HUMAN CONSTRUCTIVISM: A UNIFICATION OF PSYCHOLOGICAL AND EPISTEMOLOGICAL PHENOMENA IN MEANING MAKING

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Ausubel's (1963, 1968, 1978) assimilation theory of learning is used to describe the process by which humans engage in meaningful learning. High levels of meaningful learning are characterized as underlying the process of new knowledge construction. Concept maps and Vee diagrams are employed to illustrate aspects of assimilation theory, foundational constructivist epistemological ideas, and tools that can facilitate meaningful learning and knowledge construction. The central thesis is that the process of meaningful learning, as understood through assimilation theory, is fundamental to both the psychological process of cognitive development of individuals and the epistemological process of new knowledge construction.

THESIS

There is a belief shared by most psychologists who study human learning, that from birth to senescence or death, individuals construct and reconstruct the meaning of events and objects they observe. It is an ongoing process, and a distinctly human process. The genetic makeup of every normal human being confers on him or her this extraordinary capacity to see regularities in the events or objects he or she observes and, by age 2 or 3, to use symbols to represent these regularities. No other animal species has anything close to the capacity of *Homo sapiens* to achieve this feat, although some other mammals may also use signals or symbols to code experiences and to communicate ideas about the world around them (Flaherty, 1985). It is also evident that each person constructs idiosyncratic meanings for the regularities he or she observes, because every person has, at least in some respects, a unique sequence of experiences from birth to death. It is this unique sequence of experiences, combined also with a unique genetic makeup (except for identical twins) that leads to the personal meanings each individual constructs. This reality has been

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recognized by great thinkers for at least the last two millennia, but it is only relatively recently that scholars have developed methods and tools for the characterization of personal meanings. Foremost among these tools have been Piaget's (1926) clinical interview; Kelly's (1955) repertory grid for eliciting personal constructs; and, more recently, other tools for the representation of ideas or meanings, two of which are described in this article.

My thesis is simple. It is my view that the psychological processes by which an individual constructs his or her own new meanings are essentially the same as the epistemological processes by which new knowledge is constructed by the professionals in a discipline (Schwab, 1964; Toulmin, 1972). Thus, I hold that a better understanding of the individual's acquisition and organization of knowledge leads to an understanding of the structure of the knowledge constructed by scholars in a discipline. In both cases, knowledge construction is a complex product of the human capacity to build meaning, cultural context, and evolutionary changes in relevant knowledge structures and tools for acquiring new knowledge. In this article, I describe briefly two tools we have developed at Cornell University that are proving to be powerful for characterizing both disciplinary and individual knowledge structures and also for augmenting the construction of new knowledge by individuals and by scholars in disciplines. We call these tools *concept maps* and *Vee diagrams*. These tools show promise for both improving instruction and empowering individuals to learn more effectively (Novak, 1990a; Novak & Gowin, 1984).

CONSTRUCTIVISM

There is much discussion about constructivism in psychology, philosophy, and education today. In each of these fields, scholars recognize the fact that human beings are not born with preformed concepts and concept meanings, but rather these meanings must be constructed over time. Older philosophical views held that old ideas interfere with the "objective" study of phenomena and that new knowledge is discovered best when we observe the world carefully, unfettered by previous ideas or beliefs (Bacon, 1620/1952; Pearson, 1900). These older views held that from careful observations and application of logic, we could discover universal truths about nature. These epistemological ideas have been variously characterized as positivism, logical positivism, and empiricism. They stand in contrast to more contemporary epistemological ideas such as realism,

which maintains that there is a definite, knowable "reality out there" and humans strive ever more closely to know it (Boyd, 1973; Miller, 1987). Constructivist or evolutionary (Toulmin, 1972) ideas of epistemology hold that knowledge is a construction based on previous knowledge and constantly evolving over time. Radical constructivism, as described by von Glasersfeld (1984), maintains that there surely is a reality "out there," but we shall never know when we are moving closer or further away from describing that reality as we construct new schemes to explain how the world works. The history of the "hard" sciences provides many examples to support radical constructivism, and theories in the social sciences show even greater mutability.

Von Glasersfeld (1984) distinguished between what he called trivial constructivism and radical constructivism. He maintained that because for millennia people have recognized that everyone builds new ideas on the foundation of prior ideas, mere psychological constructivism is trivial. Radical constructivism holds that there is no end point to evolution in the explanatory models we construct, and this von Glasersfeld maintained is a radical, relatively modern view. In fact, few scientists would claim to be radical constructivists in their epistemological thinking.

Kelly could be classified in the group of radical constructivists because he clearly rejected the idea that there was one true way of seeing the world. He emphasized the salience of idiosyncratic constructions:

> The fact that my only approach to reality is through offering some responsible construction of it does not discourage me from postulating that it is there. The open question for man is not whether reality exists or not but what he can make of it. If he does make something of it, he can stop worrying about whether it exists or not. If he doesn't make something of it, he might better worry about whether he exists or not. (Kelly, 1979, p. 25).

It is important to recognize the distinction between constructivism as a psychological belief and constructivism as an epistemological belief. Virtually everyone today who works in the realm of human learning holds constructivist views on how people learn. However, when it comes to research and activities to advance their disciplines, most cognitive scientists, and especially scientists interested in artificial intelligence, operate and write much as did positivist or empiricist philosophers. To use von Glasersfeld's terms, most cognitive scientists are only trivial constructivists, not radical constructivists. I believe this issue has great significance for the advance of science and also for education.

HUMAN LEARNING

Decline of Behaviorism

For almost three quarters of the 20th century, the dominant view of learning was that a stimulus (S) from the environment produced a response (R) from the organism, and, with repetition, an S–R bond was formed such that a given S was almost inevitably associated with a given R. This associationist or behaviorist theory of learning, based largely on animal experimentation in laboratories, never gained popularity in much of the world; however, in North America not only were associationist views popular, but most alternative theories of learning were eschewed or ridiculed. The rigid prescriptive nature of associationist psychology was consistent with and supported by the widely held positivist or empiricist views of the nature of knowledge and knowing made popular by Bacon (1620/1952) and later by Pearson (1900) and other philosophers of the Vienna School. The leading philosophers/epistemologists of the early 20th century worked to establish the hegemony of positivism by the 1930s and 40s. Skinner's *Behavior of Organisms*, published in 1938, was the epitome of wedding associationist psychology with positivist epistemology in an alliance that virtually swamped out other psychologies of learning in North America. The hegemony of associationist ideas dominated psychology and education until the 1970s. However, the failure of these ideas to describe and predict how scholars produce knowledge and how humans learn allowed new views of knowledge as paradigm construction (Kuhn, 1962) and evolving populations of concepts (Toulmin, 1972) to emerge. In psychology, cognitive views began to take hold, and concern with meanings of knowledge as held by individuals began to dominate.

