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AUTHOR Claycomb, Mary
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ABSTRACT

Current research on brain activity has many implications for educators. The triune brain concept and the left and right hemisphere concepts are among the many complex theories evolving from experimentation and observation. The triune brain concept suggests that the human forebrain has expanded while retaining three structurally unique formations that reflect early ancestral relationships to reptiles, early mammals, and recent mammals. The left and right hemisphere and division of labor theories attribute functions to specific regions of the brain. These theories lead to the conclusion that educators must be concerned with educating all areas of the brain, since all of the areas interact. The research suggests that a basic education must include informational and processing skills as well as creative behaviors and artistic activities. Educational issues such as learning disabilities, genetic and biological differences, and instructional designs have already been in influenced by brain research. Teachers must use current developments to make preparations for future practices. (FG)

Brain Research and Learning

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A position paper written by Mary Claycomb, Manager for Product Development, Publishing Unit, NEA Instruction and Professional Development.

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INTRODUCTION

The belief that education can and does change the lives of children and adults is as old as recorded human thought. It is one of the most optimistic of our beliefs, one that for centuries has led capable and enthusiastic men and women to become teachers--in spite of difficult teaching conditions and small material rewards.

We live in a time when the teaching profession's optimism for education is frequently threatened by negative comments about the schools, by well-articulated criticism, some of which is based on what is called scientific data, and by inadequate funding. We are often assailed by pessimistic judgments, both from the popular press and from some areas of the scientific establishment itself. It is of the utmost importance, then, for us to realize that our optimism and our daily practice are supported by a body of scientific findings that is increasing knowledge of human learning potential at an astonishing rate.

We as teachers should continually bear in mind that the rapid growth of neuroscience in particular holds many vital implications for the future of education. Because of the positive nature of these implications, brain research, like other areas of science, seems especially liable to misunderstanding and oversimplification. For this reason we need to review the current evidence with care, examining particularly those findings from which we may infer far-reaching possibilities for our professional endeavors and the future of our students as well as ourselves.

In spite of the dangers of misrepresenting such an intricate body of material by treating it too rapidly and in too small a space, this paper is intended to invite readers' interest and to lead them to an in-depth examination of an important area of research.

THE HUMAN BRAIN

From the earliest written records of events and philosophical inquiry we know that a close correlation has been made between the human body and the processes of thought, learning, reasoning, and feeling. The Western view has long associated reason, thought, and the retention of information and experience with the brain, and feelings with the heart. These associations have influenced the structure of many of society's institutions, and they have permeated the language.

Consider such phrases as "use your head" or "he's all heart" or "she's the brains of the family." They suggest that the brain is the location of good sense, restraint, responsible thought, and that the heart is the source of warmth, kindness, and generosity. Although it became clear in the nineteenth century that what are called feelings are also governed by the brain and are closely interactive with thought, the old phrases die hard. We are still aware of the separation of thought and feeling in everyday expression as we look at greeting cards and hear popular songs.

Through the centuries much scientific and philosophical speculation has been devoted to the brain, with relatively little being known about how it functions. In ancient and medieval times, memory was given a central position in teaching and learning.[1] Elaborate systems of image-association were developed to help people retain words and instructive stories that were vehicles for social values. This method of teaching lasted well into the twentieth century, and for some people it is a component of "basic education." More recent learning theory has focused on the behavior and performance of learners rather than on the constructive qualities of their mental processes. The study of cognitive functions has become prominent of late, however, and has led educators to concentrate their attention on the operations of the brain as revealed through the work of medical scientists with brain-damaged patients.

