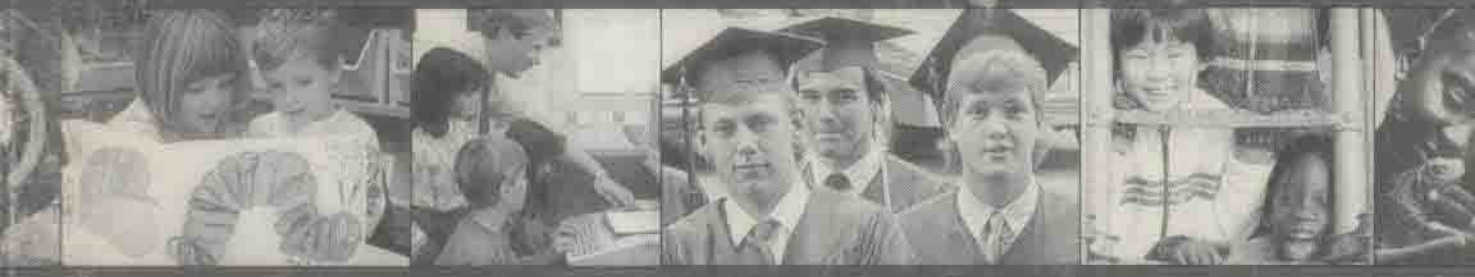

MAKING CONNECTIONS

TEACHING AND THE HUMAN BRAIN

RENATE NUMMELA CAINE
GEOFFREY CAINE

MAKING CONNECTIONS

TEACHING AND THE HUMAN BRAIN

RENATE NUMMELA CAINE
GEOFFREY CAINE

ASCD
ASSOCIATION FOR SUPERVISION AND CURRICULUM DEVELOPMENT
Alexandria, Virginia

The Authors

Renate Nummela Caine is Associate Professor of Education at California State University, San Bernardino (CSUSB). She is also the Executive Director of the CSUSB Center for Research in Integrative Learning/Teaching.

Geoffrey Caine is a consultant specializing in adult learning. He is also an Adjunct Member of Faculty at the University of Redlands, California, Whitehead Center for Lifelong Learning, where he teaches management and law.

With their colleague, Sam Crowell, the Caines have created a workbook, *Mindshifts*, that assists educators at all grade levels, working in study groups, to develop a deeper and more practical understanding of the theory of learning presented in this book. *Mindshifts* retails for $24.95 plus 7.75% tax in California, plus $1.50 for shipping. Bulk and distributor prices available. Order from **4C Connections**, P.O. Box 1614, Idyllwild, CA 92549, or contact **Caine Learning**: Phone (714) 659-0152, FAX (714) 659-0242. ISBN 0-9632520-0-3

Printed in the United States of America. Text and cover design by Weber Design.
Printed by Banta Company.

Association for Supervision and Curriculum Development
1250 N. Pitt Street
Alexandria, VA 22314
Telephone: (703) 549-9110

Ronald S. Brandt, *Executive Editor*
Nancy Modrak, *Managing Editor, Books*
Carolyn R. Pool, *Associate Editor*
Stephanie Kenworthy, *Assistant Manager, Production Services*
Valerie Sprague, *Desktop Specialist*

Price $15.95
ASCD Stock No. 611-91025

Library of Congress Cataloging-in-Publication Data

Caine, Renate Nummela.
Making connections: teaching and the human brain / Renate Nummela Caine, Geoffrey Caine.
p. cm.
Includes bibliographical references.
ISBN 0-87120-179-8 (pbk.)
1. Learning, Psychology of. 2. Learning—Physiological aspects. 3. Brain 4. Teaching I. Caine, Geoffrey. II. Title.
LB1057.C33 1991
370.15'23—dc20 91-7631
CIP

FOREWORD

In these times, when reform and restructuring are on everybody's lips, a treatise that provides insight into the rationale for educational change from the perspective of the recipient and appropriate teacher responses is most relevant. Here, the wife-and-husband team of Renate Nummela Caine and Geoffrey Caine discuss the fascinating functioning of the brain in optimal and depressed conditions and how the brain and therefore learning is affected by health, stress, and teaching approaches.

