Brain Research and Learning

The human brain can be compared to a shrink-wrapped Microsoft disk—a program with precise, coded instructions that evolution has written for the operation and maintenance of a person. The brain is likened to a computer, possessing about "100 billion nerve cells wired together with 100 billion interconnections." There are about 1,000 different varieties of connections, each with a special subset of instructions, which make us individually prone to exhibit love or hate, obedience or rebellion, intelligence or lack of intelligence.

Recent controversies involved in brain research include (1) the ages at which synaptic densities and brain connections peak (ranging from age 3 to puberty); (2) whether early visual and auditory experiences increase synaptic densities or numbers during or after puberty; (3) whether the use of language, and what type of language (formal, informal, oral, reading, TV, digital, etc.), training, and education increase the efficiency of connections; (4) whether there is a critical age period in which synapses that are developed influence how the brain will be wired and whether the synaptic densities are more susceptible to being eliminated after puberty; (5) what kinds of synapses are pruned when pruning begins, and at what rate, and to what extent does it affect behavior and memory; and (6) whether one can determine for sure whether people with greater synaptic densities or connections are more intelligent.

In general, according to the research, an optimal brain requires that humans use as many synapses as possible before puberty or lose them afterward; that brain connections and intelligence have a genetic and environmental component; that connections used to a lesser extent during a critical period (some claim prior to age 3, some say prior to age 10 or 11) are more susceptible to being eliminated; and that the brain area undergoes considerable reorganization during puberty and these changes modify how people process information and behave after puberty.

Learning Styles

According to research, the way people think and learn is associated with different brain functions, such as preferences toward movement, intake (of foods or liquids), and reaction to sound and light. These brain functions result in areas of personal strengths and weaknesses, and, in some cases, different learning styles. Yet, most teachers treat their students alike and teach as if they were all the same. In short, learning differences are not solely tied to ability factors; rather, all people have propensities that influence their thinking and guide their intellect. Just as

baseball players have different batting styles; people have different ways of thinking and learning.

For example, some individuals learn best alone, and others prefer to learn in small groups and share information. Some students exhibit on-task persistence, whereas others fidget, tap, or doodle while taking notes in class or studying at home. Some learn best with "hands-on" activities and manipulative materials, and others are better able to digest abstract and verbal information. Some display preferences toward eating and drinking while reading or studying, and others need little intake. Some are "night owls"; others are "morning people," suggesting when individuals are most efficient in performing school work or studying. Many students process cognitive information with background music or when stretched out on the couch or even on the floor; others need a quiet place and to be seated upright behind a desk or table. Some seem to procrastinate, and need extra time to warm up, whereas others immediately jump into the assignment and perform meticulously. Hence, you need to observe your students in class and make adjustments in your instruction to suit the way each of them learns. There is no one ultimate way for all children to learn.

One of the more popular theories of the brain involves left-right brain or hemispheric functioning. Traditionally, teachers have taught students in a "left-brain" way—based on verbal symbolism, logic, and analytical thinking. Yet, a substantial percentage of students (40 to 75 percent, depending on the research study) are "right-brain" oriented; that is, they are more global than analytical, more deductive than inductive, less structured and more dependent on tactile or kinesthetic resources.

According to the prevailing view, the right-brain thinker tends to rely on one or more of the following functions: (1) visual, in which the student "sees" information, doodles while listening to the teacher, draws lots of pictures and arrows when taking notes, and needs a quiet place for studying; (2) auditory, in which the student "hears" information, reads aloud and talks aloud when problem solving or writing, often studies with background music, and says things over and over to memorize information; and (3) tactile or haptic, in which the student learns by "moving and doing," doesn't like to listen to or read directions, prefers the floor or couch rather than a desk, needs frequent breaks when doing homework or studying, sometimes procrastinates, and takes notes in class but rarely studies them.

Some caution is needed. Many students, it would appear, are equally proficient in left and right thinking, although they may have some difficulty in making switches.

It is questionable whether auditory preferences always connote right-brain thinking. For example, "visual" activities, such as reading and spelling, are in part based on auditory discrimination. Auditory preferences might be more cognitive and related to verbally symbolic and logical thinking than the literature on brain theory suggests.

Related to different kinds of learning styles is the notion of different forms of intelligence, which leads to the theory of multiple intelligences (discussed later), not just intelligence based on tests of verbal and abstract patterns of thought. Similarly, there are ways of thinking and learning that are culturally bound, or, more precisely, associated with ethnic, racial, and immigrant factors. For example, cultural differences exist toward schoolwork; teacher authority; on-task effort versus social interaction; time orientation (coming early or late to class or meetings, and meeting deadlines); present versus future orientation; the value of hard work and studying; abstract versus visual, auditory, or tactile processing; physical space (perceiving the teacher as "pushy," when in fact the intent is to foster comfortable interpersonal space or personal relations); touching and kissing in public; role expectations and behavior toward people based on age, gender, job status, and family interactions; group and individual learning situations; and a host of other culturally laden values and behaviors that influence performance in school and how people act.

In short, learning styles differ from culture to culture, as well as among individual students, and possibly also on the basis of urban-suburban-rural patterns. Furthermore, many learning modalities are not recognized in classrooms, unless schools and teachers are sensitive to and respect diversity. Obviously, teachers need to adapt their instruction to coincide with the learning styles of their students, to capitalize on the students' strengths or preferences, and to accommodate all students. In a classroom of 25 or 30 students, the teacher has the daunting task of recognizing individual and group differences based on ability, needs, and interests, as well as cognitive processing and learning styles.

Memory and Brain Expansion

"Who am I?" The question is either the start of a provocative thriller story, an existentialist inquiry, a plot in an artsy-craftsy movie, or a reason to purchase a book on memory exercises or a ticket to a memory fitness class to help our parents and grand-parents remember where they left the car in the parking lot. But the appealing notion that our individuality is bound up in our memory runs up against the idea that memory is not reliable and it fades as we age.