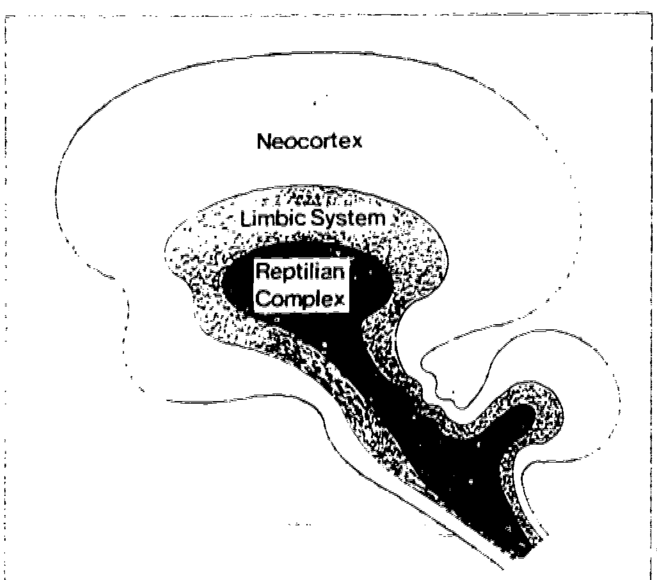
Since the nineteenth century, scientists have known that each hemisphere of the brain--left and right--generally acts as a kind of control mechanism on the muscles and sensations of the opposite side of the body. But the nature of that mechanism and its exact range and manner of functioning is only beginning to be discovered. And although it is not known in great detail what the exact correlations are, fascinating and provocative information about brain function is beginning to accumulate. We seem to be on the threshold of a great repository of new insights and information.

In the past century, and particularly in the past decade, enormous progress has been made in discovering how the anatomy and physiology of the brain are involved in thinking, remembering, speaking and writing, listening and seeing, as well as in feeling, in emotional expression and reaction, and in certain kinds of artistic endeavor. The brain, in fact, seems to be involved in all human actions, in all the processes that make teaching and learning possible. As educators we can readily jump to the conclusion, then, that our concern with brain activity must touch on curriculum, classroom design, learning equipment and materials, evaluation of learning, recognition of socio-economic factors that influence teaching and learning, and the assessment and treatment of learning disabilities, as well as on different student learning styles and, ultimately, on teacher education.

Much has been written recently on the complex issue of hemispheric dominance and lateralization of functions, on the triune concept of brain function--which is an elegant scientific hypothesis based on knowledge of human evolution--and on genetic determinants. The facts form an extremely intricate web about which considerable reflection is necessary. Although the major theories tend to be metaphoric, they are plausible and worth our examination because even in their barest outlines they support a philosophy of humanistic and holistic education. To illustrate how many possibilities for the classroom can already be projected from brain research, two of the theories are examined here: the triune concept and the left-right hemisphere concept.

The Triune Brain

The triune brain concept was formulated by Paul D. MacLean, M.D., chief of the Laboratory of Brain Evolution and Behavior, National



Institute of Mental Health. Dr. MacLean describes his theory in these words: "In its evolution the human forebrain has expanded to a great size while retaining the basic features of three formations that reflect our ancestral relationship to reptiles, early mammals, and recent mammals. Radically different in structure and chemistry, and in an evolutionary sense countless generations apart, the three formations constitute a hierarchy of three brains in one. . . ."[2]

The first formation is the reptilian or R-complex, located in the midbrain. It influences primal patterns of behavior in mammals, such as territorial siting and marking, hunting, foraging, fighting, greeting, grooming, mating and breeding, grouping and flocking, establishing social hierarchies, making ritualistic displays, and other, similar activities. In human beings such behavior may take the form of impulses and compulsions, routine habits, seeking and following precedent, and practicing ritual. Displacement reactions in uneasy moments--e.g., nail biting, throat clearing, or head scratching--are thought to be controlled by the R-complex. On a bureaucratic level this behavior may take the form of a procedure such as appointing a committee to study a problem that cannot be solved easily or immediately. Deceptive behaviors like those practiced to throw a competitor off the track of what one is doing, or tropistic behaviors that may include imitation (following fads and fashions, collecting at favorite hangouts), may all be controlled in the R-complex. In brief, what we might think of as instinctive or peer-influenced behavior may well be the product of the R-complex.

The layer surrounding the midbrain is the limbic system or old mammalian brain. This second formation seems to be the source of emotions and some aspects of personal identity. Many drugs, such as the hallucinogens and alcohol, act on it. Carl Sagan[3] speculates that the limbic system may control such feelings as exhilaration and awe, which seem to be particularly human. Dysfunctions of the limbic system can cause strong emotions, such as rage or fear, that may appear to have no outward cause. (Classroom teachers have often seen learning-disabled students undergo such reactions.) The sense of smell is probably the oldest capacity of the limbic system, although it is not located exclusively in this area of the brain; some olfactory ability is also contained in the third and outer formation, the neocortex (described below).

