Mediating Meaning in the Social World of the Science Classroom

Daniel P. Shepardson
Purdue University, USA

Susan Britsch
Purdue University, USA

Abstract

This article examines science teaching and learning by drawing on Vygotsky's sociocultural theory of learning and development as well as a social semiotic perspective. The latter perspective includes in semiosis the science equipment, science phenomena, teacher and student actions, talk and writing that are involved in science teaching and learning. In much the same way a Vygotskian perspective views science phenomena and equipment as technical tools that mediate both teacher and student meaning making, as do the symbolic products created by the teacher and the students. We suggest an inclusive view in which all are seen as active mediators in science teaching and learning

Correspondence concerning this article should be addressed to: Department of Curriculum and Instruction, Purdue University, 100 North University Street, West Lafayette, IN 47907-2098; dshep@purdue.edu; sbritsch@purdue.edu

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This article suggests a sociocultural/social semiotic framework that may undergird science teaching and learning. This draws on Vygotsky's theory of learning and development and on social semiotic theory. Vygotsky's sociocultural theory draws on social interaction and the psychological processes in meaning making. He unified speech and action as "*one and the same complex psychological function*, directed toward the solution of the problem at hand" (1978, p. 25). While speech initially follows action, it later takes on a proactive "planning function" and such "vital importance that, if not permitted to use it, young children cannot accomplish the given task" (Vygotsky, 1978, p. 26). On the other hand, social semiotics views "all semiotic acts and processes as social acts and processes" (Hodge & Kress, 1988, p. 122). Here, as in Vygotsky's work, both micro and macro environments mediate the actions of the participants in a context and, thus, their meaning making. Both views characterize language in terms of semiotic, or sign-mediated meaning making, emphasizing its grounding in context and relationship (Gergen, 1995). We argue here for an explicit integration of social semiotics with Vygotskian theory. This would include in semiosis (a) the science equipment, (b) the +-science phenomena, (c) teacher and student actions, and (d) talk and writing that are

involved in science teaching and learning. A social semiotic view would see these as resources (or modes) that represent meaning in social context (Kress, Jewitt, Ogborn & Tsatsarelis, 2001). In much the same way a Vygotskian perspective views science phenomena and equipment as technical tools that mediate both teacher and student meaning making, as do the psychological tools (i.e., symbolic products) created by the teacher and the students. Thus, we suggest an inclusive view in which all are seen as active mediators in science teaching and learning when viewed in terms of both Vygotskian theory and social semiotics.

We first review aspects of Vygotsky's sociocultural theory in terms of internalization as related to concept development. We then explore the socio-interactional nature of externalization, followed by a discussion of psychological and technical tools as mediators in science teaching and learning. We conclude the Vygotskian examination by addressing the Zone of Proximal Development as a site of mediation (Vygotsky, 1978). Next, we address the social semiotic nature of mediation as activity (Hodge & Kress, 1988; Kress & VanLeeuwen, 2001), recasting a selection of psychological and technical tools as verbal and extra-verbal semiotic resources in science classrooms. We conclude by presenting a model for science teaching and learning that integrates Vygotskian theory with social semiotics... Our purpose is thus not to create an opposition but to foreground the overlap between these perspectives.

Vygotsky's View of Internalization: The Development of Concepts

Vygotsky's view (1986) of conceptual development includes two categories of concepts: spontaneous (i.e., everyday) concepts and scientific (i.e., non-spontaneous) concepts. Essentially, everyday concepts are formed through interactions and experiences outside formal school settings while scientific concepts are formed through interactions and experiences within formal school settings. Scientific concepts originate in the structured and specialized activity of classroom instruction and are organized by formal, hierarchical, logical, and decontextualized structures. Everyday concepts emerge from the child's own reflection on experience; they are experiential, unsystematic, and contextual. Thus, concept reflects context.

