The Advancement of Learning

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> Neither the hand nor the mind alone would amount to much without aids and tools to perfect them. (Bacon, *Novum Organum*, 1623)

This loosely translated quotation is taken from Francis Bacon's *Novum Organum*, not from Vygotsky, as one might well imagine. In this article, I argue that designing aids and tools to perfect the mind is one of the primary goals of educational research. In this spirit, the major themes of the article are that:

- Instruction is a major class of aids and tools to enhance mind.
- To design instruction, we need appropriate theories of learning and development.
- Enormous advances have been made in this century in our understanding of learning and development.
- School practices in the main have not changed to reflect these advances.
- The question posed is, Why?

My title, *The Advancement of Learning*, is also taken from Bacon (1605). The title is a metaphor, as I will view the advancement of learning particularly during the 30 years or so since the cognitive revolution. Contemporary theories, unlike those of the past, concentrate on the learning of complex ideas as it occurs in authentic situations including, but not limited to, schools. In keeping with Bacon, I will paint a general picture of progress but at the same time add a cautionary note concerning the infanticide rate of our profession. We repeatedly throw out babies along with bathwater, when we should build cumulatively. No community can afford to lose so many valuable offspring in the service of progress.

I will begin with a personal odyssey. In rereading the Presidential Addresses from the past 10 years or so, I realized that this genre, the odyssey, is a popular one. Indeed, the metaphor of an odyssey was the leitmotif of Eliot Eisner's 1993 address. Pivotal to this narrative genre is the retelling of the myriad interesting life experiences of those who subsequently went on to become President of AERA. Now here's my problem. I am a psychologist. I have always been a psychologist of sorts. I started my academic career as an undergraduate studying learning, and I am still doing that today, in my fashion. But what I did then and what I do now are as distinct as night and day.

I was well prepared for my career as a learning theorist. In high school, I specialized in 18th century literature and 19th century history, and was on my way to study history in college. Why switch? I saw a television program on animal learning, on how animals learn naturally in their environments, an introduction to ethology. The heroes of this piece were Huxley, Lorenz, Thorpe, and Tinbergen. Fascinated, I looked up animal learning in my handy guide to universities and found that to study learning you needed a degree in psychology.

Thus prepared I set out for an interview, having seen one television program on ethology and having read Freud's *Psychopathology of Everyday Life* on the train getting there. By chance the head of department was an expert in 18th century literature. We discussed poetry for 2 hours. I got a scholarship to study psychology!

So in the early 60s I started out for London to study animal learning. I arrived in Iowa, or maybe it was Kansas, feeling a little like Dorothy in *The Wizard of Oz*. The cognitive revolution had not yet come to London. What followed was 3 years of exposure to behaviorist learning theory. Rather than learning about animals adapting to their natural habitats, I learned about rats and pigeons learning things that rats and pigeons were never intended to learn.

Pan-Associationism. Experimental psychologists in England (and Iowa) at that time were enthralled with a certain form of behaviorism. Dominating the field were the all-encompassing learning theories of Hull/Spence, Tolman, and Skinner.[1] These theories shared certain features that limited to a greater or lesser extent their ability to inform educational practice. All derived their primary data from rats and pigeons learning arbitrary things in restricted situations. They shared a belief that laws of learning of considerable generality and precision could be found. These basic principles of learning were thought to apply uniformly and universally across all kinds of learning and all kinds of situations. The principles were intended to be *species-, age-, domain-,* and *context-independent.* Pure learning was tested in impoverished environments where the skills to be learned had little adaptive value for the species in question. Paul Rozin (1976) argued that by studying the behavior of pigeons in arbitrary situations, we learned nothing about the behavior of pigeons in nature, but a great deal about the behavior of people in arbitrary situations.

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I will illustrate with a surely apocryphal tale related by Mary Catherine Bateson (1984). Her father Gregory Bateson's favorite tongue-in-cheek psychologist anecdote was the following:

> It occurred to a thoughtful rat-runner after many years of running rats that as rats do not usually live in mazes, mazes were perhaps less than optimal testing grounds for learning. Therefore, he bought a ferret, a species that in nature does hunt in mazes—rabbit warrens. He baited a maze with fresh rabbit meat and set the ferret to find it. On the first day, the ferret systematically searched the maze and found the rabbit quicker than a rat. But what happened on the second day? The rat, as expected, searched the maze and found the bait more quickly than on the original trial. Learning was said to have occurred. But not so for the ferret. It searched the maze and came to the route that had previously led to the reward, but didn't go down it. Why? He'd eaten that rabbit yesterday. What the ferret had learned was colored by its expectation of how the world works—for ferrets. (anecdote adapted from pp. 170–171)

How did this dominance of certain forms of behaviorism come about? Psychology as a nascent science didn't start out that way. One of the few female pioneers in the early part of the century, Mary Calkins (1915), criticized the overwhelmingly male establishment by arguing that psychology started out as the study of consciousness and then set about to explain it away, even to deny its existence. Throughout her career she argued, in the wilderness, that psychology should be the study of "conscious interacting social selves in relation to other selves and objects." Vygotsky, perhaps, but a far cry from Thorndike, Watson, and Hull.

