

# MIND, BRAIN, AND EDUCATION SCIENCE

A COMPREHENSIVE GUIDE TO  
THE NEW BRAIN-BASED TEACHING



TRACEY TOKUHAMA-ESPINOSA  
FOREWORD BY JUDY WILLIS



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“The book is a milestone in this emerging discipline. It provides an eye-opener for all involved education, from preschool to learning later in life. The contributions of the three parent disciplines of education, neuroscience and psychology—which are equally important for the subject—are described with their unique contributions to the integrated domain. Issues are described which are encountered by teachers every day. Some of them are not given enough consideration in everyday practice, and the book provides relevant background information and also ‘tools’ with which to participate in this area.

All in all, the book provides an important basis from which to bring mind, brain, and education insights into the classroom and educational practice in a broader sense. I expect that it will also be of interest and support for many parents who are now seeking to expand their insights into their developing child and his or her needs, learning strategies and interests. Scientists, researchers, policy makers, curriculum designers, publishers of school materials, school directors, teacher educators, and teachers have different levels of previous knowledge and look at MBE in different ways. Disagreement among researchers from different disciplines may cause lack of common focus. Yet, Dr. Tokuhamma has done a great job in providing a book with a broad view and a both multidimensional and multidisciplinary approach. In this way, it is of relevance for many different professionals in the domain of teaching.”

—Jelle Jolles, Director, Leonardo Institute for Research in Education, VU University Amsterdam, the Netherlands and director of the National Platform on Brain & Learning in the Netherlands

“Recent discoveries in cognitive neuroscience have major consequences for teachers and educators. In this accessible volume, Tracey Tokuhamma-Espinosa provides the first in-depth survey of this exciting field of research. Anyone interested in how education works and how it can be attuned to the child’s brain should read this important review.”

—Stanislas Dehaene, PhD, Professor, Collège de France, Chairman of the Experimental Cognitive Psychology Department, Director of the Cognitive Neuroimaging Unit, and author of *Reading in the Brain: The Science and Evolution of a Human Invention* and *The Number Sense: How the Mind Creates Mathematics*

“This volume casts a wide net to define the interdisciplinary work needed to base new research on basic principles arising from education, neuroscience and psychology. It forms an excellent introduction to this vast and important field.”

—Dr. Michael Posner, Professor Emeritus, University of Oregon, and author of over 200 books and articles on attention and memory, including *Cognitive Neuroscience of Attention*

“Tokuhamma-Espinosa provides a whirlwind tour through the emerging interdisciplinary field of Mind, Brain, and Education. Along the way, she bursts many of the neuromyths that plague the field, and proposes in their place a list of tenets that range from the well-established to the controversial and provocative. The highlight for me was the history of recent (and not so recent) attempts to bridge between psychology, neuroscience, and education, which have coalesced and matured and are beginning to bear fruit.”

matured and are beginning to bear fruit.

—Dr. Sashank Varma, Assistant Professor of Educational Psychology, University of Minnesota

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“Tokuhama-Espinosa unravels the conceptual and practical confusions that inevitably arise with the self-formation of a new but composite field of academic endeavor, particularly one which seeks to integrate the natural and social sciences. Such a task, it has often been noted, has rarely if ever been successfully undertaken, but the shortcomings of our modern systems of education—so well-noted but so frustratingly opaque to effective change—cry out for such an evidence-based, neuroscience-based, and educator-inclusive reform agenda. I recommend this book to all educators who are interested in taking stock of current thinking about these matters in order to embark on pursuing the revolutionary agenda of basing their educational endeavors on what is known about the workings of their students’ brains, to the mutual benefit of all involved.”

—Professor John Geake, Deputy Head of School (Research & Research Training),  
School of Education, University of New England, Australia

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# **Mind, Brain, and Education Science**

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*A Comprehensive Guide to the New Brain-Based Teaching*

**Tracey Tokuhama-Espinosa, PhD**



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**I** would like to dedicate this book to several inspirational leaders.

Stanislas Dehaene has been a model and leader in Mind, Brain, and Education (MBE) science, conducting powerful and transformative research in both Math and Reading.