Everyday concepts center on objects or phenomena in immediate experience; they are based on the physical appearance and characteristics of objects or phenomena encountered in everyday experiences and, thus, are perceptually bound (Vygotsky, 1986). In contrast, scientific concepts are not directly tied to phenomena or objects and are defined in a generalized fashion; that is, they are defined in relationship to other concepts. Scientific concepts relate to phenomena through previously established concepts (either scientific or everyday). Scientific concepts are formed through the "functional use of the word, or any other sign, as a means of focusing one's attention, selecting distinctive features and analyzing and synthesizing them, . . . direct[ing] our mental operations, control[ling] their course, and channel[ing] them toward the solution of the problem confronting us" (Vygotsky, 1986, pp. 106-107). The formation of scientific concepts,

then, involves the use of words as psychological tools that function for their users as mediators for either problem solving, product creation, or task completion.

While children's everyday concepts move upward from phenomena (as objects in nature) to generalization, scientific concepts move downward toward the phenomena (Vygotsky, 1986). Thus, the scientific concept can change the everyday concept even as the everyday concept changes the scientific one, transforming the conceptual system itself (Vygotsky, 1986). Children's everyday concepts, therefore, shape the formation of the meanings children make on the intrapsychological plane:

> The dependence of scientific concepts on spontaneous concepts and their influence on them stems from the unique relationship that exists between the scientific concept and its object . . . this relationship is characterized by the fact that it is mediated through other concepts. Consequently, in its relationship to the object, the scientific concept includes a relationship to another concept, that is, it includes the most basic element of a concept system (Vygotsky, 1987, p. 192).

To learn science, children must be introduced to scientific concepts as a way of seeing and talking about phenomena. This engages children in activity that relates their everyday concepts to the scientific concept: "Analysis of reality with the help of concepts precedes analysis of the concepts themselves" (Vygotsky, 1986, p. 141). Concepts first form as "concept-in-itself" (sign-object relation) and as "concept-for-others" (socially) then as "concept-for-myself" (individual, intrapsychological) (Vygotsky, 1986, p. 124). Both objects and phenomena provide reference points from which conceptual systems may be built. "The child's and the adult's [teacher's] meaning of a word often 'meet,' as it were, in the same concrete object" (Vygotsky, 1986, p. 111). In this way, the scientific meanings children make depend upon the context of the experience. This suggests that in order for children to construct rich knowledge structures (conceptual systems) they would need to experience scientific concepts through multiple objects in multiple contexts. The learning of scientific concepts, however, should not be viewed as the end point of schooling, but as the appropriation and development of a set of tools that can be used to solve problems of significance to the student (Wells, as cited in Daniels, 2001).

Further, on a Vygotskian view, children's understanding of natural or scientific phenomena exists within a socio-interactional frame where language acts as an essential mediator of social and individual functioning (Kozulin, 1990; Shepardson, 1999). Language, as Halliday put it, is "the essential condition of knowing, the process by which experience becomes knowledge" (Halliday, 1993, p. 94). Scientific concepts do not exist in nature *a priori*, but are dialogically constructed in social and individual psychological activity. This means that both scientific concepts and activity occur on two planes--first on the interpsychological plane and then on the intrapsychological plane. As Vygotsky explained it:

> Any function in the child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane. First it appears between people as an interpsychological category, and then within the child as an intrapsychological category (Vygotsky, 1981, p. 163).