Animal Learning. The dominance of behaviorism in the mid part of the century has often been blamed on the increasing dependence on animals as experimental subjects. Animals are not known for their introspection, and few investigators were concerned whether animal thought was imageless or not, or whether they entertained theories of mind. This argument does not follow through, however, as early work with animals had a distinctly mentalistic flavor. Leonard Hobhouse, in his delightful book, *Mind in Evolution* (1901), studied a variety of animals, albeit somewhat informally: One reads that the subjects were: "a dog, a cat, an otter, and an elephant" or "a rhesus monkey called Jimmy and a chimpanzee named Professor." Using a variety of puzzle-like, meaningful situations (a dog opening a gate to escape its own yard, rather than playing in a Thorndikian puzzle box), Hobhouse found evidence for such mental-sounding entities as purpose, planning, cunning, and deceit, mental entities again being studied today (Griffin, 1992). So too, during the first world war, Kohler's chimpanzees, such as the famous Sultan, were also seen to be insightful as they set about building towers of boxes to reach fruit hanging out of reach, or combining short sticks into long ones to reach outside cage bars.

This mentalism was almost stamped out, but with notable exceptions, such as Lashley's rats on the jumping stand experiencing vicarious (mental) trial and error, or Tolman's rats buried in thought at the start box of a maze, troubled by ideas, hypotheses, and mental maps. Lashley and Tolman were atypical, however; Lashley was trained as an ethologist, and Tolman was always a closet cognitivist, and a self-proclaimed cryptomentalist.[2] But to the dyed-in-the-wool behaviorist, learning did not imply conscious intent but rather was seen as the autonomous outcome of the formation of S-R bonds stamped in or out by reinforcement contingencies with no need for conscious intent. This position had powerful implications for education, whose residual clings today.

Developmental Psychology. Child psychology underwent a similar history. Although at the beginning of the century we saw ingenious studies of children's thought (witness those of Binet, Baldwin, Piaget, and Darwin for that matter), they were forgotten, and a large part of the field became imprinted on behaviorism. The Zeitgeist affected not only the *theories* of learning that were tested but also the *methods* by which they were examined. What were children asked to learn?

Some were asked to stack boxes or use sticks to obtain objects out of reach, just like Sultan the chimp (Sobel, 1939). It did not seem to occur to anyone that a set of boxes more readily affords climbing to an ape than to a less agile human toddler.

Others were asked to run mazes! They were "run" through a child-size maze of darkened runways where they had to complete routes to reach goal boxes in a similar inferential pattern to that shown by rats. It was not until well into the school years that children performed as well at this as did rats (Maier, 1936)! Again, the fact that running in a darkened maze may be a task suitable to no organism, but better suited to rats than preschoolers, did not seem to be open to debate.

Children were tested in cages—well, almost—specifically, a Wisconsin General Test Apparatus designed by Harlow[3] for use with monkeys that bit. I assume children in the 1960s were not rabid, and, therefore, the physical protection of the experimenter could not have been a prime motivation for this odd practice, engaged in, I might add, by myself and many of my closest friends. The prime motivation was in fact to minimize social or verbal interactions with the child. Deliberately, the child could not see the experimenter's facial expressions behind a one-way mirror, and hence could not be influenced by them. The fact that a great deal of learning is inherently social was not a topic of discussion; indeed, we explicitly controlled for such undesirable influences.

The point of this little walk down memory lane is not only to amuse you, but also to make the point that it was on the basis of studies like these that children below 7 or so were deemed incapable of inferential reasoning, insightful learning, and all kinds of logical operations, a position later reinforced by simplistic interpretations of Piaget.

Impact on Education

These developments in psychology impacted educational practice. The dominant learning theories for many years encouraged educational psychologists to concentrate on such external factors as reward schedules and transfer gradients. Transfer could be expected only if identical elements of external situations were held constant, thereby capturing the mind willy-nilly. Even though Thorndike, the originator of much of this, gave up on his position concerning learning and transfer in the late 20s (Thorndike & Gates, 1929), the theories, albeit somewhat disguised, are still alive today.

Equally important was the model of the child that emerged. It was received wisdom that young children had limited attention spans. They got bored easily in those boxes, mazes, and cages. So it was assumed that the young bore easily in any learning situation. Similarly, young children performed abysmally in settings designed to exploit animal wit. As a result they were deemed incapable of inferential reasoning, of performing certain types of classification, of insightful learning and transfer in general. Because of these assumed problems of immaturity, it was believed that children in school should work to mastery on simple decontextualized skills for short periods of time under appropriate reinforcement schedules.

