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Introduction

Student Brains, School Issues: A Collection of Articles

Education is at the edge of a major transformation. Recent dramatic advances in the brain sciences and computer technology are moving us toward a new perspective of what it means to be and to teach a human being.

THE BRAIN SCIENCES

Brain imaging technology monitors can now display the activity of a normal human brain while it responds to problems posed by researchers. For example, as a subject reads, writes, or plays a computer game a monitor simultaneously shows the activity level of various brain areas associated with the activity. Scientists, thus, are determining how and where our brain processes a wide range of educationally significant cognitive tasks. These studies focus primarily on the identification, organization, and operation of the vast number of neural network systems that interconnect the 100 billion neurons in our brain and on the dozens of neurotransmitter and hormonal systems that regulate the activities of neural networks. Such studies will lead to a better understanding of changes that occur within our brains while we're learning something and of the differences among individuals or groups of people as they respond to an

identical problem (such as male/female or immature/mature brain differences).

These research developments have sparked an immense interest in the development of a comprehensive brain theory that will be of the scientific magnitude of $E=MC^2$ in that it will spark a revolution in the brain sciences analogous to the revolution in the physical sciences that followed Albert Einstein's relativity theories at the beginning of the twentieth century. Powerful new theories tend to escalate the quality and quantity of our knowledge in an area. It's difficult to predict when such a definitive brain theory might emerge, but it inevitably will lead to a new major educational theory early in the twenty-first century that will transform educational thought and practice. The twentieth century has been the century for physics. The twenty-first century will be the century for brain/body biology—our century.

COMPUTER TECHNOLOGY

A related electronics explosion is occurring in computer technology, which has gone through three distinct revolutions within one human generation: from mainframe computer to personal computer to Internet. Computer technology has been important to the escalation of brain research because it takes powerful computers to quickly analyze and report the vast amount of information that a brain constantly processes. Similarly, brain research advances computer technology in the development of intelligent systems that better complement our cognitive systems.

The recent development of relatively inexpensive, powerful portable computers is fundamentally changing many areas of human life, and especially those that require rapid and precise verbal and/or numerical computations. Regrettably, schools have lagged in the use of computerized technologies. The school, alas, is the last pencil-driven institution in our society.

EDUCATIONAL CHALLENGES

As we discover more about the capabilities and limitations of brains and computers, educators will need to explore how best to approach instructional tasks that we historically have assigned to brains because we had no real processing options (for example, a pencil doesn't have a spell checker) or that we taught via a currently much

more cumbersome technology (such as paper-and-pencil arithmetic computation). Further, computerized research technologies now available to elementary students often contain relevant musical and filmed information that is impossible to include in print encyclopedias.

Our profession is relatively unacquainted with brain research and computer technology, and that's a large part of the problem of incorporating them into educational policy and practice. Our profession is grounded principally in the social and behavioral sciences—we teach student in classroom-sized groups—and the social and behavioral sciences provide useful information on how to work effectively with groups of brains, even if they don't understand how one brain works. Further, the cognitive sciences only recently have begun to solve the teaching/learning problems that have long mystified us, and inexpensive portable computer technologies, such as laptop computers and pocket-sized calculators, likewise have emerged relatively recently.

We thus have no reason to apologize for what we did, but we now have massive curricular reconstruction and staff-development problems. We shouldn't necessarily abandon our social and behavioral sciences roots or the print and paper/pencil technologies we've depended on. Rather, we now also must understand and incorporate the biological substrate of the educative process and comfortably use the marvelous new information technologies that are available to us.

It's a monumental task. This book will help you to begin that process. It focuses on four especially significant areas: the nature of the current cognitive science revolution, the emerging importance of emotion in cognition, the biological substrate of intelligence, and the emerging relationship between our brains and computers in computational thought processes. The book includes fourteen recent articles that address various elements of these issues and recommended reading lists of the best recently published nontechnical books in each field—books that will get you into a deeper exploration of the specific issues that interest you. (And a bit of advice here: this is such a rapidly developing field that, in general, you should focus your reading on materials published within the past five years.) In addition, mass circulation magazines include articles about developments as they occur, and this book includes four such articles. These cognitive/computer revolutions interest many people, and so mass media tend to provide useful nontechnical reports of related developments.

Section 1

Education and the Current Cognitive Science Revolution

DNA was discovered in 1953. Thus, more than forty years ago, scientists understood the biology of genetics, but it has been only during the last decade of the twentieth century that most of the genetic engineering applications have occurred, with one such application, cloning, occuring only within the late 1990s.

Similarly, the road between brain theory, laboratory research, and practical applications will be much longer and more tortuous than most educators realize. Laboratory researchers can reduce variables and focus entirely on the specific cognitive system they are studying. For example, a researcher attempting to identify a specific element of the attention system can eliminate all extraneous sounds, sights, and smells that might distract the experimental subject and thus compromise the study. An educational researcher trying to study *attention* within a classroom faces a much more complicated situation in that it is almost impossible to similarly control the distractions. Further, ethical constraints limit the kind of research that one can conduct with children. Thus, difficult as it is for scientists to study the neurobiology of attention, educational researchers face an even more daunting task in discovering how best to regulate it so that it is biologically appropriate.