As one psychologist puts it, what we commonly refer to as memory are "confabulations, artificial constructions of our own design built around . . . retained experience, which we attempt to make live again by influences of imagination." Such a definition leads to all kinds of theories about memory loss, memory boosting, memory manipulation, and memory and imagination." It can lead to the theater of the absurd, a semantic cul-de-sac, and a postmodern conversation: "What?" to which the answer is: "This is what." And "What is this?" "This is what is." "Which is?" "What you want it to be." So a fork can temporarily be a knife; good teaching can be defined as a stroll in the park; and for an aspiring art student one red dot on a large white canvas or a series of Campbell soup cans can be construed as the ultimate in modern art.

Now, if you think this is a little silly, absurd, or mystical, there is always Yogacara, a mind-only school, in which you can find enlightenment and hear sermons that are reflected and rooted in Buddhism, the holiness of the Dali Lama, and ancient Chinese philosophy, that separates the self and the world and dates back a thousand years before Descartes's rationalism. That kind of "trip" would certainly add to the conversations, stories, metaphors, and voices of the postmodernists; it might eventually allow participants (not only monks and the faithful) to become ferociously brainy and understand "ultimate reality." Am I talking about the meaning of life? No. I am playing with some of the cerebral ideas of revisionist thinkers who complicate rational thought and criticize traditional theories and research methods as western, white, male oriented, and technocratic, and who enjoy poking fun of scientific principles that encourage predictability and empirical answers to questions. I am providing them with a new idea of which way to go—basically to the East—and analyze some mountaintop view in Nepal or Tibet, or to contemplate the complexities of Buddhist truth or the Odyssey of life through the eyes of "The Great Tang," who lived a monk's life in the seventh century.

Reading about the brain or mind is obviously confusing. We are told that about one trillion neurons are ready to connect in a newborn's brain, and how "the wiring" takes place will depend on the baby's early experiences. It is the experiences of childhood that determine what neurons are used and how they interconnect in the brain; the connections subsequently determine the potential and limits of cognitive capacity and other domains of learning such as social, moral, and psychomotor. The strategy for optimal brain development is to stimulate and use as many synapses and circuits as possible during childhood that correspond with traditional behaviorists and environmental theorists.

In a somewhat similar viewpoint, two psychologists declare that the brain consists of a "quadrillion connections supported by trillions of nerve fibers," its branching neurons and "protoplasmic kisses, [whereby a message] vaults across a sliver of space called a synaptic cleft and into the outstretched arm of another neuron." In simple terms, we seek all kinds of memory aids, from tests and files to training methods and drugs, with the hope that we will come up with a smart pill for the brain. Right now, however, no imagery, no training method, no drug can save us from brain plaque and neurofibrillary tangles. According to researchers, plaques are the "litter" and "rubble" that clog our memory banks, just like plaque forms around our teeth and arteries and lead to gum disease and heart problems. The popular remedy among Indian and Chinese scholars is to sip on warm water to clean out your system of all plaque. And, if you don't believe in warm water (with or without lemon), special chemical drugs, or genetic engineering, there is always the potential for a computer chip. In 10 to 20 years, we should have "smarter brains, happier brains, calmer brains, brains that are less forgetful" and less vulnerable to age, disease, and damage.

There is no question that we will soon have drugs to enhance cognition, to compliment the many psychoactive and mood-changing drugs we already have on the marketplace. We already have treatments for depression, schizophrenia, tangled nerves, and hyperactivity; in fact, we have raised a whole generation of children on Ritalin, which makes it easier for teachers and counselors to modify behavior and control students. We are on the verge of treating Alzheimer's disease and enhancing memory. Soon, we will be shaping and expanding intelligence, repairing and improving brain networks, and possibly using computers for a complete brain overhaul. The availability of all these new chemicals (and computer chips) will pose difficult ethical questions concerning their use by whom and for whom.

One might argue there is nothing wrong in increasing intelligence for kids who have trouble learning or eliminating from their memory painful or emotional experience such as rape or the death of a parent. But equally important is, unless you believe in Nazi eugenetics, human beings must come to terms with loss and emotional injury as part of growth and development. The best we can all agree on is the basic need for brains, what the scarecrow in The Wizard of Oz wanted. We can also agree on some form of memory improvement through conventional methods such as a two hour course or reading 10 tips on brain exercises in a magazine or book, as well as some recognition that there are different forms of brain development, intelligence, and styles of learning.

DNA, Genes, and the Brain Pool

When Watson and Crick discovered the mysteries of DNA some 50 years ago, the understanding of inheritance was advanced. As Crick stated, "DNA makes RNA, RNA makes protein and proteins make us." Until recently, we could only theorize about the process. Now, we have the knowledge to direct this process. Designer babies are set to follow in the wake of genetically modified crops, which promise better nutrition or environmental contamination, depending on one's politics and view of Green Peace. There is no doubt, however, that gene research has the capacity to change our lives, to extend it, and to improve our intelligence.

A dissenting view is expressed by Evelyn Fox Keller, who argues that genes no longer shape destiny but behave as second-tier players in the game of life. DNA is bequeathed from one generation to the next, and, except for mutations, explain our potential for human growth and development, including cognitive, social, moral, and psychological learning. But the exact coping process from parents to child stems from associated proteins that perform "proofreading" tasks. Without RNA and related proteins, the error rate that reflects in mutations would jump from one in 10 billion to one in 100.

Although mutations are deleterious, occasionally they increase survival of species or populations within a particular animal grouping sequence and become the basis of adaptation by natural selection. Under stressful or hazardous conditions, DNA has evolved to create genetic variability in physical characteristics. The controversial aspect of the equation is whether it also leads to genetic variability in cognitive characteristics. If so, this leads us to the hereditarian or genetic school of thought, which has been squashed since the 1950s by the environmental school. The demise of hereditarian thinking coincides with the defeat of Nazism and the decline of colonialism around the world; it also coincides with the increased popularity of Piagetian and developmental theories of growth, followed by the compensatory education movement based on environmental theory and research.

Culture, Geography, and "Smart" Thinking

On a global, much more theoretical level, growth and prosperity among cultures and civilizations can be explained by environment, or by the limits of geographical isolation. Given a make-believe world in which every individual has identical genetic potential, there would still be large differences in education, skills, and related occupations and income among people because of demographic differences, which, over centuries, shape human behavior and attitudes.