The formation of the intrapsychological plane, however, does not constitute a simple replication of the external, social plane but instead constitutes a transformation or restructuring by means of external signs, including primarily words, that serve as the mechanism for the formation of the intrapsychological plane (Wertsch, 1985). For Vygotsky oral words as signs at first stand as direct symbols for "real entities and relations" (Vygotsky, 1978, p. 106). Written language then designates the "sounds and words of spoken language" as a second order of symbolism (Vygotsky, 1978, p. 106). On this view, linguistic signs first appear within interpersonal communication between human mediators, gradually becoming internal psychological tools for the child (Kozulin, 1990). For Vygotsky, however, both gesture and drawing work as visual signs in development. The gesture as sign predates written language because it is gesture that first "assigns the function of the sign to the object and gives it meaning" (1978, p 108). Gesture also links to children's drawing, which Vygotsky viewed as a kind of gesture that has been "fixed" on paper (1978, p.107). Through drawing as "indicatory gesture" children may depict concepts that are complex or abstract (Vygotsky, 1978, p. 108). These are characterized as general qualities (e.g., a horizontal hand motion symbolizing "earth") (Vygotsky, 1978, p. 108). Gestures, too, "assign the function of the sign to objects" (e.g., a stick as a riding horse) which then substitute for other concepts in a symbolic way (e.g., a pencil for a person) (Vygotsky, 1978, p. 109). At the pinnacle of this development, Vygotsky viewed written language, not in terms of mechanics, but as a sign system that "heralds a critical turning point in the entire cultural development of the child" (1978, p. 106). As objects, however, material (or technical) tools differ from graphic, gestural or linguistic signs in that they are externally-oriented mediators used simply to accomplish goals (Lee, 1985). They are not seen as "reversible;" that is, they "do not feed back upon or control their users" (Lee, 1985, p. 76).

Thus, through interpsychological activity, children appropriate or internalize signs as psychological tools. These serve as a lens for seeing, talking, acting, and thinking about scientific concepts, phenomena, and activity. Initially, then, activity gives meaning to signs such as words while later signs give meaning to the activity. From this perspective, children learn science by engaging in social activity, participating in scientific discourse that leads to the formation or restructuring of the intrapsychological plane. Scientific concepts come into existence first between the teacher (more knowledgeable individual) and the child through social activity. The child then internalizes these as individual activity.

Externalization: Linking the Social and Individual

While work that is based in Vygotskian theory has often focused on "the movement from social to individual" meaning making (i.e., internalization), less attention has been paid to the movement from the individual to the social (i.e., externalization) (Daniels, 2001, p. 44). Externalization involves the creation of artifacts or products (Engeström & Miettinen, 1999; Prior, 1997) as "the production of cultural artefacts through collaborative activity" that may lead to "enhanced self-reflection and

metacognitive development" (Daniels, 2001, p. 45). Focusing on both internalization as well as externalization thus expands the dialogic process:

social → individual (internalization) → social (externalization)

This casts both child and teacher as active agents in teaching and learning (Daniels, 2001) as they collaboratively create products (artifacts) that have the potential, not simply to represent, but also to transform each other's meanings. On this view, collaborative activity can mediate social as well as intrapersonal activity. This means that not only psychological tools such as language and drawing, but also technical (material) tools such as materials and equipment can be viewed as cultural artifacts of the educational process itself, of the science classroom and of both teacher and student understandings about the nature of science and of science content. Externalization may be reflected in students' use of material tools (e.g., science equipment) in specialized ways and in the use of the specialized language of science, a psychological tool that provides a privileged way of talking (Wertsch, 1991) and writing. Clearly, different types of science activity result in the production of different types of artifacts that in turn promote different ways of knowing and meaning making.

Psychological and Technical Tools as Science Mediators

Mediation is central to Vygotsky's theory of development. The formation of the child's intrapsychological plane is mediated by what Vygotsky (1986) termed "tools." Tools are either of a technical nature or of a psychological origin; they are objects used to accomplish an activity. Both are "artifacts or artificial adaptations" (Vygotsky, 1978, p.54). Although technical tools mediate the physical environment, signs (psychological tools) mediate psychological functions; they are social devises for making meaning. The use of technical and psychological tools is dependent upon the context and the child's level of development (Daniels, 2001).

Psychological tools change nothing in the phenomenon, they are an internal, psychological activity that influences behavior, either another's or one's own, and so they are sociocultural products that therefore do not exist in the phenomenon. Psychological tools are neither invented nor discovered by individuals independent of social interactions; they are "appropriated." Individuals gain access to psychological tools by being a part of a sociocultural milieu. Psychological tools at first help children "shape an activity into a structure. However, that structure may be changed or reshaped when children learn to use language in ways that allow them to go beyond previous experiences when planning future action" (Vygotsky, 1978, p. 28). Vygotsky (1986), then, viewed language as a psychological tool that expresses thought:

> [T]hought does not express itself in words, but rather realizes itself in them. . . . thought is mediated by signs externally, but it also is mediated internally, this time by word meanings. . . . Thought must first pass through meanings and only then through words (pp. 251-252).

