corresponds to reality. It is only logical then that instruction be the *transplanting* of knowledge to the learner, i.e., rote learning.

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Insert Figure 1
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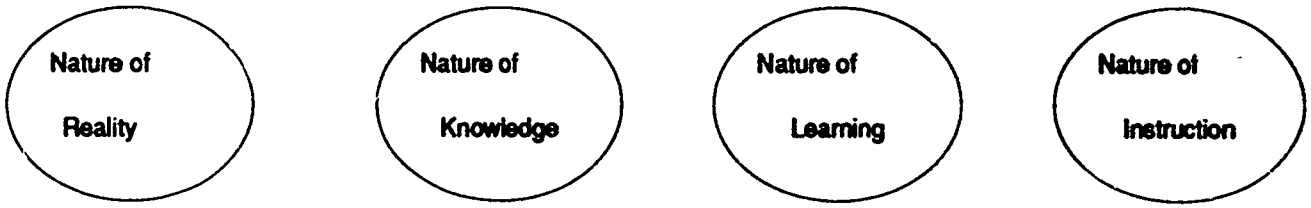
Based on this argument, radical constructivists maintain that teacher education should work at persuading teachers to adopt radical constructivist ontology (von Glasersfeld, 1989a).

Figure #1

Ontology to Pedagogy



The realist teacher who asks students to memorize facts because the facts are objective, once converted to radical constructivism will more readily adopt pedagogical constructivist teaching strategies (Briscoe et al., 1990).

Wishful Thinking

Does this dramatic connection between ontology and pedagogy really exist? Many science educators have ample reason to think that any teacher who makes extensive use of memorization will do so independent of ontological beliefs. Such a teacher, once converted to radical constructivism, would have the students memorize *constructed* facts. After all, what is there to keep this teacher from arguing that students need to know these facts because these facts have been shown to be *viable*? Or worse, what is to keep the teacher from using memorization because teaching for memorization is easiest or the least time consuming way to teach, regardless of ontology? The reasons that teachers have for using memorization are countless, and they rarely have to do with philosophical issues.

Consider a different type of example. Virtually all science educators including classroom teachers will say, when asked, that science should be taught "hands on." Nevertheless, one of the most consistent criticisms of science teaching is that it is not taught hands on. And the reasons are rarely philosophic. They have more to do with facilities, equipment, tolerance for disorder and noise, etc. Certainly beliefs play a significant role in behavior. It is nonetheless very difficult to predict accurately specific behavior when in possession of only limited knowledge about beliefs. It is even more difficult when little or no consideration is given to the influence of the social and material environments. Research may yet establish a significant link between ontology and pedagogy, but at this point the research in this area does not allow for a

wide range of important beliefs held by teachers, nor for the external influences upon teachers. The research that looks at student and teacher beliefs is indeed interesting. To achieve greater validity, however, research on teacher education and teacher change as influenced by ontology and epistemology needs to broaden its scope.

The emphasis on radical constructivism raises concerns relative to research and to teacher education. The argument for adopting radical constructivism has a meager research base especially when one considers the dramatic nature of the change of view point that is being advocated. At that, the research invoked is narrowly conceived and does not include other significant influences on teaching practice. At this point, the danger of an ontological focus in research is that it will obstruct the researcher's vision of other factors influencing science teacher behavior. In defence of researchers such as Clement (1987) it should be noted that the research cited by radical constructivists is often pedagogical constructivist research done independent of ontological considerations. The researcher needs to see ontological views as a part of a nexus of beliefs, including beliefs about self, students, learning, and the nature and purpose of education.

Implications for Science Teacher Education

It is clear that radical constructivists advise making radical constructivism an important part of science teacher education (von Glasersfeld, 1989a&b). Many will find it equally clear that the lack of a solid research foundation attenuates the argument for promoting radical constructivism in the education of teachers. Even if the argument were stronger, one must remember that time for the preparation of classroom science teachers is a limited commodity to be used wisely. How much time can the science education professor afford to spend on issues

of ontology? Science education professors generally agree on the importance of the philosophy of science in the preparation of teachers (Hodson, 1985), but as things are, philosophy is one of many important topics competing for scarce time. It is hard to conceive of a justification for the amount of additional time that would be required to do justice to the complexities of ontological arguments. The thorough discussion of ontological issues is probably best left for graduate education.