For Thomas Sowell, nothing so much conflicts with desire for equality as geography; it is the physical setting—reflected by large bodies of water, deserts, mountains, forests—in which civilizations, nations, races, and ethnic groups have evolved and in turn produced different cultures. Put simply, the people of the Himalayas have not had equal opportunity to acquire sea-faring skills, and the Eskimos did not have equal opportunity to learn how to farm or grow oranges. Too often, the influence of geography is assessed in terms of natural resources that directly influence national wealth. But geography also influences cultural differences by either expanding or limiting the universe of ideas and inventions available to different people.

When geography isolates people—say by mountains, a desert, or a small island the people have limited contact with the outside world; so, subsequently, there is technological and innovative advancement. While the rest of the world trades skills, ideas, and values from a larger cultural pool, isolated people are limited by their own resources and what knowledge they have developed by themselves. Very few advances come from isolated cultures, and those that do are usually modified and improved on by people who have learned to assimilate and adopt new ideas from other cultures.

The British, French, Portuguese, and Spaniards were tiny countries, compared to China and India, but the Europeans traveled the navigable waterways of their continent as well as the Atlantic. They came in contact with many countries and civilizations, including South America, Egypt, Turkey, India, China, and Japan—and thus gained from their knowledge. But the older civilizations did not draw from the Europeans or from each other and eventually those great civilizations (which were once more advanced, but isolated) were overtaken and conquered by the smaller countries that had expanded their knowledge base. Once japan broke from its isolation, the country rose to one of today's economic powers. Similarly, the rise of the United

States—in particular, its technology, innovations, and economic advances—is based on the history of immigrants, people coming from all parts of the world and exchanging knowledge and ideas. It is this constant flow of different people from around the globe that helps create an American entrepreneur spirit and sense of innovation and creativity not enjoyed in more static, less dynamic countries.

New knowledge in the United States doubles about every 15 or 20 years. In many third-world countries, mules and horses are the main mode of transportation, and the local economy is picking berries, dragging banana trees to market, or cleaning

out goat intestines that can be turned into leather. This is the real rural China, India, and Pakistan—possibly representative of two-thirds of the world, a world that American students and teachers cannot fathom. This is not to say that these type countries don't have a corporate mentality, and a class of people who are both old-fashioned industrialists and a new brand of technocrats who are versed in computer software, media, and other high-tech and electronic ventures. What is less clear is the extent to which this new economic and human capital trickles down to the mass who live in poverty—both in the countryside, far from the "new economy" that deals with the exchange of knowledge and ideas, and in urban squalor, where old and new knowledge, ideas, and values collide. In third-world cities, East meets West and low-tech meets high-tech—causing a great cultural rift and the makings of revolution.

For 2,000 years, before the invention of railroads, trucks, and airplanes, water was the key for traveling and exploring. Up to the 1850s, it was faster and cheaper to travel by water from San Francisco to China than over land from San Francisco to Chicago. The Europeans, since the Viking era, understood that geographical isolation could be overcome by the sea or ocean. Given their capitalistic and religious zeal, and attitudes of superiority, they went out and traded with and colonialized other peoples and other cultures; subsequently, they made industrial and technological advances by adopting and modifying the ideas of other civilizations.

Anyone familiar with New York City, Chicago, or Los Angeles understands that these cities house people from a vast assortment of countries with different knowledge, ideas, and values. Far from "celebrating" their particular identities, most U.S. urban dwellers have contact with different people and become more "hip," "sophisticated," or "cosmopolitan" than their nonurban counterparts. Even kids who come from the backwaters of the world, say from the rice paddies of Vietnam or the mountains of Montenegro, quickly become enculturated into the American environment, especially if they settle in large cities and they step out of their parents' cultural and historical isolation. The computer and cell phone may increase our ability to communicate with people from around the world, but there is still limitation to exposure of new thoughts without actual contact with different people. In short, our thinking is shaped not only by our home environment and community but also by diverse people we come in contact with who reshape and expand our knowledge, ideas, and values. Those who come in contact with people from around the world assimilate more information than those who remain isolated in their urban neighborhoods, rural villages, and islands.

Multiple Intelligences

Howard Gardner argues for a theory of multiple intelligences and contends that there are different mental operations associated with intelligence. But Gardner feels the search for empirically grounded structures or components of intelligence may be misleading, since it avoids many roles and skills valued by human cultures. He maintains that there are many different types of intelligence and that too often (at least in a technological society) we emphasize only verbal or linguistic factors. He outlines eight types of intelligence:

1. Linguistic intelligence. This ability is reflected in the effective use of language and literacy forms. For the oral language, this skill may be demonstrated by actors, politicians, newscasters, and public speakers. For the written language, writers of literary works, poets, journalists, playwrights, and editors would display this intelligence.

2. Logical-mathematical intelligence. This intelligence has to do with the ability to use numbers and arithmetic operations extremely well, such as that exhibited by mathematicians, statisticians, and accountants. These people also have the ability to reason, hypothesize, and theorize logically, such as that seen in scientists and engineers, and to engage in propositions and abstractions in thinking.

3. Spatial intelligence. This type of thinking is the capacity to deal with and reconstruct the experimental, nonverbal world to a high degree of successful performance. This would be a- visual-spatial thinker negotiating or reconstructing the visible world, such as a painter, inventor, sculptor, architect, and designer. These people also have the capacity to pictorially or graphically represent visual/spatial ideas, and to orient themselves spatially, as would be the case with pilots, sailors, architects, builders, and chess players.

4. Bodily-kinesthetic intelligence. This ability is the craft of using one's persona—one's whole bodily self—to handle objects and excel at physical dexterity. This skill is exemplified in people such as dancers, athletes, mimes, surgeons, and artisans. These people use their bodies and physical dexterity to express ideas and feelings and can use their hands to create, transform, and manipulate objects and tools.

5. Musical intelligence. This ability is bestowed on those who have a strong sensitivity to such aspects as pitch, melody, rhythm, and tone of a musical piece. These people may be able to discriminate, create, and transform using musical forms or "language," such as a composer, music critic, and avid listener of music.