Intuitively, I have known for some time now that many capable youngsters are either so bored with their education or so stressed out by their experiences, that optimum learning cannot take place. I have also seen many students "flower" in a learning environment that builds on their current knowledge base and personal experiences. The authors not only explain why this is so but also show how a reconceptualization of teaching, based on a knowledge of brain functioning, can enhance students' learning. At the same time, we can more successfully produce the worker requested by business and industry—with open-endedness, flexibility, and resourcefulness. Teachers must become facilitators of learning, and they must expect students to go beyond the surface knowledge frequently achieved through rote memorization of unconnected content. By integrating the curriculum, we can assist students in their search for deeper meaning and thus enhance the brain's quest for patterning. Other helpful practices include incorporating stress management, nutrition, exercise, and relaxation into the learning process.

The implications of this seminal work for teaching, testing, and remediation are far reaching. Repeated practice on isolated skills becomes inappropriate as an option for acquiring knowledge. It becomes obvious that skills and content must be presented in a context that is familiar to the learner. This contextual approach also supports authentic modes of assessment.

As a side benefit of this work, the authors have legitimized the right of a learner not to fit the mold of the "average American student" and have challenged teachers and students to find those familiar contexts, "schema," within which to embed new learning.

Also of note, the authors openly discuss the benefits to learning provided by the regular practice of meditation and other methods of achieving a state of relaxed alertness, from the perspective of the positive physiological impact on the brain of such efforts—a bold step.

Finally, the clarity and easy style with which this book is written cannot mask the substantive content. This work may be the most powerful work written this year in terms of its potential to produce a long-range impact on education. It certainly invites a dramatic shift in the conceptualization of the teaching and learning paradigm—one that undoubtedly will have a positive impact on our educational system and the lives of the students who experience it.

DONNA JEAN CARTER
ASCD President, 1990–91

INTRODUCTION: TIME FOR A CHANGE

This book is for educators and others who know that schools must change. It adds to the growing body of knowledge and research suggesting that we need to move beyond simplistic, narrow approaches to teaching and learning. The book contributes to this knowledge base by focusing on information from the neurosciences that can help educators understand their role more fully.

From the very outset, it became clear that direct translation from the neurosciences into educational practices would be impossible. We have therefore taken the liberty of extrapolating the educational significance of the research we have explored. We have done this in three ways. In the first part of the book, we examine education today in light of critical findings of brain research. In Part II, we select specific topics, theories, and models of brain functioning that appear to address current issues in education and provide implications for curriculum restructuring and design. We then reorganize major aspects of such research for the purpose of eliciting a useful and practical set of general principles. In Part III, we describe elements of instruction that we believe more fully use the brain's capacity to learn. These later chapters serve as guides for translating what we know about how the brain learns to actual orchestration of the learning environment.

We challenge some strongly held beliefs. For example, the brain does not separate emotions from cognition, either anatomically or perceptually. Hence, brain research challenges the belief that teaching can be separated into the cognitive, affective, and psychomotor domains. Such artificial categorization may be helpful in designing research projects, but it can actually distort our understanding of learning. A physiological model of memory also calls into question the notion that learning must take place through rote memorization. In addition, by understanding properties of our spatial memory system, educators can understand that teaching to behavioral objectives ignores other functions of the brain and other aspects of memory and learning. Indeed, we have come to the conclusion that educators, by being too specific about facts to be remembered and outcomes to be produced, may prohibit students' genuine understanding and transfer of learning.

We need to expand our notion of learning and teaching. The brain is far from simple, and implications are always more complex than we initially perceive. It is not so much that what we are doing in education is right or wrong, it is more a matter of seeing beyond our heavily entrenched mode of doing business. We therefore invite educators to move beyond what Ivan Barzakov of Optimalearning™ calls "the fallacy of the familiar." This requires that in order to genuinely expand our knowledge and understanding of an issue, we avoid the tendency to reduce the new to something we already know and to practices that are familiar. Given that learning and teaching involve multifaceted human beings in complex interactions, we have no choice but to acknowledge and comprehend this complexity and move beyond narrow definitions and practices to genuinely improve education on a large scale. This is why coming to terms with complexity, tolerating ambiguity, and accepting active uncertainty are so critical and why these, rather than the actual information, may be the principal opportunities provided by this book.