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Insert Figure 2
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This is not to imply that issues of ontology and related issues of epistemology are unimportant. Actually, these issues have a great deal to do with culture, a topic of rising interest in science education. Currently, classroom discussions about culture usually focus on students rather than teachers. It can be argued though, that one focus is as important as the other. Figure 2 is an illustration that provides a context for raising the issue of teacher culture, including metaphysical issues. Blocks A and B represent cultural issues while block C represents environment. View of persons refers first to culturally based understandings of self and others, in this case the teacher and students respectively. Metaphysics refers to culturally based understandings of what the world is like. School environment is where the first two meet, and together they bear on instruction or teacher behavior. For introductory purposes a professor may wish to use this illustration along with readings for each block. For example, with regard to view of persons one might assign Contreras & Lee (1990); for school environment, McLaughlin et al. (1986); and for metaphysics, Glasersfeld (1989a) and Hodson (1982a&b). Without taking too much time, the illustration accompanied by appropriate readings will provoke a discussion that

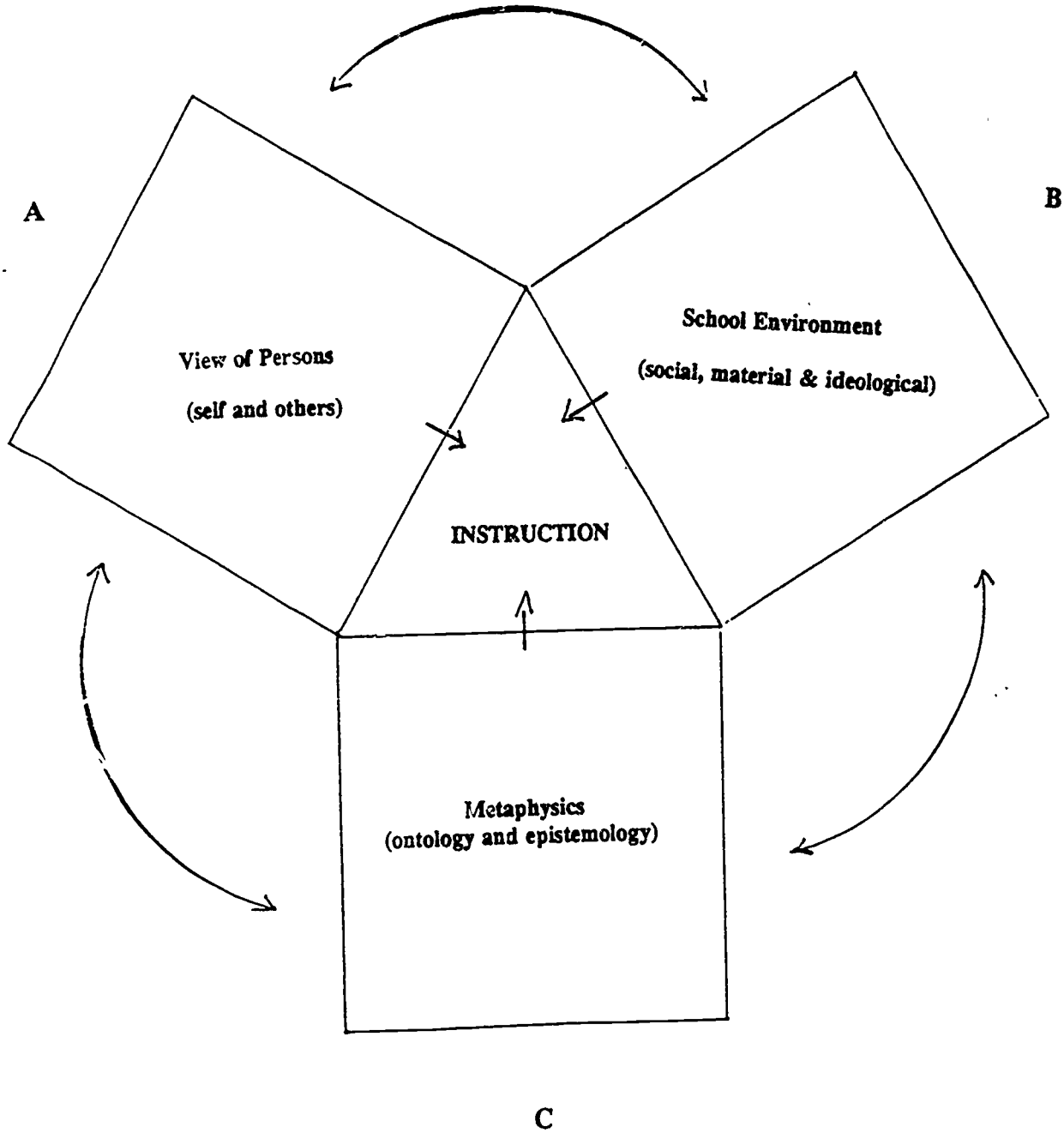

Fig. 2. Factors Bearing on Teacher Behavior

focuses attention on several ways in which culture can influence teacher behavior. This strikes me as both an appropriate and valuable activity in science teacher education. If radical constructivism is to have a greater part in science teacher education than this, concerned researchers and theorists must first improve their case.

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