David Daniel, the Managing Editor of the International Mind, Brain and Education Society Journal has perhaps the most extensive knowledge of leaders MBE and is an amazing “connector,” bringing people and ideas together across disciplines.

Antonio Battro, the former president of the International Mind, Brain and Education Society, medical doctor, psychiatrist and educator, is the epitome of the interdisciplinary expertise that MBE stands for.

Hideaki Koizumi, leading researcher, inventor and founding board member of the International Mind, Brain, and Education Society, who generously mailed me boxes of books on the Japanese contribution towards MBE and who selflessly reviewed not only my doctoral thesis, but the draft for this book is deserving of my deepest gratitude.

These four leaders have selflessly displayed a level of intellectual generosity that only scholarly giants possess. Not only were they a part of the original research project that is the foundation of this book, but over the past years have responded to every query with not only meticulous detail but also with enthusiasm. As mentors they have guided with silk gloves, as friends they have shared a joy for new discoveries, and as scholars and research-practitioners, they have enlightened.

This book is also dedicated to Cristian, Natalie, Gabriel and Mateo, who not only share in the world of ideas, but who are also the pillars of “real life.”



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A single person cannot write a book that seeks to define a new academic discipline, there are hundreds of people who have established the foundations of Mind, Brain and Education (MBE).

I am thankful to Kurt Fischer, one of the main initiators of the MBE movement and the Society's first president, for his encouragement. Howard Gardner, Jelle Jolles, Hideaki Koizumi, Michael Posner, and John Bruer are all amazing, internationally renowned professionals who have generously guided my thinking over the years; my sincerest thanks. I am grateful to Sarah-Jayne Blakemore, Daniel Ansari, and Cristina Hinton whose own work has guided my developing viewpoints on MBE. My thanks to Mary Helen Immordino-Yang and Marc Schwartz who are my heroes for working tirelessly to ensure that educators, neuroscientists, and psychologists share visions, vocabulary and viable research projects. They are part of the new generation who will lead MBE into the 21st century with fanfare and strong foundations. Thanks to Judy Willis and once more to David Daniel, Stanislas Dehaene and Antonio Battro who have enthusiastically supported my work. Patricia Wolfe cannot be thanked enough for her inspiration, guidance and challenges to presumptions. Special thanks to all of the members of the Delphi panel who generously contributed to the invaluable bibliography for this text and to many core ideas: Donna Coch, Jane Bernstein, Michael Atherton, John Geake, Usha Goswami, Marian Diamond, Eric Jensen, Renata Caine, and Rita Smilkstein. A warm thanks to Sashank Varma for his careful reading, comments and the joint development of the Glossary found here.

I am indebted to the subtle, structured, consistent guidance of Deborah Malmud at W. W. Norton for her professionalism and thoughtful reflections (which were changes disguised as questions). I am also very thankful for Vani Kannan and Margaret Ryan, also of W. W. Norton, for their editorial guidance.

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Finally, thanks to the Universidad San Francisco de Quito in Ecuador and specifically to Santiago Gangotena, Carlos Montúfar, Gonzalo Mendieta, and Diego Quiroga, who offered me the intellectual freedom, beautiful working facilities, and time to write this book.

While I am indebted to all, any errors are mine alone.

Tracey Tokuhama-Espinosa  
Quito, Ecuador



# Foreword

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*Judy Willis, MD, MEd*

The need for an analysis of education-related mind and brain research has never been so critical. Educators are in need of ways to teach the most overwhelming quantity of information for which students have ever been accountable on standardized tests. There is no time or money that can be afforded to programs, curricula, or consultants who claim that their “brain-based” intervention is the solution to everything from differentiation and “behavior management” to expanding working memory and boosting test scores.

These concerns need to be met, but as most educators are not trained in the background knowledge needed to evaluate the research tagged onto these commercial products or gurus, it takes the collaboration of experts from the specialties of neuroscience, cognitive psychology, educational testing, and others to evaluate the methods used to conduct the research and the interpretations of the data.