Despite this pessimistic legacy, behaviorist theories of learning of the mid-century had their clear value. They were in fact remarkably successful at explaining the range of phenomena they set out to explain. For example, Skinnerian theory gave us token economies, fading, scaffolding, and today, valuable clinical methods, such as those used to control nausea during chemotherapy. Tolman was a clear forerunner of cognitive psychology, lending a legitimacy to mental models and states. And Hullian theory has much to say to contemporary connectionism. And in defense of psychologists, those concerned with educational practice were only too ready to adopt these theories in the absence of viable alternatives that did include concerns for context, content, and developmental status.

Behaviorist conceptions of learning and development postulated 30 years ago had important implications for instruction, both positive and negative. The theories permeated the language of schooling—and are still in evidence. Lauren and Dan Resnick (1991) have made this point forcibly regarding the state of the art in standardized testing, where the design of tests still reflects behaviorist theories of the past. Cognitive learning theory is only now beginning to have an effect on classroom practice and the testing industry. The vocabulary is slowly changing. The practices lag behind. Where we once had behavioral objectives, we now have cognitive objectives, although it is sometimes a challenge to find the differences.

New Learning Theory

So what's new in learning theory? Slowly, the cognitive revolution did come to town and upset many accepted beliefs. A dramatic change occurred in what "subjects" were required to learn, even in laboratory settings, accompanied by a dawning awareness that real life learning is intrinsically entangled with situations. One cluster of such situations is the classroom.

The model of the human learner, including the child, was transformed. Learners came to be viewed as *active constructors*, rather than passive recipients of knowledge. Learners were imbued with powers of introspection, once verboten. One of the most interesting things about human learning is that we have knowledge and feelings about it, sometimes even control of it, *metacognition* if you will. And, although people are excellent all-purpose learning machines, equipped to learn just about anything by brute force, like all biologically evolved creatures, humans come *predisposed to learn certain things* more readily than others.

We know now that small children understand a great deal about basic principles of biological and physical causality. They learn rapidly about number, narrative, and personal intent. They entertain theories of mind. All are relevant to concepts of readiness for school, and for early school practices.

Those interested in older learners began to study the acquisition of disciplined bodies of knowledge characteristic of academic subject areas (e.g., mathematics, science, computer programming, social studies, and history). Higher order thinking returned as a subject of inquiry. Mind was rehabilitated.

Psychologists also began considering input from other branches of cognitive science: anthropology, sociology, linguistics, and they began to consider learning settings outside the laboratory, or even the classroom walls. Clearly a strictly laboratory-based psychological theory of learning is, and always was, a chimera.

Community of Learners

I now turn to my current work in urban classrooms, where my colleagues and I are attempting to orchestrate environments to foster meaningful and lasting learning in collaboration with inner-city grade school students and teachers. We refer to this as the *Community of Learners* (COL) project (Brown & Campione, 1990, 1994).

How did I get here from there? How did I make the journey from testing kids in cages to designing learning communities? To me the journey felt seamless. From studying rote memory for words and pictures, and strategies to enhance it, I progressed to studying memory for stories, narrative, and expository text. As the human mind does not resemble a tape recorder, memory for texts involves seductive simplification and inadvertent elaboration well documented by Bartlett (1932) at the early part of the century. Inferences and strategies abound, and their development in the young interested me.

Texts are understood and re-created in the telling. Understanding admits of degree, monitoring one's understanding of texts requires far more subtle judgment than monitoring if one can recall lists of words or sentences. It was this move away from rote learning of discrete stimuli to understanding text that led me down the slippery slope toward an area of research with obvious educational implications: reading comprehension and comprehension monitoring.

Children have difficulty in recruiting strategies to help them understand lengthy texts. So too the subjective judgment required to monitor whether or not one has understood presents the developmentally young with difficulty, not surprising given the problems college students have with calibrating their attention to avoid the illusion of comprehension. So, my colleagues and I began a series of studies to help children learn from texts, training individual strategies such as questioning, clarifying, and summarizing to help them monitor their progress (Brown, Bransford, Ferrara & Campione, 1983). This was the precursor to the next step, the design of a reading comprehension instructional intervention that would combine these activities in an effort after meaning. Reciprocal teaching, designed by Annemarie Palincsar and me (Palincsar & Brown, 1984) became that intervention, and, as we will see, it is still a central part of the COL.

Reciprocal teaching involved the development of a minilearning community, intent not only on understanding and interpreting texts as given, but also on establishing

an interpretive community (Fish, 1980) whose interaction with texts was as much a matter of community understanding and shared experience as it was strictly textual interpretation. It was to capture this influence of common knowledge, beliefs, and expectations that the notion of a community of learners was developed. For the past 10 years or so, my colleagues and I have been gradually evolving learning environments that would deliberately foster interpretive communities of grade-school learners.

Engineering of a Community of Learners

The fundamental engineering principle behind the design of a COL is to lure students into enacting roles typical of a research community. I take this metaphor seriously. The COL classrooms feature a variety of activities that are essentially dialogic in nature, modeled after research seminars, that when working well facilitate interchange, reciprocity, and community.