Move to Assimilation Theory

My own studies of learning began in 1955 with an effort to understand parameters of problem-solving ability in the context of a college botany course (Novak, 1957). Rejecting the dominant associationist theories of the 1950s, I tried to design my research and a test of problem-solving ability (Novak, 1961) on the basis of a cybernetic model (Wiener, 1948, 1954) of learning. This model of learning considered the mind as an information-processing unit wherein information storage and information (knowledge) processing were separate components, with the latter being relatively stable over time and the former varying over time with new information and feedback information. The difficulty with the cybernetic model for me was that my doctoral thesis data and subsequent research data all pointed in a direction that suggested that information-processing capacity and the rate of acquisition of new information were highly dependent on the store of prior relevant knowledge and the context of the problem-solving or learning task (Novak, 1977a). I also became increasingly aware of a distinction between information and knowledge, in that information could be coded in binary units and shuffled in almost any way, whereas knowledge has structure, a history of creation, and affective connotations.

Because concepts play a very central role in both our psychology of learning and epistemology, our group has given careful attention to our definition of concepts. We define *concept* as a perceived regularity in events or objects, or records of events or objects, designated by a label. Most concept labels are words, and most of the 460,000 words in the English language are concept labels, many of which are used to represent several different regularities. *Propositions* are two or more concepts linked to form a meaningful statement, for example, "The sky is blue." For a good discussion of how children acquire early concepts and proposition meanings (and word labels), see Macnamara (1982).

When Ausubel's *The Psychology of Meaningful Verbal Learning* was published in 1963, our research group saw immediately that our research results were better explained by his assimilation theory of human learning than by the cybernetic model. It took another decade, however, for our research group to become comfortable with Ausubel's theory and subsequently to modify and extend the theory in our work (Ausubel, Novak, & Hanesian, 1978). During this decade, we also moved from predominantly pencil-and-paper testing to adaptation of Piaget's clinical interview techniques (Pines, Novak, Posner, & VanKirk, 1978).

The principal contributions of Ausubel's (1963) theory were its emphasis on the power of meaningful learning, as contrasted with rote learning, and the explicitness with which it described the role that prior knowledge plays in the acquisition of new knowledge. In the epigraph to *Educational Psychology: A Cognitive View,* Ausubel (1968) stated

> If I had to reduce all of educational psychology to one principle, I would say this: the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him [sic] accordingly. (p. vi)

Ausubel was not the first to emphasize the importance of prior knowledge in new learning. Bartlett's (1932) theory of memory held that schemas influence perception and recall of information, in a way similar to the way schemas are seen to operate in contemporary cognitive science views of learning and retention (e.g., Estes, 1978). In contrast, assimilation theory places central emphasis on cognitive processes involved in acquisition of knowledge and the role that explicit concept and propositional frameworks play in acquisition.

Kelly's (1955) personal construct psychology, based on his clinical experience as a psychologist, also gave emphasis to the role of prior learning in new learning, but not with an emphasis on specific concept and propositional frameworks. Kelly saw prior learning as resulting in a repertory grid of generic traits or personal constructs that influence how a person thinks or responds to a new experience.

It was Ausubel's emphasis on school learning that has made his theory useful to us. In first developing his assimilation theory of cognitive learning in *The Psychology of Meaningful Verbal Learning*, Ausubel (1963) showed how school learning could be made more meaningful and that didactic instruction or reception learning need not be rote. He rejected the then-popular idea that discovery learning, in which the learner recognizes independently the regularities or concepts to be learned, was a viable alternative, and showed instead that didactic (reception) teaching could lead to meaningful learning. He put forth the idea of an "advance organizer" that could serve as a kind of cognitive bridge between new knowledge to be learned and existing relevant concepts and propositions in the learner's cognitive structure. This has been one of the most researched ideas from Ausubel's work, with most studies showing that advance organizers facilitate learning if principles of meaningful learning are applied and evaluation tests for meaningful learning rather than rote learning (Ausubel, 1980). The Piagetian idea of age-related general stages of cognitive development that limit new learning has been rejected by our research group in favor of the idea that the quantity and quality of relevant concept and propositional frameworks are the primary limiting factors in new learning or problem solving and are age-related primarily in an experiential rather than developmental manner after about age 4 (Novak, 1977b, 1982).

A continuing problem for teachers and researchers who hold that prior knowledge is an important variable in new learning has been how to assess what the learner already knows. Various pencil-and-paper tests have been tried, but the general consensus is that these are comparatively crude measures of prior learning, accounting perhaps for only about 10% of variance in total functional knowledge held by an individual. Clinical interviews have emerged as much more trusted indicators of the quality and quantity of relevant knowledge a learner possesses, but interview transcripts are notoriously laborious and difficult to interpret. Moreover, interviewing is not an evaluation tool teachers can use in routine class evaluation.

Concept Mapping

Working from principles of assimilation theory, our research group initiated in 1971 a long-term study on the effect of early instruction in basic science concepts on later science learning. A series of audiotaped tutorial (Novak, 1972) science lessons were developed and administered to a sample of children in Grades 1 and 2. Each child was interviewed periodically over a span of 12 years. A comparable sample of children who did not receive audiotaped tutorial instruction in Grades 1 and 2 were also interviewed occasionally through Grade 12 (Novak & Musonda, 1991).

By the end of the second year of this longitudinal study, hundreds of interview transcripts were accumulating, and we were overwhelmed with the task of trying to describe the acquisition of concepts and the changes in understandings that were occurring. We sought to find a simpler way to represent the children's science knowledge revealed in the interviews, and this led to the development of concept mapping. We initially began by taking key statements or propositions given by students in the interviews and comparing the set of propositions offered by students before and after instruction, or at a later date. It was evident that the information in the propositions left out key features in the knowledge held by the students, namely, the interrelationships between concepts and propositions. To show these interrelationships, we developed the technique of concept mapping. Figure 1 shows a concept map that describes concept maps.