6. Interpersonal intelligence. This type of thinking is strongly manifested in those who work with people. Individuals with this capacity understand and interact well with others, such as would be in the case for teachers, ministers, counselors, social workers, and (hopefully) politicians. These people are sensitive to the feelings and needs of others, and respond well to verbal cues and gesture and facial expressions.

7. Intrapersonal intelligence. People with this ability have strong self-knowledge and perceptions of themselves so that they can skillfully plan and direct their own lives. They know their strengths and weaknesses, their interests and motivations. People with strong intrapersonal intelligence might pursue such disciplines as theology, psychology, and philosophy, as well as the entertainment industry.

8. Naturalistic intelligence. The human ability to discriminate features among living things in the plant and animal kingdom and the ability to be sensitive to other conditions (such as stars, cloud formations, and types of vegetation) of the natural world are the capacities that make up this thinking. Such abilities were highly valued in the past, when humans were hunters, gatherers, and farmers. The same type of thinking is central for the natural scientist, biologist, botanist, as well as to the outdoor adventurist who climbs mountains, backpacks for weeks, hunts for bears in remote areas, sails or sky-dives in highly dangerous places with drinking water and flareguns (prepared for an emergency).

Guilford's Influence on Gardner

What Gardner has to say is not new, but rooted in the work of J. P. Guilford, who, in the. 1950s and 1960s, formulated a theory of intelligence around a three-dimensional model called the structure of intellect. It consisted of six products (units, classes, relations, systems, transformations, and implications), five operations (knowledge, memory, divergent thinking, convergent thinking, and evaluation), and four contents (figured, symbolic, semantic, and behavioral).

The three dimensions produced a 6 x S x 4 model: six products, five operations, and four contents, yielding 120 cells of distinct mental abilities. By 1985, Guilford and his doctoral students had recognized and separated more than 100 abilities by factor analysis of standardized achievement and aptitude tests. Guilford concluded that the remaining cells indicated uncovered mental abilities. It is possible, however, that cognitive tests do not measure other mental operations or that such abilities do not exist.

The Guilford model is highly abstract and theoretical and involves administering and grading many extra tests. But rather than a single index of IQ (or of aptitude), we are required to recognize and report several scores. Thus, the theoretical issues surrounding intelligence and cognitive operations take on added complexity, much more than Gardner's theory of intelligence or Binet's and Weschler's idea of reporting one IQ score.

The point is, the idea of multiple intelligences stems from Guilford's work who, in turn, formulated his theory to challenge the idea of Charles Spearman's factor of intelligence—that is, intelligence is composed of a general factor g, underlying all mental functions, and a multitude of s factors, each related to a specific task. To be smart meant to have lots of g, since it was an umbrella factor permeating all mental operations. Whereas Gardner feels the search for empirically grounded components of intelligence may be misleading, and delineates fewer components (eight in broad areas of life), Guilford maintains the criteria for intelligence can be quantified and consists of many (120) mental operations, or cognitive processes. The idea of 120 different mental operations confounds teachers, and thus remains a theoretical construct. Gardner is more popular with school people because his discussion avoids statistics and is more positive and democratic. He stretches the notion of what is important for human growth and development—more than cognition—fitting the progressive idea of the whole child, expanding the child's full human potential, opening academic and career doors, and encouraging low achievers who might otherwise be shunted aside by schools.

Beyond Gardner

Gardner's ideas provide a place in the school curriculum not only for the 3 Rs and academic core subjects but also for music, art, dance, drama, sports, and even social skills (winning friends, influencing people, negotiating, etc.). The latter bodies of knowledge and aptitudes have a place in our "other-directed" society and foster social and economic achievement and success in adulthood, including corporate America, the local and civic community, and the entertainment, artistic, and sports world. Academic merit is not the Only avenue for social and economic mobility—which is a highly important factor in a democratic society that tries to foster excellence in many endeavors and provides multiple options and several chances for people to succeed. In a society that requires all the trains to run on time, academics are prized. Now, it's kind of scary, if in such a society, you can't find anyone at the train station who is physically impaired, learning disabled, or

just plain slow in thinking or moving about. Excellence has been stretched beyond the pale of reason.

Subscribing to Gardner's ideas means not only being a cognitivist but also a positive cognitivist, if l may coin a new term. It means there are many opportunities and chances in life. Someone who can paint, dance, sing, act, or accurately hit a golf ball 250 yards can rise to the ranks of a master. If encouraged and given a chance, and if many talents are recognized, then many of our potential school dropouts would not drop out. For those who do, this country allows second, third, and fourth chances to go to school and college. In the same vein, it allows individuals and companies to go bankrupt several times with minimal or no penalties—to try again and then again. There is no debtors' prison in the United States, and fingers and toes are not cut off by government officials, as in many other countries, for failing to pay a debt.

Those in charge of planning and implementing the curriculum are faced with the task of expanding their vision beyond intellectual and academic pursuits without creating "soft" subjects or a "watered-down curriculum." Teachers must nurture all types of talents and all types of excellence that contribute to the worth of the individual and society. They must be guided by reason and balance and consider the versatility of children and youth. They must also be aware of students' multiple strengths and abilities, and their multiple ways of thinking and learning. Indeed, there are many ways of reaching Rome and finding the end of the rainbow; fixating on one method is restrictive, myopic, and/or all-authoritarian.

What Gardner says has little to do with the traditional concept of intelligence; rather, what he says has more to do with aptitude and talent. In the final analysis, intelligence is reflected in the ability to function effectively in one's environment, to support oneself and loved ones, and to prosper and live a full life. In a hunting, fishing, or farming society, verbal skills play a minor role, and the importance of "muscle" power and "naturalistic intelligence" is noted. ln a farming society, what counts is the ability to plow the soil and plant, not to read Plato or Kant. Given a technological and information society, however, most jobs and daily routines have a verbal and/or mathematical component needed to function effectively. Less than one out of 100,000 Americans can support themselves as baseball or basketball players, country western singers, artists, and dancers. People with these special abilities are few in number. Although they should be encouraged as children to maximize their potential in these special areas, like it or not, the vast majority of children and adults need to be schooled in cognitive bodies of knowledge that deal

with verbal and numerical symbols. Why? Because present society requires those skills, and the vast number of employers reward those skills.