Educators do not need another method or approach or model guaranteed to "save" education. From the point of view of educational theory and methods, much of what we say has been said or done before. What is needed is a framework for a more complex form of learning that makes it possible for us to organize and make sense of what we already know. In addition, such a framework has to have "bottom line" integrity; for us, that means it must integrate human behavior and perception, emotions and physiology. To make our point, we borrow heavily from cognitive psychology, education, philosophy, sociology, science and technology, the new physics, and physiological responses to stress, as well as the neurosciences. We believe this book contributes to the creation of such a framework.

Both in the neurosciences and in education, we will no doubt learn more in the years to come. Though we make strong recommendations and suggestions, the book has an open-ended quality. For example, we do not directly deal with the question of consciousness or the brain/mind issue. We use the two interchangeably and in a metaphoric sense. This suits our purpose but leaves the issue for others to unravel. Our translation of the research also raised many questions, which we hope will serve as the link between the neurosciences and education as we begin a critical, but tentative, bridge of communication between these disciplines.

Strangely enough, understanding the enormous complexity of issues in the neurosciences left us with an even deeper respect for the job teachers must do in the classroom. Properly understood, the issues plaguing the neurosciences become the inside mirror image of what educators deal with on the outside with ongoing behavior. Teaching in the traditional way, dependent on content and the textbook, is

demanding but not very sophisticated. Teaching to the human brain, however, based on a real understanding of how the brain works, elevates teaching into a challenging field requiring the finest minds and intellects.

A word of thanks is due to many people. California State University, San Bernardino, supported Renate with a creative leave grant. Our friend and colleague, Sam Crowell, devoted a great deal of time to the exploration of these ideas with us; and we would like to thank Les Hart for his work and his encouragement. Many others have reviewed this book in some valuable capacity. Diana Caine gave us excellent advice and some appropriate words of caution about extrapolation from the neurosciences. Peggy Atwell has been a continuous source of encouragement and support. Other welcome assistance came from Tennes Rosengren, Betty Snow, Lynn Dhority, and Donald and Peggy Caine. Lynn Nadel gave generously of his time for several years; without his help, this book would not have been possible. Renate wishes to acknowledge the outstanding group of humanists who contributed to her education at the University of Florida in the 1970s, among whom were Art Combs and William Purkey. Renate dedicates this book to the memory of Donald L. Avila.

MAKING CONNECTIONS
TEACHING AND THE HUMAN BRAIN

I

ACCESSING THE BRAIN'S POTENTIAL

1

MAKING CONNECTIONS

There are perhaps about one hundred billion neurons, or nerve cells, in the brain, and in a single human brain the number of possible interconnections between these cells is greater than the number of atoms in the universe.

Robert Ornstein and Richard Thompson,
The Amazing Brain, 1984, p. 21

We are given as our birthright a Stradivarius and we come to play it like a plastic fiddle.

Jean Houston, "Education," in *Millenium,*
1981, p. 151

What Is Brain-Based Learning?

In many ways, the brain is like the heart or lungs. Each organ has a natural function. The brain learns because that is its job. Moreover, the brain has a virtually inexhaustible capacity to learn. Each healthy human brain, irrespective of a person's age, sex, nationality, or cultural background, comes equipped with a set of exceptional features:

- the ability to detect patterns and to make approximations,
- phenomenal capacity for various types of memory,
- the ability to self-correct and learn from experience by way of analysis of external data and self-reflection, and
- an inexhaustible capacity to create.

If, then, everyone has these capacities, *why are we struggling in our ability to educate*?

One essential reason is that we have not yet grasped the complexity and elegance of the way the brain learns, especially when

it is functioning optimally. When we understand both the possibilities and the available processes, then we can access the vast potential of the human brain and, in a very real sense, improve education. In the words of Leslie Hart (1983), there can be "brain-compatible" or "brain-antagonistic" education. Understanding the difference is critical.

Many educators, for example, have assumed that learning takes place primarily through memorization of facts and specific skills. This is like looking at the moon and believing that we have understood the solar system. There is more. Almost ignored is the immense capacity of the brain to deal with and instantly remember the moment-to-moment events that constitute life experience. Even more neglected and underused is the innate predisposition of the brain to search for how things make sense, to search for some meaning in experience. This translates into the search for common patterns and relationships. It is a matter of finding out how what is being learned relates to what the learner already knows and values and how information and experiences connect. In essence we have to come to terms with meaningful learning and the art of capitalizing on experience. Although all learning is brain based in some sense, to us *brain-based learning involves acknowledging the brain's rules for meaningful learning and organizing teaching with those rules in mind*. That is when we are teaching to the human brain.

