NEW CLASSROOMS, NEW TEACHERS

New brain scans will take almost instantaneous pictures of brain activity.... And new MRIs, hardly bigger than a salon-size hair-dryer, will tackle the most challenging question of all...: how the brain develops. The MRIs will safely image the brains of children, and show step by step how the most complicated information-processing device in the world becomes wired. Not far off: using the discoveries of neuroscience to retool education. Does musical training prime the synapses for learning math? How do some brains hold thousands more vocabulary words than others? The answers may point the way to new teaching techniques.

Sharon Begley, *"Uncovering Secrets, Big and Small"*

3.1 The Quandary for Contemporary Education: What's at Stake

The challenge to language instruction

In the past, a relatively small number of children were required to be literate. Jobs for unskilled workers were available, providing money for a tolerable or even comfortable life. Now, to survive economically in the United States, adults must not only read and write but, in many instances, be computer literate. Most children with access to school learn to write and read, or they did until recently. Now schools face increasing numbers of "learning disabled" children. In addition, schools must teach every child to read and write adaptively with an eye toward future information systems for which no procedures or rules yet exist.

Traditional approaches to literacy education were effective for students who came from households where talking, reading, writing, singing, and game-playing were the norm. Many students no longer come from language-rich households. Children passively receive language from television. Television is not a conversational medium; research shows that infant brains respond to radio and television talk as sound, not as language. To acquire language, children's brains require a steady stream of emotionally charged, engaged adult language or "Parentese." Lacking adequate exposure to language learning at home, some second- and third-graders speak hesitantly, and are not ready to read or write. What is to be done?

Replacing links

When children fail to crawl, a developmental processing link may be missing. Strategies for remediating learning disabilities include crawling, with the belief that recapitulating a step in motoric development will correct some deficit in cognition. Similarly, research suggests that an early education program featuring touch, regressing children back through the stages of language acquisition, provides them with an optimal language learning environment.

The use of touch

We learn a mother tongue from our earliest caretakers; if our caretaker is a wolf, we learn how to howl. Stories about feral children raised in the wild by animals, as well as stories about children locked in closets, demonstrate the importance of early language-learning. Children who fail to acquire language normally have a very difficult time acquiring it later. If innate grammar is not triggered early, it will be hard if not impossible to lay language down, and the use of that specific language will never be as expressive as it would have been if it were acquired during early childhood. Intensive, highly tactile therapy is necessary to introduce language to a person who has been deprived of early language learning. Books like Harlan Lane's The Wild Boy of Aveyron (1976), Helen Keller's autobiography, The Story of My Life (1908), and Jill Paxton Walsh's Knowledge of Angels (1995), as well as the movie "Nell," describe the struggles of language-deprived children.

Harlan Lane taught the wild boy of Aveyron how to speak by placing his fingers on the wild boy's lips and by placing the boy's hand on his own throat while he was speaking. Annie Sullivan did the same highly tactile work with Helen Keller. Both teachers showed their pupils how spoken language felt. Annie drew words on Helen Keller's palm; Helen could feel the shapes of written words. Lane used touch/writing on the palm of the feral boy in this way, too. Maria Montessori also valued learning through touch. When teaching the alphabet to young children, she encouraged them to run their hands over large, beautiful wooden letters, or over the shapes of letters covered with sandpaper. The students felt the shapes of the letters intensely with their fingertips, learning all the more readily to know them with their eyes. Research with young children who have learned to play the violin before the age of eleven demonstrates that their fingertips are more sensitive to electric sensation than the fingertips of students who learn to play the violin when they are older. The area for the retinotopic map for the fingertips is larger in these children's brains than in the brains of children who learn to play the violin later. What registers at the fingertips as enhanced sensitivity registers in the brain as sensibilities.

Braille allows blind people to read by touch. A word projected in rays of light on the bare back helps the blind to read, too. Even though no information reaches the brain through the eyes, touch and light stimulate the visual cortex; the result is visualization or internal sight. Visually-impaired patients who receive corneal transplants discover that they still have to touch things to recognize them. The activity of seeing is so difficult for long-blind patients that some prefer navigating by touch, choosing to live in the dark even after the transplants (Zajonc, 1993, 4).

There are certain periods in children's lives when they are particularly receptive to learning certain skills. For instance, the critical period for verbal communication is somewhere between the ages of six and twelve. The 1797 study conducted by Jean-Marc Itard demonstrated that the approximately twelve-year-old "wild boy" was never able to master speech. Brain research suggests that hormonal changes in puberty terminate the brain's flexibility for language. Current research ("Your Child," Newsweek, Spring/Summer supplement, 1997) defines the critical period as birth through three years, with the first six months being crucial for the development of the neural nets responsible for abstract thinking. Intensive, child-centered early language learning programs, including an emphasis on touch, promote healthy brains.

3.2 Where Neurobiology and Classroom Practice Intersect

The neurobiologist's ability to monitor brain activity reveals information with significant implications for teaching and learning. The results of magnetic resonance imaging, or MRIs6, can be computer-imaged and color-coded for brain activity. Highly-lit areas requiring more oxygenated blood may indicate normal activity or over activity. A lower level of activity may indicate a more efficient use of oxygen, rather than an understimulated area. Dyslexic brains struggling with language reveal hard-working, oxygen-depleted language areas.

In 1986, psychology professor David Andrews of Keene State College in Keene, New Hampshire, conducted a study with dyslexic teenage boys. Andrews reported that, after studying EKG-based computer images of their own brains at work, these boys were motivated to devise successful personal learning strategies. The potential value of brain-imaging to student-designed curricula became apparent. When I visited Andrews in the late 1980's, I envisioned the future use of "thinking caps" in the classroom (Sheridan, 1991) currently predicted by Newsweek (Begley, 1997).

Because cross-modal thinking is natural, it is logical to assume that students will invent cross-modal curricula. At least at this time, most students are unable to observe EKGs and MRIs of their brain activity. Educators can, however, provide cross-modal guidelines and
models as well as information from brain science, encouraging students toward self-directed learning.