Some short-term memory functions, as well as functions related to sleep and dreaming, appear to be situated in the hippocampus, a structure within the limbic system. (Again, however, the functions appear to be shared by other areas of the brain; research has shown that memories are also stored in the neocortex and elsewhere.)

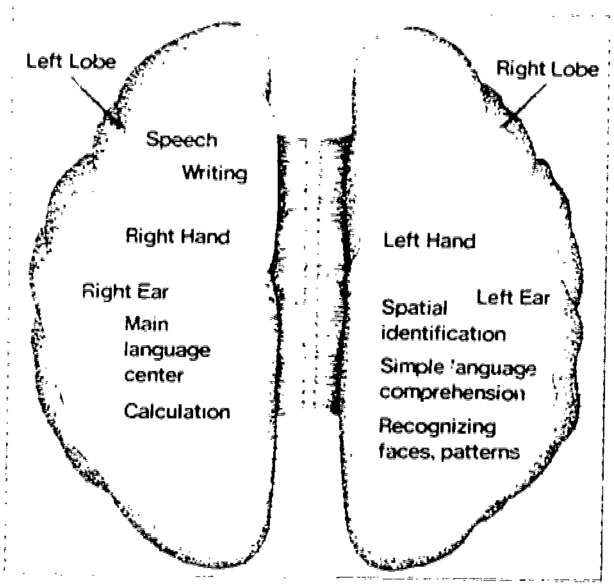
The limbic system contains the pituitary gland, which gives it a strong influence on the visceral and endocrine systems, and the amygdala, a structure associated with reactions of both aggression and fear. Recent discoveries of chemical message bearers called peptides, which are manufactured by the brain and appear to influence moods through their operation on the limbic system, have led to much speculation about possible control of mental illness through drug therapy.[4]

The third and outer formation of the brain, called the neocortex or new mammalian brain, is divided into left and right hemispheres. The neocortex is the source of reason, linguistic expression, verbal memory, and operations that involve some of what are generally considered cognitive or scholarly functions. There is evidence that visual perception is situated at the back of the neocortex and auditory perception near the temples. Anticipation of the future as well as worry and anxiety seem to have their source in the frontal lobe.

The neocortex interacts with the limbic system and R-complex through a complicated interchange of electrical impulses and chemical discharges, so that most behaviors are the result of a complex cooperation among the three layers or formations of the brain. As with memory and the sense of smell, many functions seem to be shared among the formations. The left and right hemispheres of the neocortex are also cooperative entities which appear to control numerous reasoning and creative functions through an association of action.

Left and Right Hemispheres, The Division-of-Labor Concept

As noted before, the two hemispheres of the neocortex correspond roughly to a control mechanism for our muscular activities, speech,



word processing activities such as reading and writing, and numerical calculations. In general, the movements of one side of the body are controlled by the opposite brain hemisphere. In addition, each hemisphere appears to have other functions that are not parallel, and the hemispheres seem to divide these nonparallel functions between them. The interaction of the left and right hemispheres may be viewed as part of the functioning of the triune brain, but many commentators separate the two concepts when writing about them.

Approximately 90 percent of all human beings are right-handed and otherwise favor the right side of the body in their movements. Because of this, and because it controls much of the organization of speech and thought, the left hemisphere is viewed as the more dominant one. Even left-handers appear to have much of the speech-organizing function in the left hemisphere. Although there seems to be slight evidence of a correlation between left-handedness and learning disability, problems can be caused if parents or teachers try to change left-handedness to right-handedness.

Much of the evidence for siting cognitive functions in the left hemisphere comes from the work of Dr. Roger Sperry of the California Institute of Technology. In performing brain surgery to relieve some of the acute symptoms of one form of epilepsy, and in studying stroke patients, Dr. Sperry and others have collected evidence that is supported by additional data gathered from extremely interesting, very detailed experiments with small samples of healthy individuals. This research has revealed that what we consider cognitive functions--the structuring of language, manipulating of consonant and vowel sounds and word meanings, calculation, and other logical operations--are located in specific areas of the left hemisphere.

These experiments and observations have also revealed that other, less structured functions--spatial identification, recognition of vowel sounds, sensory discriminations, recognition of faces, detection of unfamiliar tactile patterns--seem to be more closely associated with, or even specifically controlled by, the right hemisphere.