Thus, to learn science children appropriate psychological tools as a way of: (a) seeing phenomena, (b) talking about phenomena (engaging in scientific discourse), (c) guiding and structuring activity, and (d) thinking about phenomena (Shepardson, 1999). Psychological tools thus work as "a means used for social purposes, a means of influencing others and only later becomes a means of influencing oneself" (Vygotsky, 1981, p. 157).

> [T]he word intrudes into the child's perception, singling out separate elements overcoming the natural structure of the sensory field and, as it were, forming new (artificially introduced and mobile) structural centers. Speech does not merely accompany the child's perception, from the very first it begins to take an active part in it: the child begins to perceive the world not only through its eyes, but also through its speech (Vygotsky & Luria, 1994, p. 125).

Vygotsky (1986) viewed language as the interpsychological means by which teachers mediate children's psychological functions, as well as the formation or re-formation of the child's intrapsychological structure. Language does not simply facilitate activity, but also shapes and defines it (Wertsch, 1990). As Vygotsky explained, language:

> . . . does not merely accompany the child's activity; it serves mental orientation, conscious understanding; it helps in overcoming difficulties; it is speech for oneself, intimately and usefully connected with the child's thinking (Vygotsky, 1986, pp. 228).

Although linguistic signs work as key psychological tools that mediate the meanings students make, children also mediate their science activity through drawings and other visual images, such as graphic organizers, graphs and data tables. These also work as psychological tools that not only organize but also transform one's own and others' actions (Wertsch & Toma, 1995). These Vygotsky views as psychological tools or signs that are reversible.

When children encounter new, unfamiliar situations or phenomena, language is often communicative (Wertsch & Stone, 1985). On a Vygotskian view, it is through social interaction with teacher and peers that children appropriate language-as-speech, as a psychological tool for thought.

> Originally, for a child, speech represents a means of communication between people, it manifests itself as a social function, in its social role. But gradually a child learns how to use speech to serve himself, his internal processes. Now speech becomes not just a means of communication with other people, but also a means for the child's own inner thinking processes (Vygotsky, 1994, p.353).

Although the interpretation of Vygotskian theory may seem to emphasize language as a mediational tool, other mediational tools also exist in the science classroom. We suggest here that the material tools that teachers and children use and create in collaborative, or reciprocal, teaching and learning can also serve as mediators as a subcategory of artifacts (Cole, 1996) that:

> …bears a certain significance which it possesses, not by virtue of its physical nature, but because it has been produced for a certain use and incorporated into a system of human ends and purposes. The object thus confronts us as an embodiment of meaning, placed and sustained in it by 'aimed-oriented' human activity (Bakhurst, 1995, p. 160).

For example, the materials and equipment created by students (such as models) also serve as mediational tools, as do psychological tools. Like language, material tools embody meanings that are grounded in the social and cultural setting of the classroom and in the larger educational process itself. Although technical tools are directed at objects and phenomena, and do not exist separate from individuals, they do allow us to change and see objects and phenomena in different ways. While technical tools are phenomena-oriented as means for physically acting on phenomena, completing a task, they also provide individuals with access to different perspectives of phenomena by permitting the observation of different physical characteristics and by permitting changes in the appearance of that which is observed. Technical tools enable children to learn science by changing, extending, or enhancing their sensory experiences. This enables children to see phenomena from a different perspective or point of reference (Shepardson, 1999). Children may then create not only graphic or written products (as psychological tools) but also artifacts such as models that represent a point of view and that also shape their meaning making.

Both technical and psychological tools thus mediate children's interactions in classroom science interactions (Cole & Engeström, 1993). Technical tools give us some level of control over phenomena; psychological tools give us some level of control over our own thinking, acting, talking, and seeing. Psychological tools also give us some level of control over others' thinking, acting, talking, and perhaps their way of seeing. While technical tools provide children with access to phenomena from different perspectives, we suggest that it is through both technical and psychological tools that children come to see the phenomena from the different perspectives (Shepardson, 1999).