Neurobiology and reading deficits

Explanations for reading difficulties include visual problems (Geiger & Lettvin, 1987) and aural problems (Shaywitz, 1995, 1996). Solutions to visual problems range from parafoveal reading to colored glasses; aural solutions continue to include one-on-one tutoring in letter-to-sound correspondence, or phonics, as well as sound therapy (Gilmore on the Tomatis Method, 1989). The phonological deficit model describes the problem as the inability to break words into constituent sounds. Most children learn to break down the word "cat" into the letters "c" "a" "t" and to sound the word out: "kuh" "aah-tuh." Phonological processing at the level of speech is automatic for children. Dyslexic children do not usually have trouble with speaking.

Yale Medical School researcher Sally Shaywitz writes: "Speaking is natural, and reading is not. Reading is an invention and must be learned at a conscious level. The task for the reader is to transform the alphabet into sounds; dyslexia is difficulty with breaking words into their basic units, or phonemes" (Shaywitz, 1995).

In a study conducted by Sally and Bennett Shaywitz, a sounding-out activity revealed gender differences: "The men used a tiny area of their brain about a centimeter in size...near Broca's region," an area on the left side of the brain used in producing speech. Women used this region, too, but they also used the corresponding area on the right side of the brain. By identifying normal processing patterns, MRIs of children with abnormal patterns should allow parents and educators "to reliably detect young children who will have reading disabilities before they are faced with the daunting task of learning to read." The Shaywitzes concluded, "It may be possible to design ways to help these children overcome or even avoid the coming struggle" (Shaywitz, 1995).

Brains equipped with bilateral strategies burn brain fuel more efficiently and solve problems faster than brains working monolaterally. Female dyslexic brains not only over-metabolize glucose when reading, but may read in a more lateralized, less bihemispheric manner than non-dyslexic females. MRIs will help to clarify the degree to which significant differences in metabolic profiles exist in connection with gender and dyslexia.

Mature reading and writing skills are visual

Mature reading skills do not depend upon phonetic linguistic analysis (Rubin, 1989) but involve skills more fairly described as visual or spatial. Research on the "psychogenetics" of writing suggests that early attempts at writing are not a transcription of spoken language but may more accurately be described as an offshoot of drawing (Ferreiro, 1979; Vygotsky, 1979). In fact, teaching writing as if it were a transcription of spoken language may be troublesome for many children, even creating learning disabilities (Ferreiro, 1979). This information provides further support for drawing as a bridge into writing and reading. In fact, drawing presents a range of benefits to pre-readers and pre-writers without (forgive the pun) drawbacks.

A research proposal

1. If the two-week Drawing/Writing program is used at the beginning, middle and end of the academic year, accompanied by on-going drawing-based approaches to writing and reading throughout the rest of the year, dyslexic children will think about writing and reading either as extensions of drawing or as closely associated with drawing. This change in attitude about the nature of writing and reading places these activities within the Vygotskian continuum for the child, allowing him to write and read more easily as part of the natural unfolding of his mark-making process. Standardized tests, MRIs, and anecdotal evidence will demonstrate gains in writing, reading and thinking skills for these students. A comparison of pre- to post-Drawing/Writing brain scans will demonstrate changes in activity that may then be identified as indicators of improved brain function. There may or may not be a standard dyslexic brain pattern for students who think of writing as an advanced or more abstract form of drawing.
2. By using Drawing/Writing as described above, pre- and post-test writing and reading scores for experimental and control groups of pre-K, kindergarten, first, second and third graders recorded at one to five-year intervals will show a marked improvement in the experimental group.

The brain scans of children who are encouraged to recognize writing, reading and mathematics as logical extensions of drawing will produce MRIs which differ from those
of children who regard abstract symbol systems as discontinuous and non-related. This Drawing/Writing brain scan profile will be distinctive and characteristic. It may or may not be similar to scans of brains raised with calligraphic systems for writing.

A testable hypothesis

If Drawing/Writing is used pre-K through third grade, there will be a lower incidence of "dyslexic" students than in traditional language programs. The prediction is verifiable through performance-testing and statistics. Brain scans may identify the neural changes characteristic of integrative thinking. The neural profiles of dyslexic Drawing/Writing students can be compared on a pre- and post-test basis individually and collectively across gender to identify which neural patterns correlate with gains in writing, reading and thinking. These classroom scores and brain research patterns can be compared with non-dyslexic scores and patterns, making it possible to draw conclusions about the Drawing/Writing method as a remedial approach to writing and reading for dyslexic boys and girls.

Pieces of the puzzle

Several pieces of research support the drawing-based hypothesis outlined above:

1. Visual processing problems may occur due to the mis-organization of the retina; there may be too few visual cells in the macula, which is the area of greatest concentration of visual cells in the eye. Parafoveal vision, or reading off the center of gaze, is recommended for such students. Alternatively, the rods and cones in the retina may present information about wavelengths incorrectly. Words blur and dance on the page for some students. In some instances, colored glasses allow words to stand still for the reader; the supposition is that the colored glass corrects wavelength distortion. Both pieces of research suggest that visual processing problems for dyslexic students are mechanical, not cognitive. Drawing/Writing suggests a modified position: whether mechanical or cognitive, a change in thinking may help. Anecdotally, a second grader for whom colored glasses8 were prescribed for reading, writing and computer work, forgot his glasses on a day when he had

Drawing/Writing. He showed no difficulties with drawing or writing. His mother reports that her son does not need the glasses to draw, nor were the glasses prescribed for drawing. When this student draws, or when he writes in close connection with drawing, apparently he does not experience troublesome wavelength distortion or interference.

2. The blind learn to read through touch using their fingers or through sensations of lighted words shone on their bare backs. Their eyes may not be receiving light, but their visual cortices are functional. The impairment is mechanical and not cognitive. Some phonological deficits are mechanical and relate to receptor/transmitter problems in the inner ear. With certain dyslexic students, sound therapy has proven effective. Tones "fed" into one ear or another or both have remediated phonological processing difficulties (Gilmore on the Tomatis Listening Program, 1989).
3. The deaf learn to speak through touch, feeling vibrations in a speaker's throat, tongue and neck; they also learn to speak through gesture and vision, using sign language.
4. The blind can draw, and their drawings are like those of sighted people; they use foreshortening and converging lines to suggest depth (Kennedy, 1997). The innate templates for visualizing spatial relations are intact.
5. To learn to speak a language, children must hear language when they are very young. Yet the deaf can learn to speak through touch, even when they are older. Hearing must exert extremely powerful organizational pressure on the growing brain—even more so than sight. Or, the opposite may be true; the absence of child-directed, emotionally laden language may be more devastating to neural organization than the absence of optical information.
6. The brains of nuns whose written applications to religious orders included longer, more complicated sentences with emotional, evaluative, and speculative content were less likely to develop Alzheimer's disease than nuns who wrote more simply (Rogers, 1996). Writing more than simple sentences may structure brains for stronger neural networks which are less likely to fray and fragment. Language-use and mental health correlate at a structural/mechanical level.
7. By using bilateral strategies, female brains solve some mathematics tasks faster and more easily than male brains. Bilateral strategies may benefit all children.
8. Since drawing is innate and writing is not, and since speech is innate and reading is not, then drawing may furnish a bridge into reading as well as

> writing through sound. This bridge will be constructed by a drawing program in which writing and speech are emphasized.