Theoretically, I imagine such classrooms as enculturating *multiple zones of proximal development*, to use the now popular Vygotskian (1978) term. A zone of proximal development defines the distance between a child's current level of learning and the level she can reach with the help of people, tools, and powerful artifacts—tools and aids to perfect mind, in Bacon's terms. Within these multiple overlapping zones, students navigate by different routes and at different rates. But the push is toward upper, rather than lower, levels of competence. These levels are not immutable, but rather constantly changing as participants become increasingly independent at successively more advanced levels.

Practically I imagine classrooms as learning communities that have extensions beyond the classroom walls. I will share with you a few essential components (for fuller details, see Brown & Campione, 1990, 1994). One is that we feature students as researchers and teachers, partially responsible for designing their own curriculum. A variety of collaborative activities encourage this. I will discuss just two of them: reciprocal teaching learning seminars and jigsaw teaching sessions.

Reciprocal Teaching. Reciprocal teaching began as a method of conducting "reading group," once an established ritual of the grade-school class. Reciprocal teaching seminars can be led by teachers, parents, peers, or older students. Six or so participants form a group with each member taking a turn leading a discussion about an article, a video, or other materials they need to understand for research purposes. The leader begins the discussion by *asking a question* and ends by *summarizing* the gist of the argument to date. Attempts to *clarify* any problems of understanding take place when needed, and a leader can ask for *predictions* about future content if this seems appropriate. These four activities were chosen because they are excellent comprehension-monitoring devices. Quite simply, if you cannot summarize what you have just read, you do not understand, and you had better do something about it (for more details, see Palincsar & Brown, 1984).

Reciprocal teaching was designed to provoke zones of proximal development within which readers of varying abilities could find support. Group cooperation, where everyone is trying to arrive at consensus concerning meaning, relevance, and importance, helps ensure that understanding occurs, even if some members of the group are not yet capable of full participation. Because thinking is externalized in the form of discussion, beginners can learn from the contributions of those more expert than they.

So, unlike many decontextualized skills approaches to reading, skills here are practiced in the context of actually reading. Collaboratively, the group, with its variety of expertise, engagement, and goals, gets the job done; usually the text gets understood. The integrity of the task, *reading for meaning*, is maintained throughout.

Jigsaw. This idea of learning with a clear purpose in mind is a mainstay of all the components of the Community of Learners. In particular it carries over to our version of Aronson's (1978) jigsaw classroom. Students are asked to undertake independent and collaborative research. As researchers, they divide up units of study and share responsibility for learning and teaching their piece of the puzzle to each other.

How does this work? Classroom teachers and domain area specialists together decide on central abiding themes visited at a developmentally sensitive level. Each theme (e.g., changing populations) is then divided into five or six subtopics (endangered species, rebounding populations, introduced species, etc.), dependent in part upon student age and interest. Each group of students conducts research on one subtopic, and then shares its knowledge by teaching it to others.

As a concrete example, recent classes of *second graders* chose to study animal/habitat interdependence. Some children studied how animals protect themselves from the elements or from predators. Others became experts on animal communication or reproductive strategies. Still others studied predator/prey relations. Design teams were then formed that create habitats for an adopted animal or invent an animal of the future. These design teams were configured so that each member had conducted research on part of the knowledge. In each group someone knew about predator/prey relations, someone could talk wisely on the strengths and weaknesses of possible methods of communication, and so forth. All pieces are needed to complete the puzzle, to design the habitat, hence jigsaw. By these methods, expertise is distributed deliberately.

Majoring. Expertise is also distributed by happenstance. Variability in expertise arises naturally because of the different research paths followed by groups and individuals. We refer to this phenomenon as *majoring*. Children are free to major in a variety of ways, free to learn and teach whatever they like within the confines of their subtopic. Some become experts on disease and contagion, some concentrate on bizarre reproductive strategies; others major in pesticides or pollution. All contribute their specific knowledge, thereby enriching the intellectual resources of the community.

Let us consider just one example of majoring: *delayed implantation*. This is a reproductive strategy whereby fertilized eggs lay dormant inside the female until environmental conditions are suitable for the survival of offspring, at which point the eggs begin to develop. This principle was discovered by some fifth graders last year, but not by previous cohorts. At least 9 months after their discovery, a group of now sixth graders told me about another example of the principle, the Minnesota Mink, that they had seen in a television program. According to my informants (my commentary in brackets):

- Minks breed aggressively in late winter because their thick coats will protect them from bites and scratching.

[This was an inference. On the program, we learned only that mink shed their valuable heavy winter coats for light summer ones. And the mating minks did look like they were engaged in strenuous activity. The inference was actually an example of transfer of prior knowledge from an animal these students had previously studied, the sea otter, with a heavy coat and notably rough mating habits.]