Students in primary grades can be taught in a matter of minutes to make their own concept maps and older students or teachers in minutes or hours. Usually, we begin instruction with a reading passage from a text or other material and ask students to identify key concepts in the passage. Next, we have them order these from the

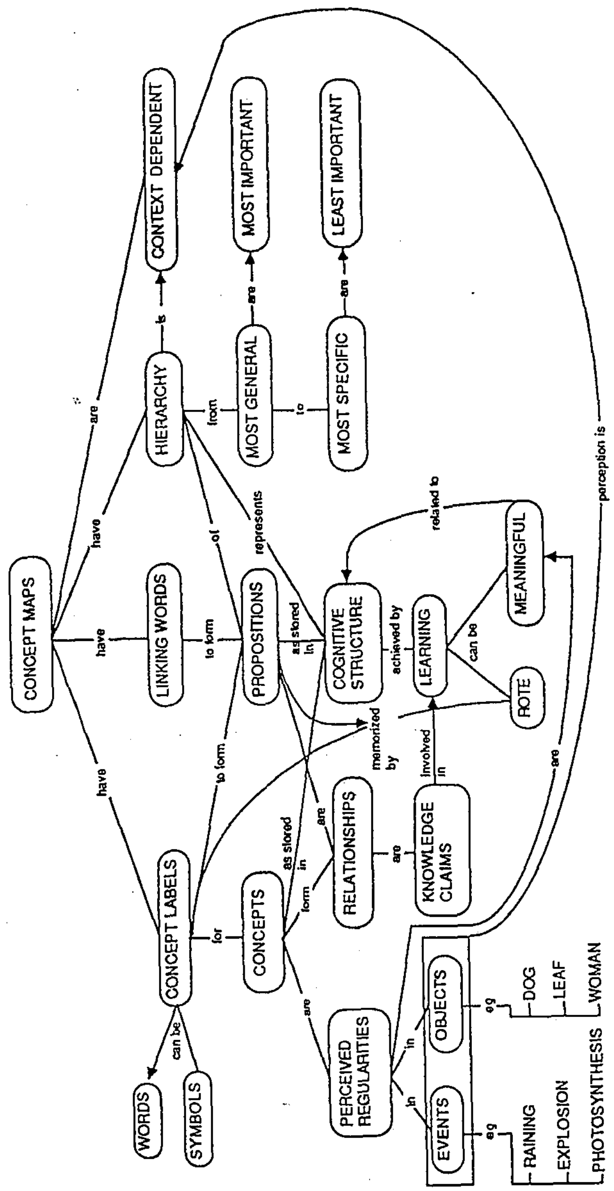


FIGURE 1 Concept map showing the key concepts and propositions (principles) represented in good concept maps.

most general to the most specific for the subject matter of the text passage. We then ask them to create a hierarchical concept map and to add appropriate "linking words" on the lines to create valid propositional statements. Usually, we model this process on the blackboard, overhead projector, or computer screen prior to assigning a text passage for them to map on their own. Other strategies for teaching the construction of concept maps have been given elsewhere (Novak & Gowin, 1984).

Concept mapping as a tool to represent conceptual/propositional frameworks, either derived from clinical interviews or constructed by the learners in our studies, was a significant breakthrough in our research program. Concept mapping subsequently proved to be a useful tool in planning instruction and helping students learn how to learn (Alvarex & Risko, 1987; Bogden, 1977; Cardemone, 1975; Gurley, 1982; Hoz, 1987; Hoz, Kozminsky, & Bowman, 1987; Novak, 1990a, 1990b; Novak & Gowin, 1984; Novak, Gowin, & Johansen, 1983; Pankratius & Keith, 1987; Stewart, VanKirk, & Rowell, 1979). A concept map we used to plan this article is shown in Figure 2. Two examples of concept maps drawn from interviews with Phil, one of the students in our 12-year study, are shown in Figure 3; they represent Phil's understanding of the particulate nature of matter in Grades 2 and 12.

Concept maps are a useful tool to illustrate key ideas in assimilation theory. Acquisition of new knowledge may range over a continuum from rote learning to highly meaningful learning (Figure 4). Most school learning is relatively verbatim, arbitrary, and nonsubstantive, as illustrated in Figure 3. Phil learned about molecules in Grades 1 and 2 (through specially designed audiotaped tutorial lessons) and later learned about atoms, but his concepts of molecule and atom were never adequately assimilated. As a result, in Grade 12, Phil believed that molecules are made of atoms but erroneously believed that gases are made only of atoms. We also see persistence of the idea (misconception) that smell molecules or sugar molecules dissolve into water molecules and hence move with the water molecules. In extreme cases of rote learning, we observe that students may be able to give a correct, verbatim definition of a concept but cannot relate it substantively to other concepts in their concept map. This is seen frequently in class instruction when concept maps are used as an evaluation tool, especially after a short unit of study. Most information learned by rote is forgotten in 3–6 weeks unless it is much rehearsed and overlearned, in which case it may be recalled years later but is not relatable to other relevant knowledge the person holds.

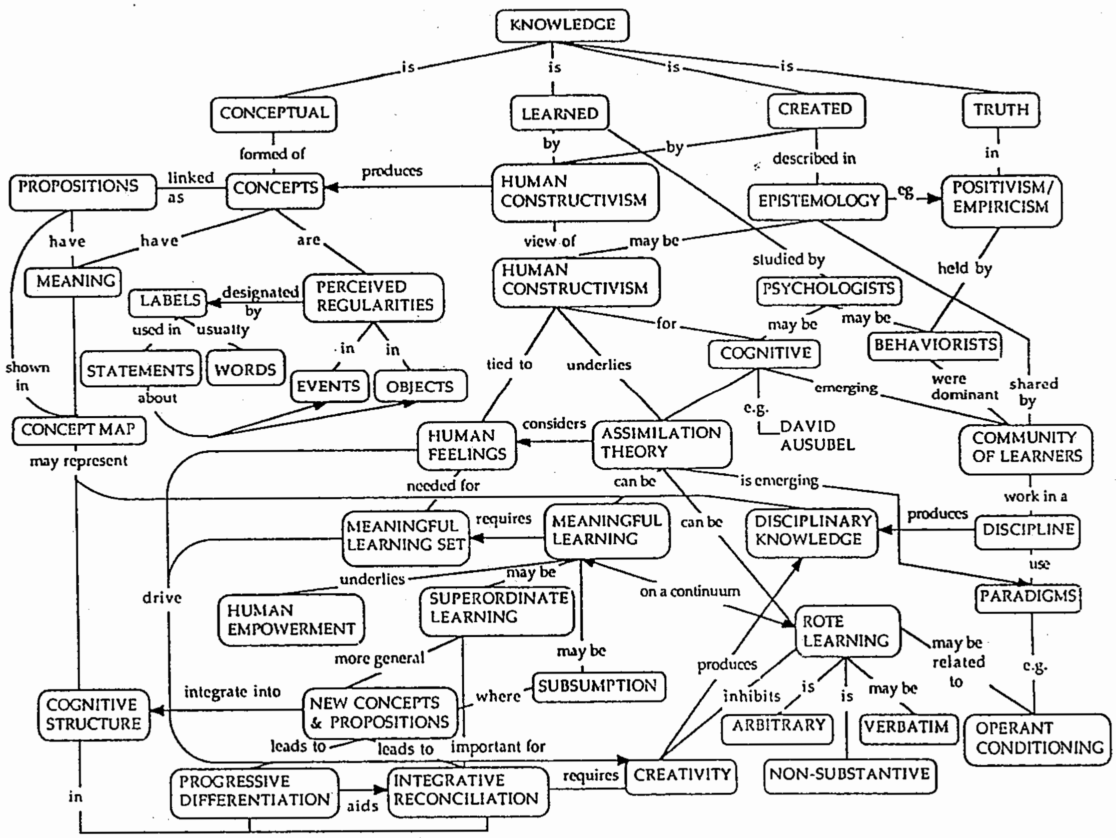


FIGURE 2 Concept map showing the key concepts and propositions presented in this article.