In the division-of-labor theory, most verbal behavior, certain other kinds of cognitive functioning, structured thinking, and similar activities are said to be left-hemisphere behaviors and more perceptual or physically constructive or appreciative responses are called right-hemisphere behaviors. The terms tend to be used loosely but are convenient for categorizing styles of activity. The distinction certainly can be a fair basis for viewing the difference in styles between highly verbal, logical, organization-oriented individuals and those who are more physically, intuitively, or creatively motivated. The interaction of the two hemispheres indicates that opposite hemisphere functions can--and should--be developed in students who appear to be oriented toward a single hemisphere.

Left-right hemisphere interaction has been the subject of numerous articles in popular magazines and the educational press. It is an attractive theory, but because it contains so much metaphoric material, we need to be cautious about basing rigid assumptions on it. Its intrinsic appeal has even caused some writers to use this theory as the sole basis for a plea to reinstate arts education in the basic curriculum.[5] Though no one can deny the importance of arts education, in tandem with the essential informational and processing skills such as reading and writing, it seems a great disservice to the arts to imply that current brain research gives a clear mandate for focusing on them in the curriculum. We should be able to justify their inclusion on the basis of other psychological, social, environmental, and educational factors, as well as on their relation to the human brain.

In an excellent article on the left and right hemispheres, Howard Gardner[6] points out that the precise nature of specialization or "dominance" is disputed, that many left-handers and right-handers alike have significant linguistic capacities in the right hemisphere. He also states that there is little scientific evidence that artistry, logical capacity, intuition, or consciousness are located in either half of the brain, though many claims have been made for situating these behaviors or attitudes in an exact location. Gardner strongly implies, however, that so many discoveries are being made in the area of neuroscience that we should take a wait-and-see posture. Although this may seem a cautious position, it is surely not without optimism for the possibilities that appear to be building in the area of left-right hemisphere interaction.

IMPLICATIONS FOR EDUCATION

The major theories of brain formation suggest that our concern as educators must be for educating all areas of the brain, an attitude that may give us a new way of approaching the whole child. The affective areas--emotion, appreciation, altruism, even those behaviors included in the concept of good parenting--which are as much in need of cultivation as the cognitive areas, demand our attention because they are so intimately interactive with the logical functions of the human brain. Indeed, the research strongly suggests that a basic education must include a substantial element of both the informational, processing skills and the nonlogical behaviors and artistic activities that form our creative life.

Students who seem to function in one area rather than both need to be given opportunities to develop the undeveloped area, whether we choose to call their style of learning right- versus left-oriented or affective versus cognitive. By the same token, it would be dangerous to assume that we should attempt to develop one style to the exclusion of the other; that is the kind of planning that tends to lead to the exclusion of some students at the expense of all.

Learning Disabilities

Disabilities in verbal processing activities such as reading and writing have their sources in brain dysfunctions or differences, just as do many behavior problems that cause classroom disruption. And even in cases of serious brain damage there is considerable hope for correcting many functional disabilities; it has been well demonstrated that some brain damage may be overcome early in life because of the plasticity of the brain. Even so, it is difficult to predict full recovery after impairment, and hence it is important for teachers to understand the nature of disabilities caused by brain damage or dysfunction.

In writing of learning disabilities, Martha Bridge Denckla[7] has pointed out that there are many causes of such disabilities, from brain damage to a variance from the majority in an individual student's style of brain processing. It is now known that the number of different dysfunctions and their causes is far greater than was once believed. So many discoveries are being made about the relationship between disabilities and brain function that educators need to be constantly aware of the changes taking place in therapy and remediation for specific problems.

There are indications that a relationship exists between reading disability (dyslexia) and noticeable disability in spoken language or verbal memory. The difficulties resulting from such problems are far-reaching, often leading to behavior problems remote from the reading class. In fact, reading disability in an otherwise able child may lead to problems of low self-esteem and depression. Experts indicate that such students need positive experiences in areas other than reading as well as small group work with other similarly learning-disabled students.

Since many social and emotional problems have their roots in brain dysfunction, the appropriate treatment may be quite different from treatments suggested for early psychological damage. The hyperactive child, for example, is one whose entire spectrum of learning and behavior is affected by a brain-related syndrome. The attention of such a student may be short in duration, and she or he may be prone to impulsive behavior. A wide array of methods and learning equipment (including books, films, filmstrips, audiotapes, and teaching-machine programs) should be available to the hyperactive student so that learning in a particular subject area can continue to take place even when the method or material has exhausted the learner's attention.