Taking these pieces of the brain/language puzzle into account, guidelines emerge for remedial strategies for language deficits. Strategies for remediating difficulties with language will feature touch, gesture, and a continual language "bath" and will include drawing as a method of discovery informed by touch; this combined strategy should establish the necessary neural preconditions for writing and reading.

If this research is undertaken, the MRIs of brains engaged in drawing and writing will prove interesting in connection with gender and in connection with the incidence and effectiveness of bilateral processing. MRIs of brains doing Composite Abstractions should prove especially interesting. How does the metabolic profile of a brain drawing a CA differ from a brain that is writing or doing mathematics? Are there advantages to bilateral processing, in particular for the dyslexic student? If a combination of results—from standardized testing, statistics on dyslexia, and anecdotal reports—confirm the fact that training in Drawing/Writing raises students' verbal and quantitative scores while lowering the population of identified dyslexics, then encouraging brains to work in less specialized, more balanced, bilateral ways moves Drawing/Writing from a research topic to intelligent classroom practice.

Most good readers read visually, not phonetically. A deep memory of sound may remain but that memory is well below the level of conscious hearing. Fast readers rely on word recognition, or sight. If good readers process words visually, then training in drawing as visual decoding provides training in competent reading skills for all brains including those in which aural strategies are impaired.

Using MRIs as diagnostic tools, it will be increasingly possible to pinpoint, analyze and remediate language difficulties. Training in integrative coding should prove especially useful to brains in which language learning is delayed or dysfunctional.

Training in decoding

Training in decoding one kind of marks provides training for decoding another kind of marks. If the skill for decoding a drawing requires attention and visual searches, then that same set of skills can be used for decoding other symbol systems, like written language or mathematical notation. A student does not need to know the sound of a contour drawing to read it. A contour drawing has no sound. It has a shape to recognize. The shape has a feel to it. Reading a drawing depends on touch, or the memory of touch. Direct touch, as well as the memory of touch captured in drawing and in writing is a particularly integrative activity. Of all the senses, touch may be the most integrative of all. We speak about the "healing power of touch." We observe the popularity of massage therapy, including a field described as therapeutic touch. This expanded appreciation for the integrative power of touch highlights the importance of drawing to a new field of inquiry described by this book as Neurocontructivism—a field in which education, medicine, brain science and psychology coverage. In the context of Neuroconstruc-tivism, drawing becomes knowledge informed far more by touch than by vision, and vision becomes an extension of touch, allowing knowledge at a distance.

Light can be described as a unified wave/particle duality. So can the bihemispheric brain. Is there a connection between the physical natures of light and the brain? The visual brain is trained by light to apprehend the visible world. The act of sensing light organizes the brain to process light. A unified duality creates a unified duality. Sensations are felt, first, then seen or heard. Once seen or heard, all sensations are translated by the brain into one, identical electro-chemical signal. A forest of neural connections take that signal and make it into meaning. The extent of the translation is astounding. It is only slightly less astounding than the precision of the astronomically complex yet unitary system responsible for making meaning out of sunlight, the brain.

Multi-modal training for reading and writing readiness

The skills developed in Drawing/Writing are useful to visual and auditory processing in general. To write and read, the brain must arrange sets of information coherently.

Peer sharing, ongoing discussions, and group critiques guarantee that the sound as well as the sight of language is practiced in the classroom. Greater emphasis could easily be placed on phonological decoding and encoding. For instance, every time a word is written on the board, students could pronounce it. Dyslexic students with phonological deficits could volunteer to read words on the board.

The hypothesis that drawing affects writing positively has been tested (Sheridan, 1991). The hypothesis that drawing remediates hearing deficits can also be tested. Because of the high spoken content of Drawing/Writing, as well as persistent training in multi-sensory, cross-modal transference, the possibility of learning to connect specific sounds to specific letters—that is, to read—becomes a likely benefit of this integrative process.

A program for intelligent thought: Cues and stimuli

As Plato observed, wonder comes first; all else follows. The brain that attends, inquires. Brain research informs us that inquiry, or visual searches of interest, increase the brain's ability to attend. A dynamic circularity comes into play. The ability to pay attention increases the brain's capacity for work. The ability to think intelligently depends on the brain's ability to work attentively and efficiently.

The Drawing/Writing program teaches a student how to wonder about, select, describe, analyze and record information. Then, the program teaches students to speculate and hypothesize about this information. The procedure models scientific inquiry. Drawing/Writing is, in fact, a program for inquiry, encouraging students as the artists/scientists championed by Goethe (Zajonc, 1993, 194) and exemplified by Leonardo da Vinci. The artist/scientist is a time-tested and accessible educational model.

Research suggests that one kind of attentional activity can "tune up" the brain for another more demanding activity. Empirical research with Drawing/Writing demonstrates that students who write after they draw transfer attention and processing power to their writing. Because the Drawing/Writing program requires writing about the knowledge encoded in drawings, students reap attentional and motivational benefits from the act of drawing and also gain confidence as writers; drawing shows students that they come to the classroom already equipped with knowledge and that they can communicate this knowledge to others.

It is important for all students, especially students who lack confidence, to know that their brains are not empty vessels. Just because they lack educational opportunities, under-educated students do not have to lag behind forever. The Drawing/Writing program assumes that students, even very young ones, come to the classroom equipped with knowledge and skills, and that interest and growing skills in drawing can be used to encourage other kinds of skills. Because practice with spatial information creates neural structures necessary for linguistic processing, drawing acts not only as an attentional and affective cue but as a neural net-weaver, too.