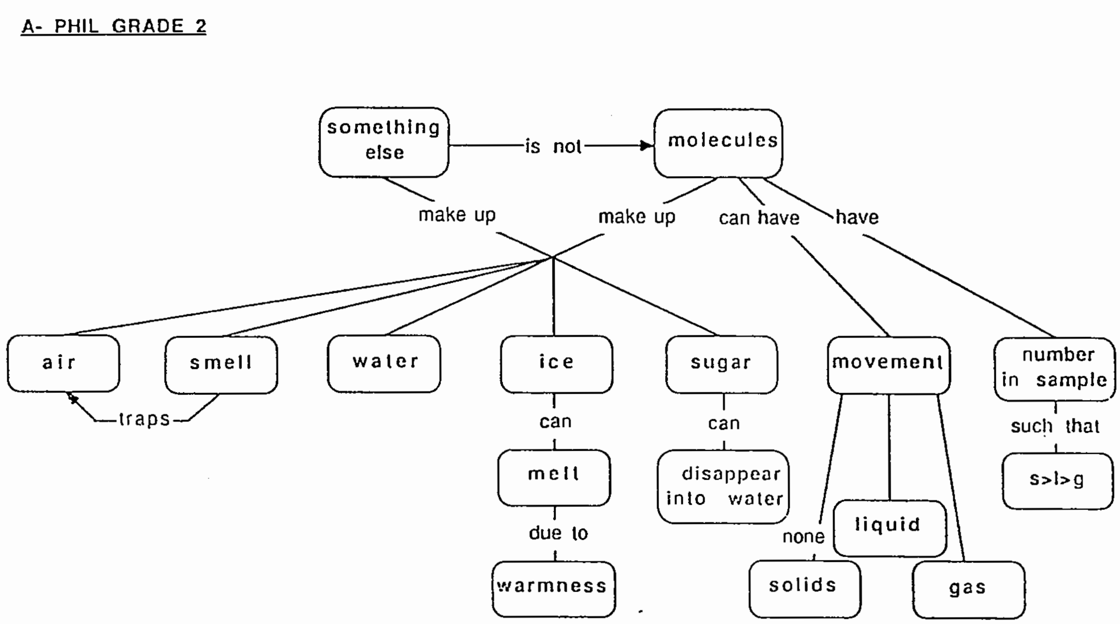


FIGURE 3 Concept map drawn from interviews with a student (Phil) in grade 2. Note that even after junior high school science, biology, physics, and chemistry, Phil had not integrated the concepts of atoms and molecules with states of matter or corrected his misconception that sugar or smell molecules are "in" water molecules. From "A Twelve-Year Longitudinal Study of Science Concept Learning" by J. D. Novak and D. Musonda, 1991, *American Educational Research Journal, 28,* p. 135. Copyright 1991 by American Educational Research Association. Reprinted by permission of the publisher.

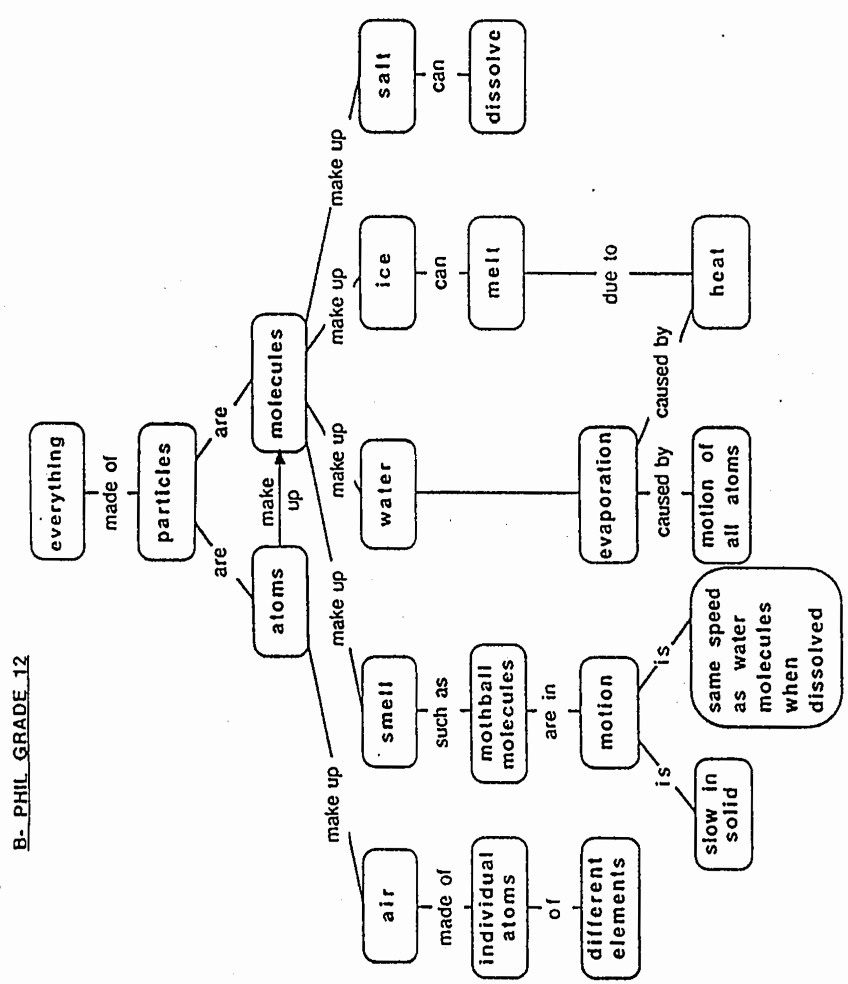


FIGURE 3 *(Continued)* Concept map drawn from interviews with a student (Phil) in grade 12. Note that even after junior high school science, biology, physics, and chemistry, Phil had not integrated the concepts of atoms and molecules with states of matter or corrected his misconception that sugar or smell molecules are "in" water molecules. From "A Twelve-Year Longitudinal Study of Science Concept Learning" by J. D. Novak and D. Musonda, 1991, *American Educational Research Journal, 28,* p. 135. Copyright 1991 by American Educational Research Association. Reprinted by permission of the publisher.