- The females mate with as many males as possible, and subsequent litters consist of pups that are fathered by more than one male. The students argued that this increased the variability of the gene pool [a biologically appropriate inference].
- The last male to mate has more pups, because, the students argued, if he could still mate at the end of the season, he must be pretty strong [inference based on a Spencerian/Darwinian notion of survival of the fittest].
- The fertilized eggs just sit there, another child corrects, lie dormant, until it is spring, and then start to develop.
- Pups are partly "acquarian." [I think they meant aquatic.]

The point about my story is not the demonstration of long-term retention of facts, or the assimilation of new facts about a complex biological mechanism, or even the inferential powers the students displayed. It is their excitement about what they are learning sustained over considerable time, and at their own expense (they were no longer accountable for this topic). I was impressed by their confidence in their own developing knowledge and their belief that this is something that the community will respect and value. And by way of metaphorical extension, delayed implantation is what we do with ideas—plant them in the community and hope they come to fruition when the time is ripe.

The Role of Performance. In telling their story, these students were putting on a performance, for my benefit. Everyone in the community is at some stage an actor and an audience. Regular exhibitions to a variety of audiences are an important component of the community. The sense of audience for one's research efforts is not imaginary, but palpable and real. Audiences demand coherence, push for higher levels of understanding, require satisfactory explanations, request clarification of obscure points, and so on. Students do not have to deal only with a single audience, the teacher, as they often do in school.

These opportunities to display provide an element of reality testing, also an important feature of many of the school activities such as dramatic plays put on by boys' and girls' clubs (Heath & McLaughlin, in press). Such groups typically engage in seasonal cycles of planning, preparing, rehearsing, and finally performing. There are deadlines, discipline, and most important, reflection on performance. So, too, in the COL we have cycles of planning, preparing, practicing, and teaching others. Deadlines and performance demand the setting of priorities—what is important to know? What is important to teach? What of our newfound knowledge do we display?

The Classroom Teacher. The classroom teacher is not absent from these proceedings. She learns along with the children as well as assists their efforts. In addition, she periodically calls the whole class into conference to consider the main theme and the relation among the research activities. The aim is to lead the students to higher levels of thinking and to help them set goals for future research. These whole-class discussions provide a reflection period in which to take stock of where they are and where they want to be.

Extending the Learning Community

Inside the School

For the program to run optimally, adults other than the classroom teacher are needed to guide the learning activities. But we have to live with the feasible. How many extra bodies can there be? Parenthetically, I note that at its peak, Dewey's (1936) Laboratory School had a 4:1 child/adult ratio, not counting adult experts. Because this is unrealistic, the COL relies heavily on the expertise of the children themselves. We use cross-age teaching, both face-to-face and via electronic mail. We use older students as discussion leaders guiding the reciprocal teaching or jigsaw activities of younger students. Such tutoring extends the teaching "capital" available to our students, but it is also a formative aspect of community building.

Outside the School

Any learning community is limited by the combined knowledge of its members. Within traditional schools, members draw on a limited knowledge capital if the faculty and students are relatively static. Or they face jarring discontinuity if there is rapid turnover, as is the case in many inner-city schools. In addition, both teachers' and students' expectations concerning excellence, or what it means to learn and understand, may be limited if the only standards are local.

Schools are not islands. They exist in wider communities, and we rely on them. For example, experts coaching via electronic mail provide us with an essential resource, freeing teachers from the sole burden of knowledge guardian and allowing the community to extend in ever-widening circles of expertise.

Principles of Learning

A major part of my personal effort in the design experiment (Brown, 1992) of creating community is to contribute to a theory of learning that can capture and convey the core essential features. The development of theory is critical for two reasons, conceptual understanding and practical dissemination. The development of theory has always been necessary as a guide to research, a lens through which one interprets, that sets things apart and pulls things together. But theory development is essential for practical implementation as well.

It is for these reasons that we have been concerned with the development of a set of first principles of learning to guide research and practice. But in this light, it is a sobering thought that for decades the Progressive Education Association of America produced sets of principles (usually 9) every few years, principles that were so vague that they could not lead to a convergence in practice of any kind (Graham, 1967). They included: freedom to develop naturally; work guided by interest; cooperation between home and school; community building; teacher as guide, not taskmaster. All these are principles that I would agree with and will probably reiterate. But what does developing naturally mean? How does one follow interest and guide learning while at the same time helping chart legitimate

pathways of intellectual inquiry? Without more specificity, more models, more documentation, more evaluation, these principles become part of a common vocabulary, but influence practice little. Descriptions of current "innovative" programs also share a family resemblance in rhetoric, but again one might ask, do they result in any consensual practice? My own rhetoric in describing principles of learning is far from safe from these criticisms.

And the problem of dissemination is a real one. As a cautionary tale, consider the fate of reciprocal teaching. The program has enjoyed widespread dissemination. It has been picked up by researchers, teachers, and textbook publishers, and has become part of the discourse of the educational community. But too often something called reciprocal teaching is practiced in such a way that the principles of learning it was meant to foster are lost, or at best relegated to a minor position. The surface rituals of questioning, summarizing, and so forth are engaged in, divorced from the goal of reading for understanding that they were designed to serve. These "strategies" are sometimes practiced out of the context of reading texts. Quite simply, if one wants to disseminate a program on the basis of principles of learning rather than surface procedures, one must be able to specify what those principles are in such a way that they can inform practice.