Implications of brain science for early education and I.Q.

Early education has lasting neural consequences which profoundly affect the structure of the developing neuron system (Fite, 1993). Strategies like Drawing/Writing can be introduced as soon as a child can hold a crayon or a marker and continue at regular intervals from kindergarten through secondary school and beyond. It is as important at the most advanced educational levels to be able to visualize and verbalize as it is at the earliest levels. In fact, at highly abstract levels, visualization, including manipulation of three-dimensional models, is the most direct way to grasp certain concepts.9 Minds trained in direct, physical manipulation of information are prepared to understand complex theoretical models; in addition, minds trained in the CA will expect to check their theories back against physical models and to modify solutions over time in response to new understandings. If children's literacy education teaches them to use visual and verbal languages not only adaptively but intelligently, those children's minds, or intelligence, will respond effectively to changing conditions.

Modifying expectations: A whole mind approach

The Drawing/Writing program is based on a "whole mind" approach. Cross-modal strategies mirror the interhemispheric, integrative, global aspects of brain operations. The name of the philosophy supporting the WholeBrain program is "The Thinking Child." The Drawing/Writing program focuses on the child primarily as a thinker, tempering expectations about mental milestones with "periods of grace," or educational lag-time. Lag-time is required for several reasons:

- Some students trail behind because of developmental delays and
- Some trail behind because of deprivation.

It is far more important for students to learn to read and write and think effectively over a lifetime than for all students to learn to write and read in the first grade. As Harvard psychologist Robert Kegan so aptly wrote, those who teach "attend upon the child" (1982). The teacher who uses training in drawing to provide a grace period for writing and reading demonstrates attentive patience.

Sustained attention and information manipulation strategies are learned skills. Because children's brains require training in a range of basic skills including attention, language-use, and thinking, and because many children are not receiving this training at home for a variety of reasons, school language programs are under considerable strain. Students' brains consolidate specific neural networks within certain time periods. For example, the visual system consolidates by about age twelve. Educators have identified the middle school years as a time when children's brains construct certain strategies like generalization and abstraction. If the first six months of language experience influence or even determine later abstract reasoning abilities—as news magazines attest—we may have to radically rethink cognitive parameters.

The Drawing/Writing program provides empirical, visual evidence that children of kindergarten age can construct fractal drawings and Composite Abstractions. It is safest to provide broad-gauge teaching and learning strategies which allow children to make their own mental breakthroughs into symbolic reasoning when they are ready to do so on their own visual and verbal terms. As parents and teachers, we must equip them with the visual and verbal tools for making these breakthroughs. Children cannot think about or know what they cannot express.

Students are ripe to learn about tolerance and right relationships at certain times, too. The emotional learning on which empathy and compassion rest occurs in the first three years of life (Begley, 1996, 1997). Still, one particular child's time for ethical understanding may not be another's, as one child's time for abstract similes may not be another's. My son, Samuel, invented his first metaphors—rainbow noodles and zebra trees—at the age of three. A language program which provides a range of approaches and time frames accommodates a range of learners. To be the most effective, the opportunities must be provided when children are very young. Currently, the optimum window of time for language stimulation in connection with neural bases for abstract reasoning skills is believed to be birth through six months (Begley, 1997). If correct, this information changes qualitatively the level of discourse with infants.

3.3 Literacy Education in Context

A low-tech approach in a high-tech society

Modern technology poses serious problems for undereducated students and overstressed schools. How will barely literate students deal with information? How will minds ill-equipped with adaptive strategies respond to rapid change? How will students with little or no access to computers acquire technological skills?

To teach competent visual and verbal information processing skills, classrooms do not absolutely require computers nor do they absolutely require teachers with computer skills. High-tech skills can be learned through low-tech programs.

Although we cannot add one more teacher to every classroom, we can add a strategy that makes every student at least to some degree into a teacher. We can also provide a literacy program which teaches every student how to process information competently, providing, as a dividend, training in an approach that resembles scientific inquiry. Technical/vocational schools can add Drawing/Writing to their curricula, adding a hands-on approach to literacy, too.

A humanistic education

This book recognizes human beings as noble in reason. The terms cross-modal, WholeBrain, and Neuroconstructivist redefine humanistic education—the privilege of so few in the Renaissance—as a general requirement, now.

> *What a piece of work is man,*
> *How noble in reason,*
> *How infinite in faculty,*
> *In form and movement how express and admirable,*
> *In action how like an angel,*
> *In apprehension how like a god.*
> *The beauty of the world*
> *The paragon of animals*
>
> *William Shakespeare, Hamlet, Act II, scene 2.*

During the Renaissance, a new emphasis was placed on the mind. Instead of being suspect or even the locus of hubris, or overweening pride, reason and logic were acknowledged as positive attributes. The mind was recognized as a tool and an organ for knowing God and what is good. By placing an emphasis on knowledgeable humanity instead of on an all-knowing god, the Renaissance expressed a change in attitude toward the human mind.

It is challenging to accept something as elevated-sounding as a "humanistic education" as a practical necessity. Still, this is what is currently required. A humanistic education places the child as thinker at the center of its ethos and its strategies. "The Thinking Child"—the curricular design program introduced by this book—focusses on the importance of the child, emphasizing two points:

- The child is not a little adult equipped with full adult reasoning powers in a smaller body.
- On the other hand, the child is not a blank slate.

The brain of the child is like the Rosetta Stone: it is carved with codes. One code provides the key to others. Once the brain of the child cracks the visual/spatial code, it is prepared to crack verbal/linguistic codes. Through extensive practice with drawing as a visual code, the brain learns to write and calculate more easily.

The child mobilizes its primary spatial code through exploratory motion. Crackling and bubbling with exuberant synaptogenesis, the pure potential of the embryonic brain kicks and thrusts, gestures and reaches, creating neural templates for thinking and learning. Equipped with these organizational templates—this deep spatial grammar—the fetal child primes its brain for other codes, including language.