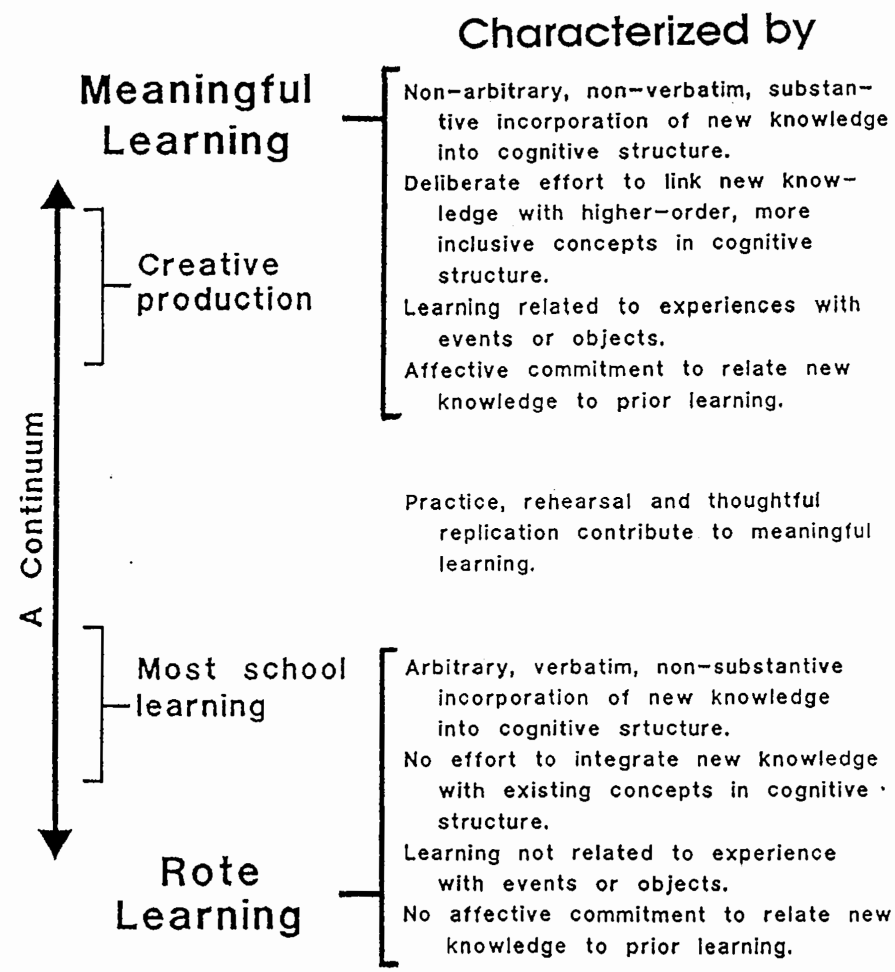


FIGURE 4 The rote-meaningful learning continuum as seen in an assimilation theory. We have found that most school learning is near the rote end of the continuum.

Two key additional ideas in assimilation theory are progressive differentiation and integrative reconciliation. As new concepts are linked nonarbitrarily to an individual's cognitive structure (represented, for example, in a concept map), progressive differentiation occurs. In our example, assimilation of the concept of atom led to some differentiation of Phil's cognitive structure. Recognition that different atoms make up different elements also showed cognitive differentiation. Integrative reconciliation occurs when sets of concepts are seen in new relationships. Phil did change his mind about the composition of matter, but he failed to integratively reconcile how gases (or anything else) can be made of molecules and their component atoms. He also failed to reconcile the concept that molecules may move independently in a fluid and smell or sugar molecules are not absorbed into water molecules. Part of Phil's learning difficulty was his failure to acquire a valid superordinate concept of the particulate nature of matter and to integrate atoms and molecules into this concept. Superordinate learning occurs only rarely, because subsumption is usually possible and sufficient; however, when it occurs, significant integrative reconciliation of subordinate concept structures usually results, as well as further concept differentiation.

Concept maps are a tool or heuristic to illustrate the cognitive or meaning frameworks through which individuals perceive and process experiences. If new experiences provide a basis for meaningful learning, new concepts are added to an individual's concept map and/or new relationships become evident between previous concepts. Over time, concept relationships may take on new hierarchical organization. For example, Cullen (1983) found that prior to instruction in a college chemistry course, the concept of entropy was either not known or held a subordinate position in students' cognitive structure. After instruction using a specially designed study guide that emphasized the entropy concept, entropy became a superordinate concept in those students who demonstrated the best understanding of chemistry principles. Similar results have been reported by Hoz (1987), Feldsine (1987), and others. Experts differ from novices in a field of study not only in that they have more concepts integrated into their cognitive frameworks, but also in the kind of conceptual hierarchies they possess and the quality and extent of propositional linkages they possess between subordinate and superordinate concepts (e.g., Chi, Feltovich, & Glaser, 1981; Novak, 1988). Concept maps are proving to be a useful tool to identify and help students "correct" misconceptions (Helm & Novak, 1983; Novak, 1987).

A growing body of evidence on the neurobiology of brain function suggests that new learning involves multiple neuron–neuron linkages and hundreds or even tens of thousands of neuronal linkages may be involved in the acquisition of a single new concept. Moreover, greater or lesser numbers of axons and dendrites of each neuron may be involved, and varying numbers of synaptic transmitter or inhibitor channels may be formed at each synapse. The net effect is that new learning of a single concept, if it is substantively incorporated through meaningful learning, involves many neurons in many regions of the brain, and constructive neuronal changes may continue for hours or days after learning (Anderson, 1992).

During learning, not only do neurons form new synapses with one another and new channels for the secretion of transmitter chemicals, but also transmission-inhibiting compounds may be secreted (Dunn, 1987). This may account in part for "learning shock" and retroactive interference, two observed psychological phenomena in which previously learned material is not recallable until a later point in time. This delayed facilitation effect, or short-term inhibition, may be illustrated in a concept map. When a single concept is added to an individual's concept map through meaningful learning, all linked concepts in that person's cognitive structure will be modified to some extent over time. Maps drawn at a later date often show some new or different linkages and occasionally some significant new cross-links that may represent new integrative reconciliation of prior concepts. The creative insights reported in the biographies of geniuses, occurring often days or weeks after intense study, are also evidence of gradually changing neural (and psychological) networks. All related concepts and propositions, at least in some small way, take on new meanings. The implications of current research in neurobiology as it relates to concept mapping have been discussed by MacGinn (1987).

It should be evident from the preceding discussion and Figures 1–4 that concept maps do not represent only the idiosyncratic knowledge structure acquired by individuals; they can also be used to represent the knowledge structure of a discipline as seen by experts in the discipline. Examples have been provided by Novak and Gowin (1984). We have found that concept maps can help teachers understand the structure of knowledge in their field and, in turn, help make the subject matter conceptually obvious or transparent to their students (Novak, 1991).