In essence, meaning making results from an interaction between psychological and technical tools, as well as other human beings (agents) in the context. In science learning, technical tools such as microscopes, thermometers, and magnifying glasses (to name just a few) provide children with access to phenomena from different perspectives; however, it is only through the psychological tools (including both writing and drawing) that children come to see the phenomena differently. Learning science involves shifting perspectives, learning to see the situation from a different point of reference. For example, in a first grade classroom where children were learning about caterpillars and butterflies, the children did not create the concept of "spines" on caterpillars until hand lenses permitted close examination revealing details that had not previously be seen. Thus, both psychological and technical tools that are appropriated through social interaction provide the access to a new frame of reference. We extend this view in the next section by applying a social semiotic perspective to science teaching and learning.

The Zone of Proximal Development

As previously noted, on a Vygotskian view, children learn science through social interaction with a more knowledgeable individual. Here, psychological tools (such as words) mediate the child's meaning making, first as a way of seeing and acting and then as a way of talking and thinking about scientific phenomena (Shepardson, 1997). Although the social environment is an important determinant in the formation of the intrapsychological plane, this does not mean that the physical environment ceases to contribute to the formation and functioning of the intrapsychological plane (Wertsch & Stone, 1985). For Vygotsky, the essential feature of the Zone of Proximal Development (ZPD) was "the interdependence of the process of child development and the socially provided tools of that development" (Valsiner, 1987, p. 64). The difference between the child's actual developmental level and the level of potential development defines the zone of proximal development (Vygotsky, 1978). The actual developmental level reflects what the child can do alone, whereas the level of proximal development reflects what the child can do with assistance from an adult or more capable peer. Science learning takes place when instruction falls within the ZPD. Science experiences that exceed or overshoot the ZPD will be overly difficult for children and thus they will fail to learn science.

> …an essential feature of learning is that it creates the zone of proximal development; that is, learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers. Once these processes are internalized, they become part of the child's independent developmental achievement (Vygotsky, 1978, p. 90).

Vygotsky, then, viewed instruction and assessment as providing support to individuals through the direct or indirect presence of others. The ZPD emphasizes teaching and assessment that focus on the potential of the learner not on a predetermined level of understanding or performance. Teaching involves children as active, collaborative, participants in socially negotiating meaning and activity, as well as taking control of their learning (Daniels, 2001). Furthermore, the ZPD may be established by structuring or organizing the child's environment in a particular way (Valsiner, 1987) or based on the phenomena, materials, and objects available for the child's use.

For Moll (1990) the key elements of the ZPD are: (a) social activity and cultural practice as a source of thinking, (b) mediation in human psychological functioning, (c) that pedagogy is central to development, and (d) the inseparability of the individual from the social. When applied to educational practice, these elements suggest that teaching and learning reside in socially created settings. The ZPD emphasizes not the transference of skills, words, or knowledge, but the collaborative use of mediational tools. Both teacher and children engage in exploratory talk and activity that assist children in the appropriation of skills, words, and knowledge as tools for meaning making (Moll, 1990). Thus, children carry out collaborative activity within a specific social (discourse) environment, an environment that is mutually and actively created by both the teacher and the children (Moll & Whitmore, 1993).