There are two aspects to the practicality of a humanistic education:

1. the more deeply engaged, successful, and happy students are, the happier and more successful schools, families and society will be. To be successful as well as happy, students must acquire skills necessary for economic and social survival. When activities that make students happy and also successful intersect, an opportunity for exciting educational design presents itself.
2. Many students are miserable, making schools miserable places to be. This misery is attributable in part to a lack of recognition or encouragement of students as thinkers. Brain science demonstrates that students' brains are destined to become artistic, literate, scientific, philosophical and aesthetic, at least, whatever else their brains may become. Something must be done about the fact that students, teachers, parents and employers are dissatisfied with the current state of affairs in schools. If classroom practice can meet the mental and emotional needs of students and bear on the larger requirements in students' lives, including successful family dynamics and job market viability, then some compromise will be achieved between the mind of the child, the needs of the family and the exigencies of society.

Because the brain is an organ for inquiry, the mind must be allowed and encouraged to question and to wonder. Because the brain is an organ for expression, the mind must be allowed and encouraged to express itself. To do so, the brain requires training and opportunity. To be a meaning-maker, the child must be allowed to make meaning.

As paradoxical as it may seem, a broad-gauge humanistic education in which logic, rhetoric, the arts, philosophy and aesthetics are combined with reading, writing, and mathematics allows students' natural mental and emotional predispositions and abilities to collide and merge with technological skills. A humanistic strategy like Drawing/Writing and curricular design plans like "The Thinking Child" designate the inquiring mind of the child as the heart of the educational endeavor. Neurobiological research places the bihemispheric, integrated and integrative brain of the child at the center of our mental gaze. Presto! the thrust of education becomes thinking skills and the method of delivery clarifies itself as cross-modal.

We cannot absolutely predict future cognitive demands and learning opportunities for the human brain. The future will probably hold less verbal stimulation and more visual stimulation; it will most probably offer less direct sensory learning experience, not more. In some instances computer-based learning may replace direct experiential learning. In many medical schools, practice with a range of diagnoses and recommendations is already provided through computer programs which train and aid medical students in comprehensive approaches to medical solutions.

The long-term neural effects of prolonged computer-use, including "virtual" or simulated reality, on the human peripheral and central nervous system are not yet known. To repeat: what the brain thinks is going on is going on for that brain. Those who design experiments in physics understand this mental/phenomenological truth. The people who design interactive computer programs understand this, too, taking into account the willingness of the brain to suspend disbelief for the sake of experiencing simulations as real. Computers and humanistic education are not mutually exclusive. What is in question is the neural effects of the computer and other electronic devices as the major delivery systems of information and stimulation to the brain, as well as how the brain will achieve its desired "highs" or peak experiences.

The "brain" is distributed neurally over the entire body (Pert, 1983, 188)10. "Mental" input from our bodies is necessary to our brains. If we did not need a peripheral nervous system, as well as a central nervous system (our brain), we would not have one. Without our bodies and our six senses (proprioception, or knowing where our bodies are in physical space, is the sixth sense—we could call the "sixth" sense the seventh), the brain would truly be a black box, closed off entirely from the world by the bony walls of the skull, the tough, protective meningeal membranes, and the cushioning cerebro-spinal fluid. Without our bodies, we are shut-ins. A lack of direct stimulation to the body affects motor and mental development; stimulus deprivation registers as deficits not only at the emotional level but at the neural level. Neural nets become less connected through disuse and once-useful synapses lose length and weight and eventually disappear.

Sensory deficits affect neural pathways and therefore performance. From what we know about the effects of enriched and impoverished learning environments on children, as well as the effects of a lack of exercise on adult physical, mental and emotional well-being, predictions can be made about the neural effects of experiences increasingly removed from the physical, sensory world. The degree to which virtual reality experiences are also kinaesthetic will affect neural outcomes.

Literacy issues: Computers

The trend toward image-heavy publications is clear. Computer technology facilitates the creation, modification, integration, and presentation of image as well as text. What it does not do is provide the direct experience of overheard, child-centered, engaged dialogue which very young children require for their brains to grow in connection with language learning. But, in other ways, as children mature, the computer provides a powerful thinking tool.

There is a tacit assumption that computers will solve our literacy problems. Because they are so visual, computers have enormous holding power. Children’s brains thrive on visual stimulation. A lighted, colored screen exerts a very strong mental pull. Beyond this basic visual need and pull, computers provide extremely powerful tools for thinking on all symbolic levels, including writing.

Currently, the human brain is being asked to process visual and verbal information at a level of layeredness, speed and abstraction that requires training. Since much of the information has emotional content with a market-driven outcome, the reader must not only process the information but evaluate its effect. Brains trained to think clearly and analytically will be able to compete and survive in the marketplace.

The assumption that computer-use will automatically solve a host of classroom dilemmas springs from the following thinking:

- Students will eventually use computers for all of their writing.
- Students need keyboarding skills, not handwriting skills.
- Light pens and mouse-driven paint programs will replace pencils, charcoal, pastels, drawing pens and brushes.

Many schools of design, art and engineering continue to value and require traditional drawing skills as prerequisites to CAD or computer-assisted design programs. No computer program—no matter how sophisticated—is a substitute for intelligence.

Animal enrichment studies demonstrate that the brain tissue of rats engaged in physically active, challenging, purposeful activities differs at the synapse from underchallenged rats' brains. The richer the options, the longer and heavier the synapse. Children learn better in situations designed with their interests and abilities in mind, including their need to be physically active. Drawing and writing with pencils and pens differs qualitatively from using a computer mouse or a light pen as motoric stimulation and training, particularly with young children whose bodies require more extensive involvement. Until MRIs are used routinely in educational settings to map brain activity, we must extrapolate the most effective teaching strategies from research with animal brains and from our direct experience.

Computer users sit very still for long periods of time, seeing no other things, touching no other people. After hours of computer use, I, for one, become restless and irritable. Whatever our position on the usefulness of computers, there are two overriding reasons to use Drawing/Writing. One reason is cognitive, the other is practical and economic:

- cognitive: The lighted screen of the computer arouses the brain through the retina. This level of cognitive arousal is low. The programs displayed on the screen and their level of interactivity are what will determine the neural consequences of computer use for the student. Even if every child had a computer, existing tutoring programs are not responsive enough to allow the active construction of knowledge called for in this book. Computer-based literacy programs lack physical action beyond striking keys and clicking a mouse. These programs also lack the high level of verbal interaction provided by approaches like Drawing/Writing. Whether their skills and needs are widely divergent or not, students require mentoring provided best at this point in the history of technology and education by attentive, responsive human beings. Peer mentoring provides an adequate number of attentive, responsive human beings even in crowded classrooms.