KNOWLEDGE CREATION

From Positivistic to Constructivist Views

That humans learn is self-evident. It is also self-evident that humans construct new knowledge, because the store of knowledge in any culture increases with time. What is not self-evident are the processes by which humans construct new knowledge. As civilization emerged from the Dark Ages, knowledge about the universe and the workings of nature began to expand at an ever increasing rate. Oriental cultures continued to advance and were not constrained by the Dark Ages; however, it was in the Western cultures that scientific experiment was invented and modern science began to blossom. It was natural that numerous philosophers/epistemologists should begin to write their descriptions of how humans increased this knowledge store. For Bacon (1620/1952), Pearson (1900), and many other early epistemologists, the truth lay in wait in nature. Humanity's task was to discover these truths by careful observation and experimentation. Communities of scholars emerged who described various views on how nature's secrets were to be unearthed and the truth revealed. Bacon wrote

> The subtly of nature is far beyond that of sense or of the understanding; so that specious meditations, speculations and theories of mankind are but a kind of insanity. (p. 107)

Much later Pearson wrote

> The civil law is valid only for a special community at a *special* time; the scientific law is valid for *all* normal human beings, and is unchanging. (p. 87)

> The right of science to deal with the beyond sense-impressions is not the subject of contest, for science confessedly claims no such right. (p. 110)

With the accelerating pace of scientific discovery in the 20th century, many philosophers, scientists, and mathematicians turned their substantial intellectual talents to the study of epistemology, especially the epistemology of science. The more popular varieties of epistemology gave careful attention to tests for truth and falsity and the criteria to be applied. These scholars, known variously as positivists, logical positivists, or empiricists, placed central emphasis on proof and refutation. The reign of positivist epistemology was nearly absolute until the middle of the 20th century. One of the problems of this epistemology is that it did not attract much interest from scientists and mathematicians, perhaps because it did not help them do what they were doing. It was probably not surprising that outstanding scholars/scientists such as Conant (1947) should have been the first to espouse what Brown (1979) called "the new philosophy of science." And when Conant's protegé, Kuhn, wrote "The Structure of Scientific Revolutions" (1962), the walls of the positivist's bastion began to crumble. Even from within, the positivist protegé, Popper, moved away from positivism and in 1982 wrote

> Everybody knows nowadays that logical positivism is dead. But nobody seems to suspect that there is a question to be asked here—the question "Who is responsible?" or, rather the question "Who done it?" . . . I fear that I must admit responsibility. (p. 88)

As Strike (1987) noted, positivists were not fools and they knew that human understanding was built on more than a logic of discovery. What they uniformly failed to described was how humans construct concepts and how their conceptual frameworks become their perceptual goggles to permit them to see what they see in their inquiries and to guide them in constructing new inquiries. Kuhn's (1962) description of the paradigms that guide the scientist and Toulmin's (1972) idea of evolving populations of concepts seemed to be much closer to the reality the working scientists face day to day. They do indeed construct new knowledge, but this is not truth, and much of the knowledge changes repeatedly in the lifetime of a scientist. Von Glasersfeld (1984) argued that radical constructivism does not seek a description of the truth or subscribe to the idea that in research we progress toward the truth. The issue now seems to center more on how to facilitate creative production than on how to tighten the criteria of proof or refutation.

HUMAN CONSTRUCTIVISM

My thesis is that we must examine closely the linkage between the psychology of human learning and philosophy knowledge. Creating new knowledge is, on the part of the creator, a form of meaningful learning. It involves at times recognition of new regularities in events or objects; the invention of new concepts or extension of old concepts; recognition of new relationships (propositions) between concepts; and, in the most creative leaps, major restructuring of conceptual frameworks to see new higher order relationships. These processes can be viewed as part of the process of assimilative learning, involving addition (subsumption) of new concepts, progressive differentiation of existing concepts, superordinate learning (on occasion), and significant new integrative reconciliations between concept frameworks. The creative person is a member of a community of learners all of whom share many concept meanings but each of whom holds his or her own idiosyncratic conceptual hierarchy. The individual most able to add to or restructure his or her conceptual framework is, in time, recognized as the most creative in that community. And, over time, the population of concepts and concept relationships held by the community evolves, according to Toulmin

(1972), or, for the individual, progressively differentiates and reintegrates according to assimilation theory.

As far as we know, only humans use complex language symbol systems to code the regularities they perceive, and hence the construction of new meanings and of new knowledge using symbol systems is uniquely human. Only humans read books. Human constructivism, as I have tried to describe it, is an effort to integrate the psychology of human learning and the epistemology of knowledge production. I place emphasis on the idea that both psychologists and epistemologists should focus on the process of meaning making that involves the acquisition or modification of concepts and concept relationships.

Gowin's Vee Heuristic

Some of the conceptual frameworks we seek to develop in our students are those that deal with epistemology. To this end, we have found the use of Gowin's (1981) Vee heuristic to be of value. Figure 5 defines each of the dozen epistemological elements that are involved in the construction of knowledge in any domain. Figure 6 shows a Vee for an experiment on spontaneous generation performed years ago by Redi. Each element shown on the Vee has its own role to play in new meaning construction. All are necessary to understand the structure and/or creation of knowledge.

The Vee represents an event-centered constructivist view of knowledge (Gowin, 1987). We center our attention on the construction of concepts, which we have defined as perceived regularities in events or objects designated by a label. Because all objects exist in time and space, it is reasonable to see the creation of knowledge as a search for regularities in events or, as is often the case, in records of events. No one has observed atoms disintegrating, but a cloud chamber or Geiger counter permits us to make records of these events, and from these records we construct our knowledge claims. Often we transform our records using photographs, computer processing, tables, graphs, etc., and each of these transformations is guided by one or more principles, including not only those related to the event we are studying but also, often, whole sets of principles related to the record-making or record-transforming tools that we employ. It is oversight or limitations of the latter that commonly leads to misinterpretation or misunderstanding of events or records. Even in the best case, the meaning of our records is always interpreted using our existing concepts, principles, theory, and philosophy. And because