Here is a simple example of the distinction between ignoring and capitalizing on experience. Children live with parallel lines long before they ever encounter school. By the time parallel lines are discussed in geometry, the average student has seen thousands of examples in fences, windows, mechanical toys, pictures, and so on. Instead of referring to the parallel lines students and teachers have already experienced, most teachers will draw parallel lines on the blackboard and supply a definition. Students will dutifully copy this "new" information into a notebook to be studied and remembered for the test. Parallel lines suddenly become a new abstract piece of information stored in the brain as a separate fact. No effort has been made to access the rich connections already in the brain that can provide the learner with an instant "Aha!" sense of what the parallel lines they have already encountered mean in real life, what can be done with them, and how they exist other than as a mathematical abstraction.

Currently literature, mathematics, history, and science are often seen as separate disciplines unrelated to the life of the learner. And much of what we presently accept as teaching is based on the mistaken belief that students can be taught reading and writing as separate from meaning and purpose, and that somehow what happens in the classroom is unaffected by the real world children and adults inhabit. Brain-based learning, on the other hand, rests on the fact that the various disciplines relate to each other and share common infor-

mation that the brain can recognize and organize. This, for instance, is at the heart of thematic teaching.

Because the learner is constantly searching for connections on many levels, educators need to *orchestrate the experiences* from which learners extract understanding. They must do more than simply provide information or force the memorization of isolated facts and skills. The changes to be made in education will usually be substantial, and teaching to the brain will therefore require most of us to make a major perceptual shift.

Taking Advantage of Brain Research

Much of what we say about learning has been said before and is supported by a significant amount of research in education, as well as by the anecdotal experience of many educators. Brain research is invaluable, therefore, in part because it confirms that many of the criticisms of education are correct. It endorses what we already know and can be used to support the many innovative educators and members of the community who have been and are striving for change.

Equally important, the brain itself can be a guide and a metaphor. The findings can help us be more precise about what is not working in education and what we need to do. As we become more familiar with the brain's capacity to seek and perceive patterns, create meanings, integrate sensory experience, and make connections, we can also become more adept at solving practical problems, such as selecting appropriate methodologies, effectively assessing learning, designing schools, and administering education.

Is There Any General Guiding Principle?

Brain research establishes and confirms that multiple complex and concrete experiences are essential for meaningful learning and teaching. Optimizing the use of the human brain means using the brain's infinite capacity to make connections—and understanding what conditions maximize this process. In essence, students learn from their entire ongoing experience. In many ways, content is inseparable from context.

Every complex event embeds information in the brain and links what is being learned to the rest of the learner's current experiences, past knowledge, and future behavior. The primary focus for educators, therefore, should be on expanding the quantity and quality of ways in which a learner is exposed to content and context. The best word we have found for this process is "immersion." We know from

other sources, for instance, that the more children can talk about what they are doing (Cohen 1984) and the more their teachers use the appropriate vocabulary in teaching, the greater the learning (Harste 1989, Moraes 1986). The learner needs to be engaged in talking, listening, reading, viewing, acting, and valuing. Brain research supports this.

Let us look at one basic example to explore the nature and power of the interconnectedness of experience. Millions of times every school day, students are asked to deal with specific issues. We'll examine an aspect of English literature, although any subject will do. Students are asked to read Shakespeare's *Hamlet* and come prepared to discuss the play and answer critical questions. A test will follow to check on their ability to understand and recall parts of the play. What can a teacher do? And what else is influencing the student's learning?

Excellent teachers do more than teach to the test. The best teachers use the background and information students bring to class, including their experiences with parents, power, and love. Such teachers attempt to help students recognize the deeper meanings and issues in *Hamlet* and make genuine personal connections with the play. These connections include increasing familiarity with a somewhat different vocabulary, society, and period in time. Students also learn about themselves and life in the process. Thus, immersion in the subject, linking the information to other subjects and personal meaning, and expansion of vocabulary, history, and psychology has begun.