Young students like to hold a pencil or pen or marker and apply it directly to a piece of paper as an act of exploration. For their brains to grow, they require visual stimulation beyond the low-level stimulation of the lighted computer screen. They need to develop fine motor skills beyond those provided by a light pen on a screen or a mouse on a pad. Brain science makes clear that direct bodily knowing helps brains to grow. Early infant stimulation programs support this finding. Early educational theory and practice corroborate this position. Drawing/Writing accommodates information on early mental growth provided by education, psychology, and neurobiology.

- economic: Paper, folders, pencils and markers are affordable. Computers for each student are not.

Not all students will have computers in school or at home. If students do not learn to write by hand, they will be unable to communicate through the written word. Computers alone will not solve the literacy dilemma. Computers facilitate writing and reading, and they return a powerful visual stimulus to the learning environment, but they do not, at least at this point, create verbal and visual skills. Nor, because of the necessity of direct, human voice input to children's brains, do they aurally stimulate the child's construction of the neural networks necessary for language development. It is the mental skills students bring to the computer that determine the quality of the visual and verbal work produced and, thus, the quality of the networks constructed in their brains.

If schools cannot afford enough computers for all their children, and if the children do not have access to computers outside of school, the question about computers as a literacy tool becomes moot.

Drawing and kinaesthetic learning

Computer literacy is a technological application of Drawing/Writing and, as such, part of the language continuum that includes speech, play, drawing and writing. How students learn to use the computer or any other device for manipulating information will be positively influenced by direct learning experiences in the physical world. A technological society requires and validates direct, multi-modal, multi-sensory learning. Even in an age of technology, physical exploration and involvement provide important opportunities for emotional and intellectual growth.

The child who uses tools and strategies independently and creatively will become a competent adult. The point is not to put the cart before the horse: simple tools and strategies first, more complex tools and strategies second. As direct bodily learning, the act of drawing is qualitatively different from drawing or writing on a computer screen. It differs motorically; the hand is less constrained. If differs visually; dark strokes on white paper provide a less tiring retinal stimulus than dark pixels on a lighted screen. It differs at the level of touch; the drawing hand is able to explore the drawn object directly for information.

Seymour Papert, MIT researcher and educator, inventor of the computer language LOGO, put his finger on the nature of the connection between the child's brain and the computer; he described the computer as a tool to think with. For Papert, the computer provides training in procedural knowledge. The child needs to construct procedures that translate between codes. LOGO is a computer program which uses a lighted cursor or "turtle" to provide exploratory experiences with geometry useful to pre-kindergarten students as well as to sophisticated college students at MIT. Using a simple example: to draw a square, a child is invited to walk a square. She learns that drawing a square means walking in a straight line of equal length and making an abrupt turn, four times. After much experimenting, she types in the LOGO command: REPEAT 4 (FORWARD 10 RIGHT 90), hits the return key, and the cursor jerkily "walks" a square for her on the screen. If she stores the procedure as "TO SQUARE," she can experiment with this command: REPEAT 10 (SQUARE RIGHT 3). The turtle will start a process that will result in a circle. The child sees that a circle can be made from a rotated square. She can store this procedure as TO CIRCLE. Papert calls this approach a nested procedure. The child learns to break a problem into its steps, testing these steps until the desired effect is achieved. By doing so, she constructs an understanding of the problem and of the solution, and, if she nests procedures, she creates complex results. Because of the iterative, recursive aspects (see Part 2 for definitions of these terms), LOGO gives children direct practice with how their brain works neurally. LOGO teaches children to think, not to follow commands. Instantaneous code-to-code translation achieved by computers precludes the brain's construction of its own "translation" circuitry. The computer is an extremely powerful tool for thinking, but it does not replace cross-modal thought.

Drawing/Writing exercises lead students through the entire history of mark-making. This experience is very different from "Draw" and "Paint" programs.

In addition, Drawing/Writing includes holding a palpable object, rich with mental and emotional associations. There is no such tangible object with Paint programs. Although computers allow the transformation from one mode of representation to another by hitting a return key, there is no automatic key in Drawing/Writing. The transfer is achieved by students' brains. Children roll over, crawl and pull up before they learn to walk and they babble before they learn to speak. Similarly, direct physical acts like scribbling, drawing and writing endure as active, exploratory developmental stages in children's language acquisition process. For many students, the process will include computer literacy. For some, it will not.

The effects of enforced passivity

All of us have seen the effects of enforced passivity on animals and children. Think about the housebound dog at the end of a long day, or confined children who bounce off the walls. In 1978, it became clear to me that my television-mesmerized, ricocheting three-year-old son, Sam, should be outside playing. I was worried about the withdrawal period from television, and I was worried about depriving my children of highly engaging training in spelling, mathematics, artistic sensibilities and humane emotions provided by "Sesame Street," "The Electric Company" and "Mister Rogers." The withdrawal period for television for my children was approximately twenty minutes. All three children are well developed emotionally and mentally, and writing and reading are integral parts of their lives. They also speak well.

Adults who sit in front of a television or a computer too long become irritable, "spacey," and eye-weary. They develop low-level anxieties as well as physical problems in their wrists, shoulders, necks and backs. The phrases house-bound, stir-crazy and brain-fried describe real situations involving physical and emotional deprivation or overload. It is the visual holding power of both the television and the computer which allows us to spend more time in front of lighted screens than is useful to our bodies.

Chemical assistance

Growing numbers of "attention deficit" children take Ritalin. These children's brains apparently require chemical stimulation. Given budget constraints, most classrooms have no choice but to increase control, resulting in even longer periods of enforced passivity. Passivity is not natural for children.

Two million American children (three to five percent) are diagnosed as having the attention disorder known as ADHD. Since 1990 the number of school-age youngsters taking Ritalin has increased 2.5 times. Among today's 38 million children ages five to fourteen, 1.3 million take Ritalin regularly (Hancock, Newsweek, March 18, 1996). The rate of Ritalin use is five times higher in the United States than in the rest of the world. The widespread ADHD diagnosis is an American phenomenon.

One theory for the increased use of Ritalin is rushed home lives ("Mother's Little Helper," Newsweek, March 18, 1996). The press of modern life requires fast moves from one activity to another. Because children can focus, involving themselves deeply in activities, it is hard for them to respond to rapid dislocation. In some cases, their understandable reluctance to be dragged from activity to activity may masquerade as impulsivity, inattention, or hyperactivity, resulting in a diagnosis and a prescription.