Denckla[8] suggests that teachers keep in mind the following points when working with any learning-disabled students:

- Never react with anger or seeming anger.
- Do not demand speed on a task.
- Be explicit and precise.
- Give as much positive reinforcement as possible, because such a response is effective, even though material rewards may have little value.
- Emphasize what is good in the student's work.
- Be willing to change course as the student grows and changes.

These and similar suggestions have numerous implications for the teacher who is working with learning-disabled students in the regular classroom, and they should be considered as approaches to all other students in that classroom.

Genetic and Other Biological Differences

The nature-nurture controversy has raged for centuries, and it continues to do so whenever the convictions of determinists confront the possibility of change through educational planning and practice or through improvement of environmental conditions.

All educators can only be encouraged by the findings of brain research, which point clearly to the significance of environment and education in enabling learning to take place. In Denckla's words, ". . .the brain is an organ designed to assimilate experience and be modified by it. . . ."[9] The statement is constantly echoed by other writers on neuroscience. The brain's ability to recover from many kinds of damage and its enormous capacity to compensate for functions diminished by injury give researchers much confidence in working with many learning-disabled students.

Although brain research does not overlook the role of an individual's genetic structure in his or her development, current findings from that research overwhelmingly debunk the controversial thesis put forward by Arthur Jensen[10] in 1969 that hereditary inferiority might be the cause of failure in school. Timothy J. Teyler summarizes accurately the position of the brain researchers when he says, "It appears that the genetic contribution provides a framework which, if not used, will disappear, but which is capable of further development given the optimal environmental stimulation. The social and political implications of this fact of brain functioning are obvious and far-reaching."[11] The mandate for education could hardly be stated more clearly.

Brain weight is proportionate to the body's density, and since human male bodies tend to be larger than those of human females, the male brain tends to be greater in weight than that of the female. The same proportionate difference holds for racial groups of different statures. Hence, the numerous racist and sexist arguments still based on brain weight must be viewed as discriminatory and be totally rejected as lacking in scientific basis.

Instructional Designs

There is strong evidence that the brain is substantially formed at birth so that learning takes place at various set stages in a child's development.[12] For this reason, there seems now to be little purpose in parents trying to hasten their infant's or child's development by programming special activities in the crib or playpen to the neglect of play and other important modes of social learning. This does not mean, however, that the stages of development require the lockstep approach to learning that has long been the result of overcrowding in classrooms and administrative decisions unrelated to the learning process. Hence the evidence certainly supports the argument for individualized instruction at the earliest levels of a child's classroom experience.

Several new instructional designs have been devised to take advantage of recent findings in brain research. One of the most interesting is that proposed by Leslie A. Hart,[13] whose Proster theory offers a brain-compatible approach to learning. Hart emphasizes that the brain seeks what it needs for adaptation to reality, that processing is individual and depends less on presentation of material to be learned than on the total previous stored experience of the learner. Since a great portion of the brain is devoted to language, young students must talk to learn well. The neocortex does not function under "threat"; and the brain as a whole seems to proceed by approximation, not step-by-step logic.

Hart, among others, stresses that the brain works by programs, as a computer does, though it can handle many more programs at one time than even the most sophisticated computer. It also works by perceiving and building on patterns.

Other designs--for example, those indicated in the practice of such philosophical approaches as suggestology[14]--stress the constant many-leveled programming and functioning of the brain. They are concerned with setting proper moods and conditions for effective learning to take place, and they seek to combine so-called mystic practices with artistic and aesthetic stimuli to advance learning in all areas. Although many of these plans are interesting and valuable in the hands of gifted teachers, they may be difficult to introduce into the average classroom. Teachers should be aware of them, however, so that they may have opportunities to use such ideas as creatively as possible in their own daily practice.