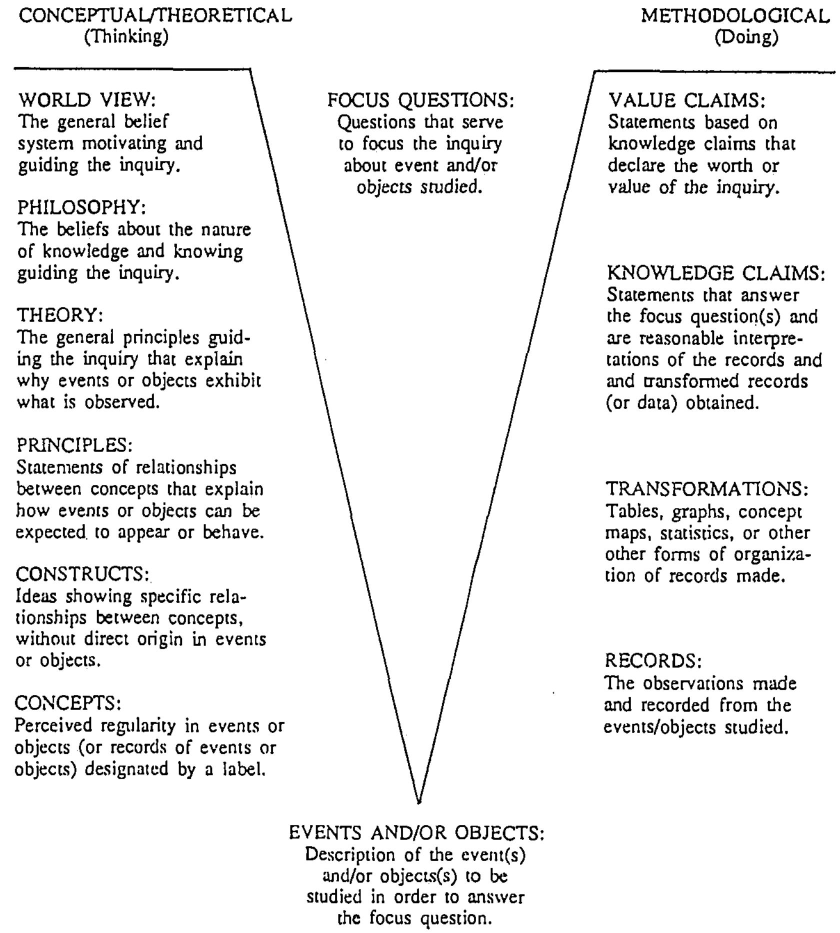
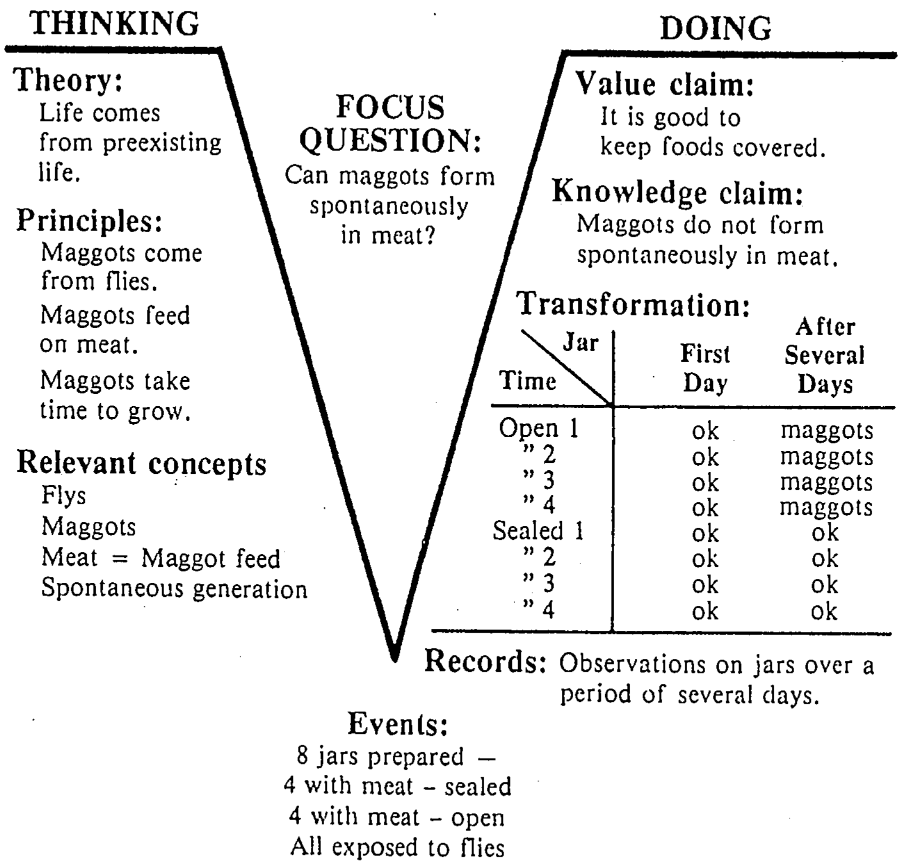


FIGURE 5 Gowin's (1981) Vee heuristic showing epistemological elements that are involved in the construction or description of new knowledge. All elements interact with one another when an individual is in the process of constructing new knowledge or value claims or is seeking an understanding of these elements for any set of events and questions.

these are all limited and evolving, we can only make claims (not truth statements) about how we believe the piece of world we are studying works.

The distinguishing trait of radical constructivism is that this epistemology claims no end point where true reality can be known. Instead, radical constructivism views the construction of new concepts, principles, and theories as a continuous process, leading to new



Jar / Time	First Day	After Several Days
Open 1	ok	maggots
" 2	ok	maggots
" 3	ok	maggots
" 4	ok	maggots
Sealed 1	ok	ok
" 2	ok	ok
" 3	ok	ok
" 4	ok	ok

FIGURE 6 A Vee diagram prepared from a biology text description of the Redi experiment. The Vee was constructed on an overhead transparency to illustrate the technique of Vee diagramming to the class. Working with junior high school students, we did not introduce philosophy or world view as elements in the Vee. From *Learning how to learn*, by J. D. Novak and D. B. Gowin, p. 115. Copyright 1984 by Cambridge University Press. Reproduced by permission.

questions or new ways to make and transform records, and hence new knowledge and value claims. This is illustrated in Figure 7. The "Parade of Vees" shown in Figure 7 does not imply that no progress is made in understanding. New concepts, principles, and/or theories can lead to more parsimonious explanations and perhaps better prediction or control of events. The key point is that there is no end point in time when truth will be known.

Gowin's (1981) Vee heuristic also serves to emphasize the human and value-based character of knowledge and knowledge production.