Some children benefit from drugs. For all of their apparent over-activity, the brains of attention-deficit students are actually under-stimulated, and need chemical revving up. It may be hard to distinguish between children whose attentional systems are deficient and children who are inattentive at school because of fragmented lives. Some children diagnosed as hyperactive are talented children reacting normally to understimulating educational environments. Feeling rushed and being overly controlled drives many people crazy. In such situations, adults have been known to act out and to take either stimulants or sedatives.

It's time to look at what is going on educationally. We cannot afford to wait until pediatricians, parents, psychologists, psychiatrists, school counselors and physical therapists announce that children have become mental, emotional and physical cripples. For the health of children's brains, kinaesthetic, multi-sensory, integrative stimulation must be factored into our educational programs. The applied and performing arts provide intelligent curricular choices for a humanistic education.

A non-pharmacological approach

A drawing-based writing program provides a "natural" way to normalize certain aspects of neurochemistry relating to attention, motivation, cognition, and "highs" or peak experiences. This process of normalization has self-regulatory aspects. Students doing Drawing/Writing bring their own attentional, motivational and cognition systems to alertness, teaching themselves to focus, attend, examine, express, to initiate, sustain, and to regulate thought processes. Such self-regulation should decrease the need for classroom drugs like Ritalin,

Experimentation, the search for novelty, and the desire for peak experiences are built into the human exploratory and emotional learning system. The arts and the sciences provide opportunities for meeting these needs. Drawing, along with a more meaningful, cross-disciplinary approach to learning, may satisfy the needs for novelty and peak experiences that drive the human brain to experiment with drugs. These two hypotheses are testable:

- Drawing/Writing normalizes attentional systems through self-regulatory training in attention.
- Drawing/Writing helps to satisfy human cravings for novelty and peak experiences by providing deeply interactive visual/verbal learning experiences.

3.4 A New Understanding of Literacy

Equalization in training: Making up for the deficits

Before they learn to read, children—even babies—are bombarded with electronic messages. Teenagers "surf" television channels, fast-forwarding programs at rates intolerable to viewers who grew up with the comparatively slow pace of reading. Like the televised messages, attention is trained to be short and fast. Many children and adults are more literate visually than verbally. The demands on their visual decoding skills are intense. Visual ambiguities, subtexts and meta-messages on television and in magazine advertising may escape them because they lack the verbal skills to bring these complexities to consciousness. The ability to navigate successfully through a stream of visual stimuli demands strong verbal skills.

The place to start literacy training, laying the groundwork for powerful mathematical and scientific skills, is at the intersection of visual and verbal stimuli. Most media combine image and text. It is the relationship between the two that carries the sub-text, or the meta-message. These additional messages can be accessed and examined through training.

Discriminating among an assortment of complex stimuli, some of which—like ads for cigarettes and alcohol—are dangerous, is important not only to economic well-being, but to physical health. Assaulted by persuasive material, a mind lacking training in discrimination has several options:

- to become hypersensitive to minimalist cues using short bursts of intense attention geared to the "hype" and speed of incoming electronic stimuli, e.g., channel surfing;
- to "go with the flow," absorbing all of the information indiscriminately; or
- to become passive, assuming an attitude of over-assaulted blankness, shutting down and shutting off.

The outcome of strategies #2 and #3 is the degradation of discriminatory mental abilities. In connection with #1, an addiction to short bursts of intense stimuli may make sustained attention less attractive. Some "channel-surfing" minds may remain capable of sustained attention, but this outcome depends upon the rest of that mind's education, including training in literature and the arts.

Time for a new literacy

Increasing problems with writing, reading, attention, critical thinking, and ethical behavior suggest that today's learning environments—the home, school, community, society—are failing to provide sufficient practice with these skills. It was not always true that people needed to be able to write and read to survive. Societal pressures change. When skills and attitudes appropriate to intelligent survival fail to develop, they can be taught. Drawing/Writing creates an environment where children learn skills relevant to their lives, as well as to a technological society.

Students need a new literacy. They need a tool to teach them to analyze information accurately and thoroughly. It is imperative that they "get" the real message; to do this, they have to work through, evaluate and reject or accept meta-messages and subtexts. For example, to make safe decisions, students need to be able to extract the salient information from drug education programs.

As well as being able to evaluate confusing or misleading messages, students themselves must learn to send clear, unambiguous messages. If they do not become adept at clear communication, they may be victimized or they may make poor choices with lifelong consequences.

Over 25 million American adults cannot read and write. Another 35 million cannot read above a ninth grade level and are described as functionally illiterate. The prison population represents the single highest concentration of adult illiterates. 85% of the juveniles who appear in court and over 1/3 of mothers receiving welfare are among the functionally illiterate. One out of 3 American adults cannot read a book. The United States ranks 49th in literacy among 158 member nations of the U.N.

Four to 6 million of the 8 million unemployed lack the basic skills to be trained for high-tech jobs. Functional illiteracy costs more than $22.5 billion annually in lost industrial productivity and unrealized tax revenues (National Coalition for Literacy, 1994 census). A child with functionally illiterate parents is twice as likely to grow up illiterate (Wolkomir, 1996, 82-91). Cross-generational as well as cross-cultural deficits challenge education.

The United States ranked 28th out of 41 nations for scores achieved by thirteen-year-olds in math and 17th in science, according to the 1997 Third International Maths and Science Study (TIMSS, The London Economist, March 29, 1997). Yet, except for Switzerland, the United States spends more money than any other nation on mathematics and science education. Neither teaching time nor money correlates with the highest scores, according to this study. Thirteen-year-olds from Singapore scored highest in both fields, followed by South Korea in the maths and The Czech Republic in the sciences. Even though the United States and Britain have had universal schooling much longer, Asian countries are pulling far ahead. The relationship of training in specific languages to brain structure and processing modes bears examination as does the relationship of literacy to achievement in the maths and sciences.

Massachusetts is a state with a reputation for doing well with literacy education. Still, according to the Massachusetts State Department of Education, of 41,400 adults seeking entrance to literacy classes, "just 27,500—two out of three—get a spot." Laura Papano in The Boston Globe Sunday Magazine (November 26, 1995), asks a critical question: "How can someone get off welfare and into a job if he or she can't read or write? Some experts say that many social and job programs fail because they leapfrog the fundamental problem of illiteracy."