Implicit in all the research that involves the brain and learning is the certainty that many modalities are needed in the contemporary classroom to match the number of differences in learning style that may exist there. Not only is the classroom teacher called upon to vary her or his modes of instruction, but a variety of technologies are also needed to complement the approaches of the teacher. For example, television in its many forms (closed-circuit, cable, videocassette), films, filmstrips, tapes, study prints, and other audiovisual media are needed to supplement standard textbooks and other printed materials. Since we know that much informal learning, whether for good or ill, takes place as a result of exposure to a number of media, particularly television, we need to find more and better ways to make use of those media both in and out of the classroom. Many teachers are doing this daily with enormous success, and all teachers need to be encouraged to do so.

Whatever modalities are used in the classroom, however, it is important that an individualized approach to instruction be stressed to an ever-increasing degree. There are so many differences in the modes of brain processing that students cannot fully enjoy the right to learn until they are offered learning conditions that take into account their individuality.

Brain Research and Education

In the concluding chapter of the excellent National Society for the Study of Education yearbook entitled Education and the Brain, Jeanne S. Chall and Allan F. Mirsky[15] summarize the implications for education put forward by writers of all the essays in that volume:

- Environmental stimulation and experience play central roles in the growth and development of the brain--even in overcoming the effects of inherited deficiencies and acquired injuries.
- Proper timing is important in the growth of both cognitive abilities and emotional capacities.
- Certain kinds of training appear to be more effective than others. There seems to be a strong implication in work done to date that matching instructional methods with the aptitudes of the learner will cause learning to take place more efficiently.
- Educators cannot ignore the great importance of left-right hemisphere interaction for the development of human cognition and for the understanding of differences in learning styles.
- The two strongest implications for education at this time seem to be (a) that we need to find out how to strengthen the

"weak" left-hemisphere processes of some students by using more right-hemisphere activity to help them learn left-hemisphere functions; and (b) that students who are weak in academic skills (based on our dependence on left-hemisphere processes in our ordering of the curriculum) should be taught music, construction, and other activities involving right-hemisphere processing, in other words, activities in which they can excel.

LET'S CONSIDER

The current state of brain research raises a number of questions for the educator. Although these cannot be answered easily or quickly, teachers should take time to examine them from all sides.

1. <u>How can classroom teachers utilize the findings of brain research in day-to-day instruction?</u> What direct classroom applications are already indicated in brain research data? How easily might these applications be adapted in daily practice? How would current teaching materials need to be modified to reflect brain research findings? What changes in the decision-making structure of a school building or district would have to be made to permit neuroscience findings to have the greatest impact on classroom teaching?

2. <u>How can the curriculum be modified to help all students develop their brain potential?</u> Should teams of classroom teachers work with brain researchers and parents to devise ways to develop a curriculum balance that would increase right-oriented skills for left-hemisphere learning styles and left-oriented skills for right-hemisphere styles? Might we examine current curriculum design to see where we could develop better curriculum/learning-style matches in existing curricula?

3. <u>How might tests be changed to reflect the current and future findings of neuroscience?</u> How can we use brain research findings to influence test design so that standards of measurement reflect a fairer approach to different learning styles?

4. <u>How might the findings of brain research be helpful to teachers in negotiating the reduction of class size?</u> How can we best examine and use the findings of brain research to support a lower pupil-teacher ratio?

5. <u>How can we find more and better ways to emphasize the values of individualized instruction for all students?</u> Should every student, regardless of ability, have an individual educational plan?

6. <u>How might audiovisual programming in the classroom help develop nondominant competencies in all students?</u> How can a variety of media help all students to increase their learning capacities, including students with learning disabilities caused by brain dysfunctions or differences? How might teachers work with local broadcasting facilities and other media suppliers to help support curriculum programming designed to match learning styles?

7. <u>How might classroom teachers keep constantly informed on the findings of brain research?</u> Should special preservice and in-service programs be regularly offered to inform teachers about the latest findings in brain research? Should special publications in the field be made available on a regular basis to classroom teachers?

8. <u>How should policies regarding federal funding for education be influenced by the findings of the neuroscientists?</u> Should all national educational policy take into account the current state of brain research findings on a continuing basis?

Although it may seem difficult for teachers to put the findings of neuroscience into immediate classroom practice, it is essential that these findings become part of the knowledge from which we plan and negotiate. Some of the breakthroughs of which we already have vague hints may become strong influences on the shape of curriculum and the methods we will be using in the near future. Awareness of current findings in brain research may indeed be one of our best preparations for future practice. It should give us more effective ways of viewing and evaluating the whole student--and the whole classroom of students.

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