Adaptation and modification are an organic part of any implementation process. When working with new teachers, we encourage *implementation as evolution* (Majone & Wildavsky, 1978) *constrained by first principles.* Here, by way of illustration, we will discuss a few of these first principles of learning. A more complete list is given in Brown and Campione (1984).

Steps Toward Learning Principles of the COL Program

1. *A great deal of academic learning, though not everyday learning, is active, strategic, self-conscious, self-motivated,* and *purposeful.* Effective learners operate best when they have insight into their own strengths and weaknesses and access to their own repertoires of strategies for learning. For the past 20 years or so, this type of knowledge and control over thinking has been termed *metacognition* (Brown, 1978).

Interest in things metacognitive is, of course, not new; it is just that a concentrated period of research has reaffirmed what was already known but not established very well. And that *is* progress. A little recognized progenitor of this position was actually Binet, known in this country primarily for the introduction of intelligence testing. Binet was also interested in the education of the child-like mind. True to the newfound confidence in testing, Binet designed tests of what he called *autocriticism* to root out metacognitive lacunae. For example, what is wrong with these sentences?

- An unfortunate cyclist fractured his skull and died at once; he has been taken to the hospital and we are afraid he won't be able to recover.
- Yesterday we found a woman's body sliced in 18 pieces; we believe she killed herself.

Gruesome Victoriana indeed, but as Binet pointed out, "You would be surprised at how many of the thoughtless young are quite happy with this nonsense."

"Apres le mal, le remede." Binet believed diagnosis to be of little use if it were not followed by remediation. "If it is not possible to change intelligence, why measure it in the first place?" Given this philosophy, not shared by many in the early part of the century who began to believe in the immutability of IQ, Binet developed a remedial curriculum for the "thoughtless young." The curriculum, called *Mental Orthopedics,* was intended to strengthen the child's "unreflective and inconsistent mind." As the thoughtless child "does not know that he does not understand," he needs help "to observe, to listen and to judge better." The curriculum was specifically designed to train, in Binet's terms, "habits of work, effort, attention, reasoning and self-criticism," leading to the "pleasures of intellectual self-confidence" (all quotations from Binet, 1909). Unfortunately for us, he was more than a little vague about how we might do this. Actual descriptions of the training or its outcomes do not survive, a problem in general for past innovative programs.

One might argue that all this talk of strategies and metacognition is silly. Who indeed would want passive, unmotivated, purposeless, indeed mindless, learning? There is certainly a place for mindlessness in human learning; a great deal of learning does occur incidentally, and humans have reasoning biases that allow them to get by on this most of the time (Bartlett, 1958; Tversky & Kahneman, 1974). But scholarship, the domain of schools, demands intentional learning (Bereiter & Scardamalia, 1989). In this context, who could possibly argue against mindful learning? My point is not that peopled argued *against* mindful learning; rather, that they did not campaign actively *for* it. Remember, a belief that rote learning trains the mind has been around for a long time. Advocates of fact acquisition, in and of itself and by whatever means, still stalk the land. One legacy of behaviorism was a concern with capturing the mind in spite of itself. Understanding and reflection were not prominent features of the psychological learning theories of the mid-century. The need for a resurgence of interest in mind and its uses was overdue.

2. *Classrooms as Settings for Multiple Zones of Proximal Development.* I take it as given that learners develop at different rates. At any time they are ripe for new learning more readily in some arenas than others. They do not come "ready for school" in some cookie-cutter fashion.

The central Vygotskian notion of zones of proximal development is one of learning flowering between lower and upper bounds of potential, depending on environmental support. Bacon's aids, tools, and guides to perfect mind serve to push as much as possible toward the upper bounds of competence. This is also a position that needed to be reinvented. The set of influential contrasting theories that has influenced American schools include errorless learning, mastery learning, skill building, and so on: All attempt to aim instruction at the child's existing level of competence, often interpreted as lower levels of performance. Indeed, many interpret Dewey as suggesting emphasis on lower bounds when he argued in favor of teaching to the child's level. I argue that an essential role for teachers is to guide the discovery process toward forms of disciplined inquiry that would not be reached without expert guidance, to push for the upper bounds.

3. *Legitimization of Differences.* A central principle of COL is that individual differences be recognized and valued. I borrowed the term from studies of out-of-school learning (Heath, 1991), but I also see reflections in Howard Gardner's (1983) concern for fostering multiple intelligences in

school and Lave and Wenger's (1991) description of multiple ways into communities of practice.