In a more positive and liberal vein, too often teachers do not recognize the skills and achievements associated with noncognitive domains—at the expense of low achievers who usually have difficulty in cognitive areas. Teachers dismiss too many students who are below average in reading or writing, overlooking the fact that many of them can develop other noncognitive areas of expertise. Indeed, there are many forms of learning and excellence. A viable society needs to reward its scholars and bricklayers, its engineers and carpenters, and its verbal-spatial learners as well as its kinesthetic learners and socially skilled learners. Emphasis in schools on one or two preferred aptitudes or talents results in rejecting many potentially creative and gifted children—and limits the nation's future human capital.

Beyond Intelligence: Cloning

Few people today complain about in vitro fertilization, which caused quite a stir some 25 years ago. Few people would also complain about genetic engineering, DNA medicines, and organ transplants to fight human disease or extend life. Although Americans have great faith in science, they also have come to fear it, partially because of history and partially because of the movies and media. In particular, we have become suspect of the deranged or diabolic scientist running amuck, a Faustian search for knowledge (at the expense of spiritual or moral values), or a Frankenstein or Dr. Strangelove outcome of knowledge. Nazi experiments in death camps, Hiroshima, and now the nuclear bomb club and threat of war among its members, and fears of chemical, biological, and radioactive warfare add to the potential evil use of science. Indeed, scientists can be bought and sold by political leaders and political fanatics all day and night, just like police officers, politicians, and judges can be bought.

Should human tissues or body parts be used to save someone's life? Should smart babies be cloned? Should the sperm cells of Bill Gates, Ted Turner, Michael Jordan, or Papavochi be packaged and frozen, then used to generate human embryos—and on what scale? Once? Ten times? One hundred times? Or should we go the route of "the Andromeda strain"? Today, people and politicians are concerned with "embryo farms" and the commercialization of body parts, as well as the mad scientist out of control. All these concerns have led to a U.S. ban on cloning and stem-cell research.

Recombinant (genetic combinations, new combinations of genes in progeny that did not occur in the parents) DNA has not been banned. The field of biotechnology remains largely intact, and works on the human body and mind continues in ways that have the possibility of altering who we are and how we think. The concept of multiple intelligence now can be expanded to a much larger idea. With mood and memory drugs, gene splicing and gene engineering, we can expand our abilities to learn as well as the concept of gifted and talented to include a multiple range of abilities and aptitudes. There is no limit to a potential new top range of ability. In 10 to 15 years, students should be beginning education at levels more typical of students now several years older.

Learning How to Learn

In this text, the concept of learning differs from the notion that the learner merely remains passive, reacts to stimuli, and waits for some reward. Here, the learner is regarded as active and able to monitor and control cognitive activities. He or she possesses new information through assimilation and integration with previous information. Without this integration, new information is lost to memory, and task performance dependent on the information is unsuccessful. Learning new information results in modification of long-term memory. The responsibility for engaging in learning—including control, direction, and focus—belongs to the individual.

Cognitive structures are searched when students want to identify, categorize, and process new information. If the cognitive structures are disorganized, unclear, or not fully developed (for the person's age), then new information will not be clearly identified, categorized, and assimilated. On the other hand, new learning based on previous learning should be meaningful to students—in context with prior knowledge and real-life experiences, regardless of whether the students are low or high achieving.

High-achieving students have a more expanded prior knowledge base in terms of in-depth knowledge and multiple forms of knowledge than low-achieving students. This mature knowledge base permits learners to integrate important and/or complex information into existing cognitive structures. Similarly, those students who are capable of learning on their own are better able to (1) narrow and place information into preexisting categories, (2) sharpen or distinguish prior information from new information to avoid confusion or overlap, (3) tolerate or deal with ambiguous and unclear information without getting frustrated, and (4) assimilate existing schemata to interpret problematic situations.

A cognitive framework proposed by Weinstein and Mayer consists of eight comprehension strategies:

1. Basic rehearsal strategies. The ability to remember names or words and the order of things.

2. Complex rehearsal strategies. Making appropriate choices or selections (such as knowing what to copy when the teacher explains something or what to underline or outline while reading).

3. Basic elaboration strategies. Relating two or more items (such as nouns and verbs).

4. Complex elaboration strategies. Analyzing or synthesizing new information with old information.

5. Basic organizational strategies. Categorizing, grouping, or ordering new information.

6. Complex organizational strategies. Putting information in hierarchical arrangements (such as in outlining notes or homework).

7. Comprehension monitoring. Checking progress, recognizing when one is on the proper track or confused, or right or wrong.

8. Affective strategies. Being relaxed yet alert and attentive during a test situation and when studying.

All of these learning skills combined represent knowledge about and control over cognitive processes—what some educators refer to as metacognition. The specific strategies deal with the identification, categorization, and integration of information.

Of all the specific strategies discussed, comprehension monitoring is often considered the most important. This skill permits a student to monitor, modify, and direct (and redirect) his or her cognitive activities. The student remains focused on the task, is aware of whether he or she is getting closer to or farther away from an answer, and knows when to choose alternative methods to arrive at the answer. A student with good comprehension monitoring has developed self-correcting cognition processes, including how to determine what part of the problem needs further clarification, how to relate parts of a problem to one another, and how to search out information to solve the problem. In short, the

student is able to identify what has to be done, focus attention, cope with errors, and make modifications in steps to work out a solution—all without losing control, getting frustrated, or giving up.

Learning-to-learn skills are basic thinking skills that are used in all content areas. Although some of these learning skills are generic and can be taught solely as general strategies, without reference to content, it is impossible to avoid a certain amount of subject matter, especially in the upper (secondary) grades. This assumption seems to make sense—for example, a good mathematical learner may not be as good in English or history. That does not mean there is no transfer of learning skills - from one subject to another; rather, it is likely just less transfer. Bruner may have been right: Different disciplines have their own principles, concepts, and research methods that are distinct from other disciplines. Or, as Lauren Resnick claimed, what is learned in one area is not easily transferable to another area of learning because it is content based.