What we tend to ignore is that this immersion process can itself be hindered or helped. Do the students ever discuss Shakespeare with friends or peers? Is that a "weird" thing to do? How often or frequently do they discuss *Hamlet* outside of class? Is the school an exciting intellectual environment where topics of this nature are mirrored in the interests of teachers and administrators and discussions among them? Does the physical environment reflect deep appreciation and valuing of the arts, science, and the social sciences? Can students discuss *Hamlet* (or any other subject) at home? How does the family allow for the student to make additional connections and to be further immersed in using and exploring the information and understanding gleaned in class? Does the community support the arts, provide good plays for students to attend, or fund community science projects in which children of all ages can participate? And what of our society? Does television encourage abstract and creative intellectual thought? Do our politicians merely call for educational reform, or do they engage learners in critical thinking and reflection on the issues affecting our society? Do adults within our society give students other opportunities to engage their brains more fully and immerse them in broader learning? Is the content of schooling compartmentalized and separated from life? All these questions illustrate other aspects of the experience

in which a student is immersed. All have a bearing on how *Hamlet* will be perceived and understood and on the number of rich connections made in the learning brain.

People can and need to grasp the larger patterns. The part is always embedded in a whole, the fact is always embedded in multiple contexts, and a subject is always related to many other issues and subjects. The capacity of schools and society to optimize learning and realize the potential of the human brain depends on their capacity to deal with this interconnectedness. Such an approach, however, calls into question many of the foundations on which the educational system has been built.

What Is the Objective?

Our general objective is to improve learning and teaching. More specifically, we want to see the emergence of learners who can demonstrate a high level of basic competence, as well as deal with complexity and change. People in business, such as John Sculley, the CEO of Apple Computers, have been saying for some time that students need to acquire judgment skills. For this to happen, education needs to accommodate both the needs and design of the human brain. The overwhelming need of learners is for meaningfulness.

To accomplish that objective, we have to more clearly distinguish between the types of knowledge that students can acquire. The main distinction, which we examine in more depth in Chapter 8, is between *surface knowledge* and *meaningful knowledge*. The former, involving memorization of facts and procedures, is what education traditionally produces. Of course, some memorization is very important. Meaningful knowledge, however, is critical for success in the 21st century.

Surface knowledge is anything that a robot can "know." It refers to programming and to the memorization of the "mechanics" of any subject. It results in specifiable performance. Meaningful knowledge, on the other hand, is anything that makes sense to the learner. A child who appreciates a plant as a miracle approaches the study of plants differently from a child who "engages in a task." It is impossible to deal with complexity and change and to make sound judgments if the tools and knowledge at our disposal do not make sense. We do not come to understand a subject or master a skill by sticking bits of information to each other. Understanding a subject results from perceiving relationships. The brain is designed as a pattern detector. Our function as educators is to provide our students with the sorts of experiences that enable them to perceive "the patterns that connect" (Bateson 1980).

An essential problem is that almost all our testing and evaluation is geared toward recognizing surface knowledge. We tend to disregard or misunderstand the indicators of meaning. Thus a person who plays around with a formula may have a better appreciation for what is actually happening than the person who can memorize it but cannot manipulate it creatively. Present testing procedures tend not to accommodate both types of knowledge.

Even more tragic is the fact that, by teaching to the test, we actually deprive students of the opportunity for meaningful learning. Testing and performance objectives have their place. Generally, however, they fail to capitalize on the brain's capacity to make connections. By intelligently using what we call *active processing*, we give students many more opportunities to show what they know without circumscribing what they are capable of learning. Testing and evaluation will have to accommodate creativity and open-endedness, as well as measure requisite and specifiable performance.

What Are the Components of Brain-Based Learning?

The brain processes information all the time. It digests experience to some extent in the same way that we digest food. It is always responding to the complex global context in which it is immersed. Educators must come to grips with that fact. Brain-based education, therefore, involves:

1. Designing and orchestrating lifelike, enriching, and appropriate experiences for learners.
2. Ensuring that students process experience in such a way as to increase the extraction of meaning.

The specific elements are spelled out more fully in Chapters 9–11.

Among the features of brain-based learning are active uncertainty or the tolerance for ambiguity; problem solving; questioning; and patterning by drawing relationships through the use of metaphor, similes, and demonstrations. Students are given many choices for activities and projects. Teaching methods are complex, lifelike, and integrated, using music and natural environments. Brain-based learning is usually experienced as joyful, although the content is rigorous and intellectually challenging; and students experience a high degree of self-motivation. It acknowledges and encourages the brain's ability to integrate vast amounts of information. It involves the entire learner in a challenging learning process that simultaneously engages the in-