A Social Semiotic View of Mediation

From a social semiotic perspective, language-as-speech functions as but one mediator that individuals use to act and shape their actions as well as those of others in a particular situation or context. Social semiotics does not view language *a priori* as the central mediator at work in a given discourse (Kress & VanLeeuwen, 2001). While Vygotsky may be seen to award some primacy to the role of language, and to written language in particular (Vygotsky, 1978), he actually defines as mediators visual representations such as works of art, diagrams, maps, and mechanical drawings (Daniels, 2001) as well as gestures and objects (Vygotsky, 1978). This actually represents a highly multimodal view of mediation that resonates with social semiotic theory. In addition, Vygotsky differentiated tools as externally-oriented mediators from signs as internally-oriented and reversible mediators. From a social semiotic perspective, however, while children may recruit words as a means of mediating an interaction, they may also recruit visual representations (or elements of them) as well as gestures, actions, and sounds apart from language (Kress et al., 2001). All function as mediational tools that can be used by both teacher and student to make meaning, to represent meaning, and to express meaning in specific social contexts (Kress et al., 2001). Because a mediational means that is put to use by an individual in a particular way may serve to accomplish a task that shapes a situation in some way, social semiotics takes visual communication, gesture, and action as "interlocking semiotic systems" (Kress et al., 2001, p. 44). Objects, too, mediate social interactions (Hodge & Kress, 1988). In terms of science teaching and learning, this means that materials and equipment interlock with other verbal and extra-verbal semiotic resources to signify transformative concepts.

To illustrate, we consider a science experience in which children use substances such as gravel, pebbles, silt and sand to make mixtures (in vials) and separations (using sieves). A Vygotskian approach would distinguish the substances, vials and sieves as technical tools that the children used to accomplish the tasks of making mixtures and separating them. The drawings and writing that the children entered in their science journals to characterize their own definitions of the processes of mixing and separating would be classified as psychological tools that symbolize the scientific concepts developed within the zone of proximal development with the teacher (and possibly with peers). We suggest that, on this view, science phenomena as objects in nature (e.g., gravel, pebbles) may function as technical as well as psychological tools.

On a social semiotic view, however, the mixing/separating task would at the very least involve as semiotic resources the following modes: (a) texture (of the substances, the sieve, and the vial), (b) shape, (c) color, (d) child (and teacher) gesture, (e) language-as-speech by teacher and child, (f) language-as-writing by teacher and child, and (g) visual image. Certain of these elements, or resources, may be foregrounded or backgrounded for different participants as the interaction proceeds. This continuous alternation of figure with ground advances the structure of the interaction. Foregrounding and backgrounding of modes thus read as shifts in serviceability as determined by the purpose and structure of the discourse (Britsch, 2005). As interlocking resources for

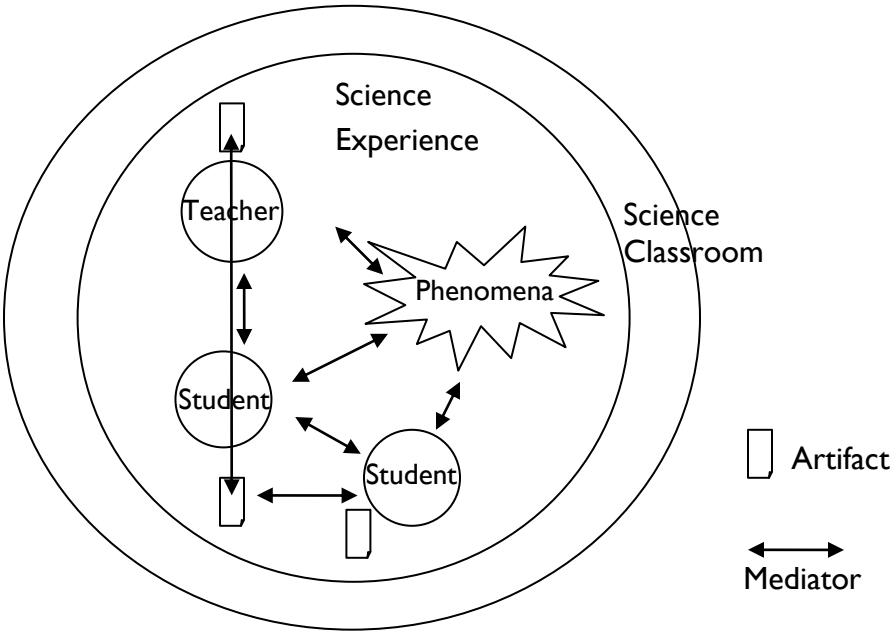
making signs, the multiple modes that mediate a discourse allow students to "modify the situation '…as part of the process of responding to it' (Cole & Scribner, 1978, p. 14).