Yet another school believes generic learning skills can be taught to most students and transferred across subjects. Most of such learning skills can be incorporated into regular classroom activities or taught in a special course that incorporates cognitive processes that cut across subjects. Separate programs designed to teach thinking include Adler's Padeia Program, Feurestein's Instrumental Enrichment, Lipham's Philosophy for Children (discussed later in greater detail), and Pogrow's Higher-Order Thinking Skills (HOTS). These special thinking programs and others are designed to make all students independent learners in all subjects. The training should begin early in the elementary grades, say around the third or fourth grade. It should continue thereafter with additional time devoted to these thinking skills, perhaps twice the allotted time by the sixth or seventh grade, when students must understand and organize increasing amounts of subject-related information. Learning skills cannot be postponed until high school, when the job of learning how to learn has become more difficult because of increasing academic deficiencies.

Critical Thinking

One of the most important things a teacher can do in the classroom, regardless of subject or grade level, is to make students aware of their own metacognition processes to examine what they are thinking about, to make distinctions and comparisons, to see errors in what they are thinking about and how they are thinking about it, and to make self-corrections. It is now believed that critical thinking is a form of intelligence that can be taught. The leading proponents of this school are Matthew Lipman, Robert Sternberg, and Robert Ennis. Lipman's program

was originally designed for elementary school grades but is applicable to all grades. He sought to develop the ability to use (1) concepts, (2) generalizations, (3) cause-effect relationships, (4) logical inferences, (5) consistencies and contradictions, (6) analogies, (7) part-whole and whole-part connections, (8) problem formulations, (9) reversibility of logical statements, and (10) applications of principles to real-life situations.

In Lipman's program for teaching critical thinking, children spend a considerable portion of their time thinking about ways in which effective thinking differs from ineffective thinking. After reading a series of stories, children engage in classroom discussions and exercises that encourage them to adopt the thinking process depicted in the stories. Lipman's assumptions are that children are by nature interested in such philosophical issues as truth, fairness, and personal identity and those children can and should learn to explore alternatives to their own viewpoints, to consider evidence, to make distinctions, and to draw conclusions.

Lipham's emphasis on reading and discussing philosophical/moral issues coincide with the objectives and procedures of the junior Great Books Program for all grade levels (starting in the first grade), originally developed in the 1930s and continuously refined and revised. The emphasis is on good literature, whereby teachers are trained in teaching specific reading strategies, encouraging students to think about and discuss ideas, how to listen for different ideas and build on their own and others' ideas, how to reason and use evidence, and how to write persuasively and creatively. Although the program is based in Chicago, trainers are available for school districts across the country.

Lipman also distinguishes between ordinary thinking and critical thinking. Ordinary thinking is simple and lacks standards; critical thinking is more complex and is based on standards of objectivity, utility, and consistency. He wants teachers to help students change (1) from guessing to estimating, (2) from preferring to evaluating, (3) from grouping to classifying, (4) from believing to assuming, (5) from inferring to inferring logically, (6) from associating concepts to grasping principles, (7) from noting relationships to noting relationships among relationships, (8) from supposing to hypothesizing, (9) from offering opinions without reasons to offering opinions with reasons, and (10) from making judgments without criteria to making judgments with criteria.

Robert Stemberg seeks to foster many of the same skills, but in a different way. He points to three categories or components of critical thinking: (1) meta-components, high-order mental processes used to plan, monitor, and evaluate what

the individual is doing; (2) performance components, the actual steps the individual takes; and (3) knowledge-acquisition components, processes used to relate old material to new material and to apply new material.

Elsewhere, Sternberg distinguishes between creative, intelligent, and ordinary thinking. Creative thinking emphasizes taking risks, the courage of one's convictions and beliefs, and deep-seated personal resources need to believe in oneself. Intelligent thinking is the ability to define and refine problems, to think insightfully, and to discard irrelevant information and zero in on relevant information. Ordinary thinking relies on known knowledge and can use this knowledge for basic tasks and highly structured solutions and problems; the person is able to meet minimum standards and general requirements.

Robert Emiis identifies 13 attributes of critical thinkers. They tend to (1) be open minded, (2) take a position (or change position) when the evidence calls for it, (3) take into account the entire situation, (4) seek information, (5) seek precision in information, (6) deal in an orderly manner with parts of a complex whole, (7) look for options, (8) search for reasons, (9) seek a clear statement of the issue, (10) keep the original problem in mind, (11) use credible sources, (12) focus on the point, and (13) be sensitive to the feelings and knowledge level of others (see Figure 3.1).

Teaching Learning/Critical Thinking Skills (Figure 3.1)

1. Defining and clarifying
    a. Identifying conclusions
    b. Identifying stated reasons
    c. Identifying unstated reasons
    d. Seeing similarities and differences
    e. Identifying and handling irrelevance
    f. Summarizing
2. Asking appropriate questions to clarify of challenge
    a. Why?
    b. What is the main point?
    c. What does this mean?
    d. What is an example?
    e. What is not an example?
    f. How does this apply to the case?
    g. What difference does it make?
    h. What are the facts?
    i. Is this what is being said?

    j. What more is to be said?
3. Judging the credibility of a source
    a. Expertise
    b. Lack of conflict of interest
    c. Agreement among sources
    d. Reputation
    e. Use of established procedures
    f. Known risk to reputation
    g. Ability to give reasons
    h. Careful habits
4. Solving problems and drawing conclusions
    a. Deducing and judging validity
    b. Inducing and judging conclusions
    c. Predicting probably consequences

Promises and Pitfalls of Critical Thinking

In general, teachers must ask students a great many questions; require students to analyze, apply, and evaluate information; take opposing sides to tease and test students; and require them to support their answers or conclusions. Supplementary materials, beyond the workbook and textbook, will be needed; it is recommended that teachers work together to develop such materials. By varying instructional activities, ensuring that groups are heterogeneous in abilities and skills, distributing relevant materials, giving instruction in constructing logical arguments, and encouraging students to rely on evidence, teachers can help students learn to think critically in a variety of academic situations.