*Mind, Brain, and Education Science* is the Rosetta Stone that educators and researchers need to translate the research data into their daily work—whether in the lab or the classroom. Tracey Tokuhama-Espinosa draws from her own neuroscience, classroom, and academic administrative background, as well as research from over 4,500 studies—a scale that clearly demonstrates the degree of support currently available for dozens of classroom strategies and practices. Tokuhama-Espinosa successfully tackles the complex and abundant research and meticulously achieves her goals with a book that is as highly readable as it is pertinent to all people dedicated to understanding how teaching can be best correlated to the brain’s processing of information.

Because this book has useful and powerful information on every page, it is a challenge to select highlights. Readers will surely find chapters highly pertinent to their own interests and specialties.

Educators in the trenches will find this book profoundly useful for evaluating the best available tools and consultants, and the interventions best suited to their own teaching. Tokuhama-Espinosa’s methodological evaluation of the research will help all of those dedicated to improving the quality and joy of education through the best teaching practices, effective curriculum, informative assessment, and planning techniques by which students can construct transferable concepts from the excess of often isolated facts they are pushed to memorize for standardized tests.

In the section “What Great Teachers Do and Why It Works,” classroom teachers will be pleased to discover scientific evidence that supports and explains the neural foundations relevant to their best teaching successes. Admirers of the work of educational visionaries such as Piaget will be delighted by the section dedicated to how many of his, and other early theorists’, keen observations correlate with the laboratory research available today.

Educators on the front lines will expand their toolboxes of practical applications of relevant research as Tokuhama-Espinosa consolidates and clarifies the theoretical, experimental, and practical findings as illuminated by the transdisciplinary field of mind, brain, and education. Because Tokuhama-Espinosa is such a careful analyst of the research, the applications she offers can be trusted to correlate with ample research, which she scrutinizes for validity.

As a neurologist who became a classroom teacher, one of my goals was to use my neuroscience background to bust the neuromyths and inaccurate applications of lab research being used to support faulty and costly commercial goods, programs, and self-proclaimed gurus. In this book and in the author’s own words she addresses “tough questions in education that have not been answered by

author's own words she addresses "tough questions in education that have not been answered by conventional means such as differentiated student needs, new types of learning problems, and educational challenges, which have not found satisfactory responses, and require a fresh look with new eyes as well as the need for remediations *and* celebrations."

One of the best characteristics of top scientists is their desire to continue to reevaluate what is believed to be true, in light of new evidence, often provided by new technology. Chapter 4 identifies 24 "neuromyths" that currently plague the educational process, such as a right and a left brain that compete for students' attention and use. Tokuhamas-Espinosa identifies the negative consequences that are the results of the application of these myths. Scientists will find this chapter so well documented that they may reconsider some of their own assumptions through the descriptions provided about recent research in overlapping fields just outside their own specialties. Tokuhamas-Espinosa's insights will give our best researchers in their specific fields relevant cross-disciplinary research findings to fortify, modify, or expand their budding hypotheses.

I am grateful, both for the knowledge this book has provided me, and for the wisdom, dedication, passion, and compassion that Tokuhamas-Espinosa applied to create it. I am certain that *Mind, Brain, and Education Science: A Comprehensive Guide to the New Brain-Based Teaching* will excite as well as inform all those fortunate enough to read it, and expand the ripples of each reader's new insights to the benefit of the most important people we serve—our students—the future caretakers of one another and of the planet.



# Preface

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We live in a time in which we count on professionals in all fields to know certain basics and adhere to certain standards. Unlike other generations, in which parameters were laxer and training depended solely on a single mentor or tutor, this generation is accountable to far stricter guidelines because far more people contribute to the formation of professionals than ever before. In the 17th century one cobbler on the road could make a bad shoe and his neighbor might make a far better one, with most of the variation in quality due to the knowledge each cobbler gained as an apprentice. While we still go through apprenticeships of sorts today, there are far more collective measures of a professional's worth, and more regulation of the quality of individual members. Holding professionals accountable for having basic core knowledge, skills, and attitudes means better service, practice, and attention, and we all benefit. (Most shoes these days have basic minimum quality characteristics, and the overall industry quality has improved because of this.) This is true of all professions, whether it be a shoemaker, social scientist, physician, or otherwise. Minimum core knowledge benefits each professional individually, but also contributes to the overall advancement of society.