While we suggest that a social semiotic view includes in this zone the use of technical tools operating as signs that allow learners to see phenomena differently, not all objects (i.e., science materials and apparatus) function as resources for making sense of science phenomena. Not all materials, however, influence how children see a given phenomenon; some materials may, in fact, simply enable children to complete a physical task. By the same token, not all linguistic signs mediate the meanings that students make; for example, the repetition of decontextualized science facts (as opposed to interactional engagement in scientific literacy) (Maienschein, 1998) may do little to modify the way in which students see science phenomena. If, on the other hand, students use materials to create a model of the deposition of earth materials, the model itself may function as a tool to shape student understanding in interaction with previous concepts (either scientific or spontaneous). Likewise, on a Vygotskian view, the substances and equipment in the mixture/separation experience above would simply enable students to accomplish the task of duplicating the mixing and separating processes. If, on the other hand, these materials are viewed as semiotic resources, they become integral to the realization of signs that are both social and conceptual in nature. On this view, materials as used by both student and teacher function within contexts where they may "express and negotiate linkages of power and knowledge" (Hodge & Kress, 1988, p. 242). Because the materials themselves help to delineate the meaning of students' roles as science learners, the importance of viewing science as social act is foregrounded in a social semiotic view.

Mediating Meaning in the Social World of the Science Classroom

The theoretical frameworks presented above provide the grounding for a model of science teaching and learning that emphasizes mediation in social and individual processes within the context of science activity. This model defines individuals (teacher and children), social interaction, instructional products or artifacts, and both technical as well as psychological tools as key mediational tools in the teaching and learning of science. Furthermore, it acknowledges the role of phenomena and evidence derived from science activity as mediators of meaning. These mediational tools provide both teacher and child with the means for internalizing and externalizing meaning; they mediate both teacher and child activity and actions. These mediational tools are embedded within activity that shapes their use and meaning and that gives them standing or authority. They are cultural artifacts of education and science, of the classroom, and of the science activity itself as situated in the social world of the science classroom. The visualization of this model shown in Figure 1 assumes both social and metacognitive parity between teachers and students within contexts of *reciprocal* teaching and learning. This turns the Zone of Proximal Development on its head and makes its dialogic process a bidirectional one.

Figure 1. The Social World of the Science Classroom



Returning to a sociocultural perspective, activity theory places organized activity and the surrounding social conditions at the heart of mediation (Daniels, 2001). This activity not only mediates individuals, but also modifies the environment (Engeström, 1999). It is multi-voiced in that the division of labor results in participants holding different positions, standings, and authority within science activities; for these reasons, participants' different perspectives, understandings, and histories are voiced during the activity (Engeström, cited in Daniels, 2001). This means that both teachers and students are "empowered as well as constrained in specific ways by the mediational means of a sociocultural setting" (Wertsch & Bivens, 1992, pp. 41-42). Different mediators can focus children's attention on the physical characteristics of phenomena and objects, or on the sequence or patterns in events. As a result, both teachers and children can provide *each other* with deliberate ways of attending to the situation at hand by linking psychological tools to a phenomenon, object, or event. When situated within the internalization-externalization dialogue, this means that teachers' instructional artifacts can mediate students' actions and meaning making even as students' actions, meanings, and products can mediate teacher understandings and self-reflections. The students' products, like the teacher's, are cultural artifacts; in other words, they are externalizations that reflect the culture of the educational process, of the science classroom, and of the specific science activity. This view depends, of course, upon teacher metacognitions that recognize a student product as an interface that requires reflection and response, and not simply correction or remediation. By the same token, teacher externalizations of thought and understanding can be subject to student-mediated transformation within social activity. Our suggestion is that classroom practice should create an ongoing dialogue between Vygotsky's sociocultural theory and social semiotic theory. Such a dialogue would enact learning as much more than the simple reproduction of knowledge,

prioritizing only selected modes as mediators. On our view, both teaching and learning would be dialectically cast as transformative of each other.

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