According to researchers, "Giving children a sense of ownership in their classroom can lead to the kind of open and cooperative learning environment that most teachers dream about." This kind of classroom climate is important for developing "confident, active" learners who learn to rely "on their own inner resources." Children must learn to listen to each other, to respect each other's conversations, and thoughtfully respond to what their classmates have to say; there must be room to think, to grow, and to build genuine concern and appreciation for others.

Similarly, David and Roger Johnson point out that students must learn to respect and value one another so they can learn from each other. Students must feel secure enough to challenge each other's ideas and reasoning, and they must be encouraged to engage in controversial discussions, debates, problem-solving activities, and decision-making activities.

No one teacher can do the job alone. It is a process that takes years to develop. It behooves the school administration to establish the professional climate and the need for cooperation and communication among teachers (of all subjects and grade levels) to implement the goal of making students into critical thinkers. It takes a critical mass of teachers who agree, and have certain student expectations, that thinking counts more than facts, and that asking "Why," "How," and "What if" are more important than "What," "When," and "Who."

One might argue that all this fuss about thinking is nothing more than old-fashioned analysis and problem solving—what good teachers have been infusing into their classroom instruction for years. Moreover, it may be argued that teaching a person to think is like teaching someone to swing a golf club or cook a stew; it requires a holistic approach, not the piecemeal effort suggested by Lipman, Sternberg, and Ennis. Trying to break thinking skills into discrete units may be helpful for diagnostic proposals, and it may sound like a good theory, but it can also be argued that critical thinking is too complex to be broken down into small steps or discrete parts. Rather, as some researchers purport, it involves a wide range of strategic activities, such as cause-effect relationships; arguments in the forms of opinions, each supported with multiple forms of evidence; and knowing what one knows and how one knows it. In short, the whole may be more important than the parts in describing or analyzing a student's mental functioning.

Perhaps the best way to teach thought is to ask students to explain their thinking, to require them to support their answers with evidence, and to ask them thought-provoking (Socratic) questions. Formulating thinking into discrete and generic skills, a special unit or course seems artificial. However, dividing thinking skills by subject matter is unwieldy and mechanistic. Hence, we are left with several options that have potential pitfalls. There is no sure argument or solution. We are forced to take educated guesses concerning the right approach.

Perhaps the major criticism of thinking skills programs has been raised by Sternberg himself. He cautions that the kinds of critical thinking skills stressed in school and the way they are taught "inadequately [prepares] students for the kinds of problems they will face in everyday life." Further caution is needed. Thinking skills programs I often stress "right" answers and "objectively scorable" test items; therefore, they are removed from real-world relevance. Most problems and decisions in real life have social, economic, and psychological implications—not just a cognitive spin. They involve interpersonal responsibility and choice.

How a person deals with illness, aging, or death or with less momentous events, such as starting a new job or meeting new people, has little to do with the way a person thinks in class or on critical thinking tests. But such life situations are important matters—for some, the essence of life. In stressing cognitive skills, educators tend to ignore the realities of life. Being an A student in school guarantees little after school and in real life. It certainly has little to do with being a good lover, possessing mental and physical health, being a moral, spiritual or good person, or earning a lot of money in our society—all in the larger scheme of life are more important than being "smart."

There are many other factors associated with the outcomes of life—and many of them have little to do with critical thinking or even intelligence. Thus, we need to keep in mind social, psychological, physical, and moral components of learning as well as "luck"—what some of us might call the unaccounted for variables in the outcomes of life. Given all the options and factors related to life, luck (good and bad) counts more than "smarts" or intelligence. Do we make our own luck? I guess type-A personalities think that they make their own luck, but no genius can swim against the tide: Events dealing with global affairs, the national economy, who gets elected to what political office, or where the next war, terrorist act, or traffic jam will take place. In simple terms, you cannot always determine or control who you will meet at the next party you attend. It could be your new lover or future spouse. Anyone with a few ounces of brains, mixed with old-style wisdom, understands that social and personal skills are more important than cognitive skills in the scheme of life, as well as how we get along with people and take advantage of events that have an impact on us.

Thinking Outside the Box

Moving from conventional and ordinary thinking to the fringe, the way we learn how to learn, think, and innovate may change in the future, since the science and math we know may be incomplete, in need for reinterpretation and rearrangement. In fact, our science and math has led us down the wrong path, according to physicist Stephen Wolfram. The mistake (phenomenologists, reconceptualists, radical critics, and ethnographic researchers will be happy to hear) is trying to describe the world with traditional scientific (Newton's world) and mathematical (Einstein's world) models.

Almost all western scientific and mathematical thought is based on abstract ideas related to time and space as a continuum that extends into infinity. So long as we keep to this continuum, we can describe things with precision. For example, we are

able to precisely describe the earth's trajectory around the sun; the time and place (within a few miles) where a space capsule will enter the earth's gravity and subsequently land; and the force with which a person falls from the Empire State Building or Eiffel Tower. But once we try to explain systems with greater complexity and numerous interacting a variables, we run into a slippery slope and we start hedging our bets. This happens when scientists try to predict the force of a hurricane or the death toll of a potential atomic blast, when social scientists try to predict the end of a recession or when and if the Dow Jones will reach 15,000, or when educators try to explain all the classroom conditions and teacher-student interactions related to successful teaching.

In all these instances, the calculations are open to confusion, contradictions, and speculation. We are left with an array of variables that cannot be fully explained by the laws of Newton and Einstein, nor the logic of Descartes or Russell; we have an incomplete model for thinking and dealing with multidimensional and elaborate calculations, and where there is unpredictability.

Our theories, models, and equations do not fully explain how the universe works. Plato cannot save us, neither can Augustine or Aquinas, Bacon or Locke, nor can the doctrines of the Vedas (Hinduism) or Zen (Buddhism). The only thing that can save us, according to Wolfram, is the computer program that can deal with all known variables and their respective interactions. All we need are spreadsheets and lots of paper to generate unlimited, infinitesimal data. Indeed, the "computer geeks" who understand and manipulate little snippets of electronic information will hopefully revamp science and math and save humankind from its incomplete thinking.