Can we do this in schools, can we rejoice in diversity? What if classrooms were designed explicitly to capitalize on varieties of talent to provide multiple "ways in"—through art, drama, technological skills, content knowledge, reading, writing, teaching, social facilitation, and so forth? Indeed, it is very much our intention to *increase diversity* in COL classrooms.

Traditionally, school agendas have aimed at just the opposite, decreasing diversity. This tradition is based on the false assumption that there exist prototypical, normal students who, at a certain age, can do a certain amount of work, or grasp a certain amount of material, in the same amount of time (Becker, 1972). In our program, although we assuredly aim at *conformity on the basics* (everyone must read, write, think, reason, etc.), we also aim at nonconformity in the distribution of expertise and interests so everyone can benefit from the subsequent richness of available knowledge. The essence of teamwork is pooling expertise. Teams composed of members with homogeneous ideas and skills are denied access to such richness.

4. *A Community of Discourse.* It is a common belief that higher thought is an internalized dialogue. To foster this we create the active exchange and reciprocity of a dialogue in our classrooms, which are intentionally designed to foster interpretive communities (Fish, 1980). The sociologist Wurthnow (1989) argued that changes in communities of discourse led the way to powerful movements in society—the Reformation, the Enlightenment, and European Socialism. At a less grandiose level, our baby COLs foster change by encouraging newcomers to adopt the discourse structure, goals, values, and belief systems of the community. Ideas are seeded (or implanted) in discussion. Sometimes these ideas migrate throughout the community via mutual appropriation and negotiated meaning, sometimes they lie fallow, and sometimes they bloom. These interpretive communities (Fish, 1980) give place to multiple voices in Bakhtin's (1986) sense of voice as the speaking personality.

5. *Community of Practice.* Learning and teaching depend heavily on creating, sustaining, and expanding a community of research practice. Members of the community are critically dependent on each other. No one is an island; no one knows it all; collaborative learning is not just nice, but necessary for survival. This interdependence promotes an atmosphere of joint responsibility, mutual respect, and a sense of personal and group identity.

These five principles are closely intertwined, forming as they do a *system.* Multiple zones of proximal development presuppose distributed expertise, distributed expertise presupposes legitimization of differences, and so on. Two final pairs of principles form systemic clusters: (a) the need for *deep conceptual content* that is sensitive to the *developmental level* of the students; and (b) the need for assessment procedures that are authentic, transparent, and aligned with the curriculum (Frederiksen & Collins, 1989). I have space to discuss just the first set.

Need for a Theory of Development

I am reminded of a story told by Jerry Bruner in his book *Actual Minds, Possible Worlds* (1986). After he had given a presentation, a member of the audience stood up and said she had a question about his claim that any subject could be taught to a child at any age in some intellectually honest way. Bruner was expecting the usual question about calculus in the first grade. But no, the question was much more thoughtful: "How do you know what's honest?" Now that really is the pivotal question.

It is not an easy question to answer. Most contemporary school reform projects finesse the problem by adopting a "one-size-fits-all" philosophy. The principles and structure of the program are the same, independent of age. The developmental model is missing. Of course, from some theoretical stances, learning and development are synonymous: learning = development; development is simply the outcome of learning, a truly Skinnerian argument.

Implicit developmental assumptions are governing school practices nonetheless. We teach the young social studies in reference to their own neighborhood. Why? Because someone decided this was developmentally appropriate? A unit on boats was thought suitable for third graders at the Lincoln School, and 6-year-olds in the Chicago Lab School studied "occupations serving the household." Why do we teach fractions (American history, biology) when we do?

It is traditional in educational circles to make up developmental theory. My favorite example is that of G. Stanley Hall, sometimes called the father of developmental psychology. Brushing aside the need for empirical validation, Hall (1881) championed a developmental-stage theory made up of cultural epochs, a notion subsequently picked up by Dewey. Hall argued that a curriculum should mimic the history of mental evolution. Young children at the "savage" stage should study material from the corresponding historical epoch, that is, ancient myths and fables. High school boys should study the knights of the feudal period because, developmentally, they were in the period of chivalry and honor. Young women were not accorded a corresponding period! There existed no scientific justification for these developmental stages whatsoever.

This story is not just one of historical curiosity. In contemporary curriculum design, in both science and history, a simplistic interpretation of Piagetian theory has led to the consistent underestimation of young students' capabilities. This slant on Piagetian theory encourages sensitivity to what children of a certain age *cannot* do because they have not yet reached a certain stage of cognitive operations. The "theory" still prevails in the face of 30 years of ingenious work by developmental psychologists emphasizing the impressive cognitive abilities that children *do* possess. Especially relevant to the design of, for example, science curricula is the painstaking documentation of children's evolving knowledge about biological and physical causality. Similarly, we know a great deal about children's impressive *reasoning* processes within contexts that they do understand. Again my point is that the design of school practice is influenced by theories of development more typical of the 1950s than the 1990s.

It is essential to the philosophy of the COL that the students be engaged in research in an area of inquiry that is based on deep disciplinary understanding, and that follows a developmental trajectory based on research about children's developing understanding within a domain.