A survey of Massachusetts employers conducted by The Massachusetts Coalition for Adult Education Network supports Papano's information: 19% of the state's adults are functionally illiterate; an additional 25% fall below the skills levels appropriate for high school graduates. One in three adults who seek assistance for literacy problems are turned away from state-offered remedial programs. Massachusetts businesses report that the most glaring training deficits they see in new employees relate to basic skills including mathematics, literacy, and English, and in the ability to learn new skills.

The bogus bell curve

The de-skilling of the work force is a cause of concern, particularly as it relates to the urban poor. Some people conclude that populations with low skills are innately less intelligent. Not only is this position untrue but it is counterproductive. Devising educational strategies to increase skills is a productive approach. It is more likely that educational opportunities, not innate capabilities, have been unequally distributed.

In their book *The Bell Curve,* authors J. Hernstein and Charles Murray use statistics to "prove" that "black" people are genetically less intelligent than "white" people. Comparing unequal skill levels in distinctly different populations using the bell curve is not statistically feasible. The probability theory behind *The Bell Curve* is questionable (Miriam Lipschutz-Yevick, 1995). Lipshutz-Yevick writes, "Hernstein and Murray's... conclusions...will not bring about a bellshaped distribution.... The authors cannot have it two ways; either the two population groups—black and white—are sufficiently homogeneous to generate a bellshaped curve with a common mean, or we are dealing with two distinct populations and the various statistical tests based on the model of the bellshaped curve simply do not apply" (22).

Hernstein and Murray use spurious statistics in prejudicial, pernicious, non-useful ways. The book *The Bell Curve* is a disservice to African Americans and to any under-educated group in our society.

A position on the distribution of I.Q.

Unequal educational opportunities in society result in unequal skill levels. I.Q. tests measure qualitative and quantitative skills in the context of the English language and mathematics. An education that equalizes English language and mathematics training will close the gap in intelligence levels between groups. This hypothesis is testable and demonstrable through standardized test scores. Until we equalize the quality of instruction, the existing methods for testing intelligence are inappropriate. Furthermore, standardized I.Q. testing is a questionable approach to judging effective, flexible problem-solving skills, or the basic skills for intelligent thought.

Drawing provides teachers with a much-needed window on student intelligence. Weak drawing skills do not mean that students are unintelligent. Powerful drawing skills, on the other hand, are indicators of powerful visual intelligence. Because drawing and writing and thinking skills are highly developable, the educational challenge is to devise strategies for encouraging intelligence and then to test for intelligence with a humane yet precise, no-nonsense, student-driven evaluation system like Rescore, where desirable skills and the criteria for assessing them are clear.

Education in the twenty-first century is more than the liberal arts, more than a mathematics and science education, more than a technical vocational education. Education for the twenty-first century is grounded in language-based, analytical and inferential, transferable thinking skills requiring a humanistic scope.

The tipping point: Applying epidemic theory to illiteracy

An analogy can be made between epidemiology and literacy education. A small change in healthcare can reverse an epidemic; a small change in teaching strategies can reverse illiteracy rates. To follow the analogy, we must make a detour through criminology.

In the June 3, 1996 New Yorker, Malcolm Gladwell writes, “Epidemic theory should change the way we think about whether and why social programs work.” Gladwell continues, “Today, bringing epidemiological techniques to bear on violence is one of the hottest ideas in criminal research (38).”

The article describes a “tipping effect” in connection with crime rates in Manhattan. In the language of epidemiologists, the “tipping point”... is the point at which an ordinary and stable phenomenon—for instance, a low level flu outbreak—can turn into a public-health crisis. “Every epidemic has its tipping point, and to fight an epidemic you need to understand what that point is... But you don’t really need to completely eliminate risk. If over time you can just cut the number of people capable of transmitting the aids virus, then our present behavior-change programs could potentially eradicate the disease in this country” (35).

Illiteracy has become an epidemic. Like crime and the AIDS virus, illiteracy reflects demographic and social trends. Social problems act like infectious agents. Bringing the number of AIDS infections down to thirty thousand from forty thousand has a “huge effect.” This statistic provides hope; a small increase in literacy may reverse snowballing illiteracy.

Gladwell writes about the AIDS epidemic, "It all depends on when and how the changes are made.... Human beings prefer to think in linear terms.... Epidemics aren't linear. Improvement does not correspond directly to effort. All that matters is the tipping point, and because fifty thousand is still above the tipping point, all of these heroics will come to naught" (35-36).

There is a relationship between the number of employed adults in a neighborhood and the rate of teenage pregnancy in that neighborhood; if over five percent of the adults are employed, the teenage pregnancy rate goes down. A five percent change turns a dysfunctional neighborhood into a more functional one almost overnight.

The Gladwell article continues, "If reading problems are nonlinear, the failure of the program doesn't mean—as conservatives might argue—that spending extra money on inner-city kids is wasted. It may mean that we need to spend even more money on these kids so that we can hit their tipping point...tipping points give the lie to conservative policies of benign neglect" (37).

The goal of teaching five percent of all school children Drawing/Writing is not impossible. If a five percent change in one domain—like AIDS—brings about a vast change, it make sense to explore a five percent change in another domain—like illiteracy. If we must set aside hope for an infusion of money into our schools, we can still adopt more effective strategies. For the cost of this book and the teacher-hours it takes to implement Drawing/Writing, the five percent tipping point can be reached. Like the fluttering of the wings of a butterfly on one side of the world, small perturbations have large effects on the other side of the world. Chaos theory sheds light on current theories about epidemiology, criminology, sociology—and education.

One thing is clear: there is no more time. Jonathan Kozol's "savage inequalities" have arrived and persist. Knowing what we do about the power of small changes, teachers can reach the tipping point for literacy. If each of us, as teachers, home-schoolers, parents, day-care providers, grandparents, believes we can achieve this tipping point, we will continue to teach children to write and read with renewed hope and intentions informed by theories from other fields. We will go back into the classroom and open this book, take a deep breath, and say, "Put your names on your folders... "

Educational practice generally lags fifty years behind educational research. Information technology accelerates change at a rate of 7:1. In 1991, the first papers on Drawing/Writing were published. It is now 1997. It is time for Drawing/Writing.