Now, some of this sounds far-fetched and perhaps like I'm playing with your mind. It can be argued by rational and logical people that computer programs are nothing more than human inventions that understand little more than 1 and O, and that the program is as good as the human mind. It is contended, however, that scientific and mathematical models got it wrong; our equations are artificial and based on flawed continuums. Time doesn't flow; it ticks. Space is not a surface, but a grid. The world we know is best described not by scientific and mathematical equations, but by computer programs that can spit out tiny pieces of information that yield endless, infinitesimal, intricate data. Behold—the computer will capture the richness of our thinking, producing dribbles of information, taking an inch (space) or second (time), then halving it, again and again, into infinity.

A Final Note: Listening to and Looking at Children's Drawings

I leave you with food for thought, something a bit more concrete, by looking through the eyes and artwork of fifth-graders in a minority school in New Haven, Connecticut. These are kids with imagination, creativity, and a sense of wonder. When asked to draw a day in their lives 20 years from now, one student drew his own body shop, painted bright yellow, where for $90 you could get your car fixed. Another student painted two women, trading volleys on a tennis court, to win a trip to the moon. There was also Pokemon saving the human race from a host of volcanoes erupting at the same time; and a bare-chested man surrounded by a half-blue, half-green background, flying to his destiny with the verbal explanation, "That's my uncle."

There was a picture of a minivan, full of children with the verbal explanation, "My mother . . . buys a minivan and she takes us places. This [van] can fly, and only she can drive it. . . . It can go anywhere you want. You just push in the speed like you push in the speed on the treadmill, and it will go. . . . You don't have to drive, you can just tell it your destination and it will take you there." There was another student with a picture of a framed diploma represented by some wavy lines on paper, a chair with wheels, a desk, and what appeared to be a computer and a file cabinet. Her explanation: "When I grow up to be a lawyer, I'd like to roll around on my chair and still be able to see the screen. . . . Being a lawyer you can make more friends. You'll help people and they'll remember, 'Yeah, that's the girl that helped me.' "

How about this last one: a picture of a baby robot and mother robot (no father figure), a balloon, and a small purse or bag. Explanation: "The baby robot is made out of tin, and the mama is made out of copper. They'll probably be just like us; they don't take showers [but] they're being our friends. It's a New Year's Eve party. . . They're listening to, probably, like sounds of machinery."

What happened to these friendly, imaginative, positive-thinking kids? What went wrong in the home, school, and communities so that many kids from the ghetto are left behind, grow angry, and lose their future? Think about it. Happy, bright, creative, fifth-grade students. Now, the flip side is that three-quarters of these kids in the class read below grade level. Is that the answer? Does it boil down to reading? Do we need to consult with some education guru? Given all the half-baked schemes for improvement, maybe we need to consult with Dr. Seuss, Timothy Leary, Master Po, or the Dali Lama. Surely, you don't need to be a genius or have the insights of the most successful children's author or be a Harvard professor, a

Chinese war lord, or Buddhist monk to figure out that reading is the strongest link to school success.

Are there other domains of learning that are important? For every Michael Jordan, Michael Jackson, or Jennifer Lopez who succeeds in sports or entertainment, a hundred thousand or more kids from the ghetto fail school because of limited reading skills—and subsequent learning and/or behavioral problems. Other things count, and they will be discussed in other chapters. However, I thought it was worthwhile to recapture the world of young, innocent kids who have managed to remain hopeful. They provide us with subtle and simple reminders about our roles and responsibilities as parents and teachers.

Summary

1. In classical conditioning, the S-R association depends on the conditioning of the response and stimulus. Pavlov and Watson represent this theory. In contrast to classical conditioning, no specific or identifiable stimulus consistently elicits operant behavior. Operant theory is best represented by the work of B. F. Skinner.
2. People can also learn through observing and modeling; this explanation of behaviorism is associated with Albert Bandura.
3. According to Piaget, four cognitive stages form a sequence of progressive mental operations; the stages are hierarchical and increasingly more complex. Piaget is also noted for his cognitive theory of assimilation, accommodation, and equilibration – namely, new experiences are modified and derive new meaning.
4. Moral knowledge can be acquired through academic content, but moral character takes years to develop and to reflect the whole person.
5. Whereas Piaget concludes there are three stages of moral development, Kohlberg contends there are six stages to moral reasoning. Both Piaget and Kohlberg view moral development as a socialization process that can be shaped, in part, by schools and society.
6. Students have different learning styles and different ways of thinking, including, but not limited to, visual, auditory, and tactile responses.
7. Our contacts with or lack or exposure to various cultures influence our thinking processes – how we perceive the world, and to what extent we make use of universal knowledge.
8. Whereas Charles Spearmen viewed intelligence as one general factor, Howard Gardner viewed intelligence in context with either broad areas of

life, and J. P. Guilford described it in terms of 120 mental operations and/or cognitive processes.

9. Students can be taught learning skills and critical thinking skills. The idea is for the teacher to move from facts and right answers to analysis and problem solving.

Questions to Consider

1. In what ways do behaviorist theory and cognitive psychology differ in terms of how students learn?
2. Why might you think that Piaget's theories of cognitive growth influence elementary teachers more than secondary teachers? What is the different between assimilation and accommodation of experience?
3. Should teachers be expected to teach moral education? If so, whose morals?
4. How does brain research influence teaching and learning?
5. What teaching methods can be used to improve students' thinking skills?

Things to Do

1. Observe two or three teachers at work in the classroom and try to observe their instructional techniques. List those techniques that reflect a behavioral approach. Discuss your findings in class.
2. Observe the same teachers. Make a list of cognitive instructional techniques. Discuss your findings.
3. Some observers argue that Piaget and Kohlberg ignored women in developing their moral theories. Check the internet to ensure the voice of women in moral education.
4. Describe your own learning style. What preferences do you have regarding movement, sound, light, and food when you study for a test?
5. School success is partially based on the students' ability to think critically. Identify four or five process, or things teachers can do, to foster critical thinking among students.