Deep Disciplinary Understanding. Although it is surely romantic to think of young children entering the community of practice of adult academic disciplines, awareness of the

deep principles underlying disciplinary understanding enables us to design academic practice for the young that are stepping stones to mature understanding, or at least are not glaringly inconsistent with the end goal. For example, in the domain of ecology and environmental science, a contemporary understanding of the underlying biology would necessitate a ready familiarity with biochemistry and genetics, not within the grasp of the young. Instead of watering down such content, we invite young students into the world of the 19th-century naturalist, scientists who also lacked modern knowledge of biochemistry and genetics. Ideally, by the time students are introduced to contemporary disciplinary knowledge, they will have developed a thirst for that knowledge, as indeed has been the case historically.

Developing Understanding Within a Domain. I take seriously the fact that a scientific understanding of the growth of children's thinking in a domain should serve as the basis for setting age-appropriate goals. As we learn more about children's knowledge and theories about the biological and physical world (Carey & Gelman, 1991), we are better able to design a spiraling curriculum such as that intended by Bruner (1969). Topics are not just revisited willy-nilly at various ages at some unspecified level of sophistication, as is the case in many curricula that are self-described as spiraling, but each revisit is based on a deepening knowledge of that topic, critically dependent on past experience and on the developing knowledge base of the child. It should matter what the underlying theme is at, say kindergarten and Grade 2; it should matter that the sixth-grade students have experienced the second-grade curriculum, and so on.

In designing the ecology/environmental science/biology strand, we seek guidance from developmental psychology concerning students' evolving biological understanding (Carey, 1985; Hatano & Inagaki, 1987). We know that by age six, children can fruitfully investigate the concept of a living thing, a topic of great interest that they refine over a period of years, gradually assimilating plants into this category. Second graders concentrate on design criteria for animal/habitat mutuality and interdependence. Sixth graders study the effect of broad versus narrow niches, and by eighth grade the effect of variation in the gene pool on adaptation and survival is not too complex a research topic. Whereas second graders begin to consider adaptation and habitats in a simple way, sixth through eighth graders come to distinguish among structural, functional, and behavioral adaptations, biotic and abiotic interdependence, and so forth.

Similarly, a consideration of extant research governs our approach to reasoning within a domain. Again in biology, we permit teleological reasoning (Keil, 1992) and an overreliance on causality, but then we press for an increasingly sophisticated consideration of chance, probability, and necessity that underlies mature disciplinary thinking.

Let us not forget domain-general scientific reasoning (Brown, 1990) if such exists. Do children understand the difference between hypothesis and evidence? What is their understanding of "the scientific method"? Indeed, what should it be? Francis Bacon's or Karl Popper's? Dare we share with them the insights of Peter Medawar that scientists as human beings do what everyday people do? They are *not* omniscient. They tell good stories, they create imaginary worlds. Indeed, the scientific method itself

> like any other explanatory process is a dialogue between fact and fancy, the actual and the possible, between what could be true and what is in fact the case—it is a story of justifiable beliefs about a possible world. (Medawar, 1982, p. 111)

And then there is the age-old problem for a developmental psychologist— transition mechanisms. What triggers conceptual change? In short, the amount of work involved in mapping a spiraling curriculum that is truly developmentally sensitive is quite overwhelming. But it would be more so if we fail to capitalize on the impressive amount we already know by throwing out the bathwater *and* the babies.

Conclusion

There is a conundrum running throughout this article. I have argued that:

- School practices are influenced by outmoded theories of learning and development that are relics of psychology's behaviorist past;
- Contemporary theories are better suited to inform the design of schooling because they take as their data base the learning of complex systems of knowledge characteristic of what we want schools to enculturate; and
- The new theories are making little headway at influencing school practices.

To quote Bacon again, "All things change, but nothing perishes." Why? I argue that this is because what the new theories ask is *so hard*. It is easier to organize drill and practice in decontextualized skills to mastery, or to manage 164 behavioral objectives, than it is to create and sustain environments that foster thought, thought about powerful ideas. We are asking a great deal from everyone in the learning community. But we know a great deal more about how to do it now than a century ago. Advancement in our understanding of learning is slow but real.

So, I conclude with a paraphrase of quotations from John F. Kennedy, Lee Shulman, and Jerry Bruner, to show my catholic tastes:

> "We choose to do this, not because it is easy, but because it is hard." (Kennedy, 1962)

> "Those that understand, teach honestly." (Shulman, 1986, p. 14)

> Those that teach honestly teach ideas that are "lithe and beautiful and immensely generative." (Bruner, 1969, p. 21)

I believe that a century of research has helped us know what these ideas are and better prepared us to design instruction in the form of aids and tools to perfect hand and mind.

Notes

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[1]For descriptions and retrospectives on the major psychological learning theories of the mid century, see Koch (1959).

[2]Koch, 1959.

[3]Koch, 1959.

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