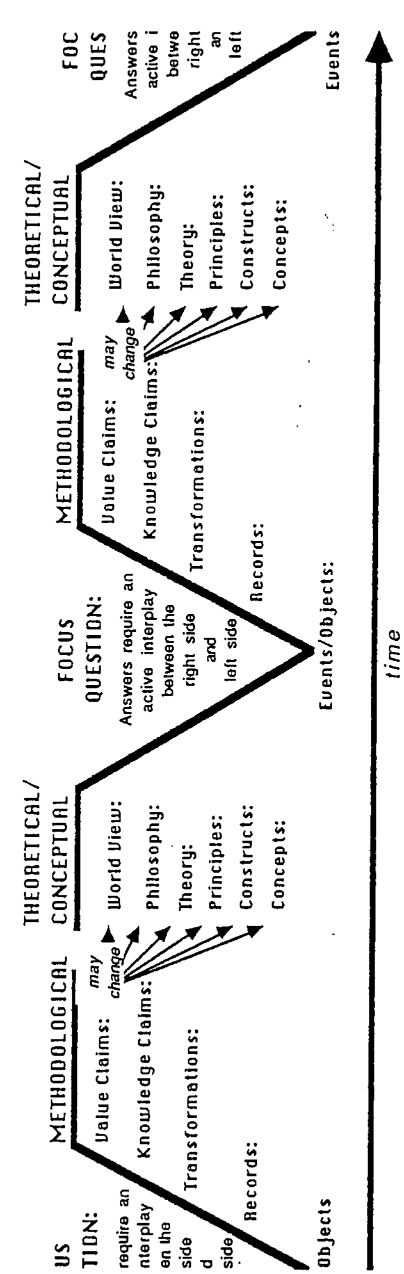


FIGURE 7 A partial set of a "Parade of Vees" to illustrate how prior knowledge is used to design new inquiries and to construct new knowledge and value claims. Radical constructivism views the process as continuing indefinitely.

Whether we choose to be a historian, chemist, or poet depends on our philosophy and commitments. The events we choose to observe, the questions we ask, and the records and record transformations we choose to make all involve value decisions: What do we care about, and what price are we willing to pay in time or dollars and personal sacrifice? If we stop to reflect, it is easy to see that every knowledge claim we construct can lead us to one or more value claims—claims about the worth of our knowledge or its application. The objective, value-free character of science or other fields of knowledge creation was only a positivist's myth sustained by ignoring the myriad subjective and value-based decisions that everyone involved in knowledge production must make. It is this constructive integration of thinking, feeling, and acting that gives a distinctively human character to knowledge production. With geniuses, we usually judge this synthesis good and praise it highly, although it may take generations for this recognition to occur. It is often human vanity that denies the creative artists, poets and scientists the recognition they deserve.

The epistemological elements shown on the right side of the Vee are usually easily grasped by students and teachers. Occasionally, we receive some strong objection to the use of the term "knowledge claims" rather than "conclusions." This reflects the deeply rooted positivistic thinking of many people (Edmonson, 1989). The idea that value claims derive from an "objective" inquiry is even more troublesome to these people. Yet even the decision to pursue a given inquiry is a value decision that the inquiry is in some manner worth pursuing. The left side of the Vee is often troublesome to most students, teachers, and professors, partly because they have rarely reflected in depth on how their minds work in the construction of new meanings. There is also the problem of learning to discriminate between each of the elements on the left.

Constructs

Gowin's (1970, 1981) idea of constructs differed significantly from that of Kelly. Gowin saw constructs as relationships between concepts that are constructed by people; often the relationship is arbitrary. For example, the I.Q. is a popular construct in psychology representing a relationship between mental age (as measured by tests of dubious validity) and chronological age. But why divide mental age by chronological age? Why not multiply the two to show better that intelligence is a product of heredity and environment? Constructs are not found in the real world; they are fabricated from

concepts that represent regularities in events or objects. No one has observed or measured an I.Q., gross national product, or chromosomal map distance. The social sciences (especially economics) are replete with constructs, many of which are made up of concepts, such as *intelligence,* that have fuzzy meanings. This is one reason why the construction of knowledge is in many ways more difficult in the social sciences than in the physical sciences.

Kelly (1955) described a construct as "a way in which some things are construed as being alike and yet different from others" (p. 105). He went on to say that constructs are "bipolar," like "black versus white," where black and white are elements of a bipolar construct. Constructs also have a "range of convenience" and apply to certain context of experience. The range of convenience differs between people. "For example, one person may classify his moods as black or white, another may classify his fabrications as black or white and another may use the construct to distinguish between cultures" (Kelly, p. 109). Our view of the world is thus dependent on the constructs we have developed by which we see or describe the world.

Kelly's (1955) view of constructs was much broader than Gowin's (1970, 1981) view and the role that constructs play in Gowin's epistemological Vee. Kelly's constructs encompass essentially all of the elements on the left side of the Vee in each construct, albeit some elements would be more salient for some constructs than for others. Constructs can be represented in a repertory grid, showing an individual's assessment of the elements of a construct as applied to different persons, things, or events. Factor analytic techniques can be used to compute weightings for each construct for an individual. Kelly's personal construct psychology has an inherent appeal for those who place high value on the quantification of one's belief system. Although an individual's concept maps and Vee diagrams can be scored (Novak & Gowin, 1984), this is seldom the key objective in their use.

A NEW SYNTHESIS

To me there is a new excitement about psychology, epistemology, and education: the excitement of a new synthesis. An emerging consensus (Linn, 1987) in psychology and education points toward the crucial role that concepts and concept relationships play in humans' meaning making and the important role that language plays in humans' coding, shaping, and acquisition of meanings. In philosophy there is also an emerging consensus in epistemology that knowledge and knowledge production are evolving frameworks of concepts and propositions. The almost infinite number of permutations of concept–concept relationships allows for the enormous idiosyncrasy we see in individual concept structures, and yet there is sufficient commonality and isomorphism in meanings that discourse is possible, and sharing, enlarging, and changing meanings can be achieved. It is this reality that makes possible the educational enterprise.

The major claim I am making is that all human beings have an enormous capacity to make meaning and use language to construct and communicate meanings. I seek to conflate issues that deal with the nature of knowledge construction into the issues that deal with the psychology of meaning making. In both cases, I see the human capacity for meaning making and the nature of that process as the bottom line. What really counts, in my view, is how to empower human beings to optimize their phenomenal capacity to make meaning, including their awareness of and confidence in processes that are involved. This capacity for meaning making is what I refer to as human constructivism.

What remains to be demonstrated are the positive results that will occur in schools or other educational settings when the best that we know about human constructivism is applied widely. To my knowledge, no school comes close to wide-scale use of such practices, even though there are no financial or human constraints that preclude this. What we observe in our studies of learning in schools, universities, or businesses is an almost ubiquitous, pernicious, pervasive positivism. This right/wrong true/false instructional and evaluation pattern justifies and rewards rote learning and often penalizes meaningful learning. The importance of constructivist views for the redesign of instruction and teacher education has been put forth by others (Cobb, 1987, 1988; Confrey, 1985; Driver & Oldham, 1985; Pope, 1985; Pope & Keen, 1981). There remains the enormous task of implementing the ideas of human constructivism in all educational settings.

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