How does all this impact professional formation? Through key core knowledge requirements. For example, the study of modern psychology requires certain basics in terms of core knowledge. Professionals are assumed to be versed in at least a minimal level of understanding in topics as wide ranging as consciousness, perception, emotion, personality, behavior, cognition, and interpersonal relationships. This requirement has not changed in decades, if not centuries.

Over the decades psychologists have studied the course of the mental processes of perception and memory, of speech and thought, of the organization of movement and action. Hundreds of courses for university students have been prepared and thousands of books have been published during this period of intense activity to teach and describe the character of the human gnostic processes, speech, and behavior. The close study of these areas, in the context of behavioral science, has yielded information of inestimable value and has given important clues to the nature of the scientific laws that govern these processes.

Likewise, in cognitive neuroscience there are also certain basics required of professionals, despite being a "younger" field of study than psychology. General neuroscience formation focuses on the nervous system, the brain, and an understanding of neurons, synapses, and neurotransmitters (which can be specialties in and of themselves: neurophysiology, neuroanatomy, neuropharmacology, and molecular neuroscience). Studies for the neuroscientist in training also normally include classes in neural networks, sensory systems, and motor control (as in systems neuroscience). Beyond these basics, neuroscience studies learning and memory and cognition and arousal mechanisms, which relate directly to developmental neuroscience, behavioral neuroscience, and most especially, cognitive neuroscience.

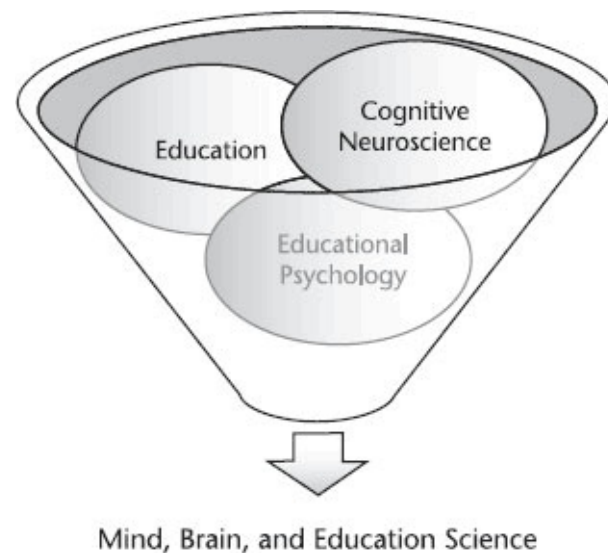
In education we have certain basic core curriculum subjects as well, but they are suffering a change in modern teacher training programs. When I studied for my master's in education degree at Harvard over 20 years ago, I focused on international comparative curriculum studies (what is "smart" in different cultures based on what different countries choose to teach), but I was also expected to know something about teaching practices, planning, assessment, educational research, philosophy, and technology, as well as the application of this information to a variety of age groups. But the world is changing.

When I completed my doctorate in 2008 my focus was on Mind, Brain, and Education science, and

creation I was allowed to devise from a basic education program by adding elements of psychology and neuroscience. This program was decidedly interdisciplinary in nature and celebrated the union of basic courses, concepts, knowledge, skills, and attitudes traditionally found in the once separate disciplines of neuroscience, psychology, and education (see Figure P.1).

FIGURE PREFACE. 1

## **How Education, Cognitive Neuroscience, and Educational Psychology Equal Mind, Brain, and Education Science**



The new discipline of Mind, Brain, and Education science is indicative of new parameters that embrace the tough questions in education that have not been answered by conventional means. Differentiated student needs, new types of learning problems, and educational challenges, which have not found satisfactory responses, require a fresh look with new eyes. According to Palmer (1997), “[t]he way we diagnose our students’ condition will determine the kind of remedy we offer” (p. 41). I believe that the exactness with which we can analyze learning problems has become more accurate with the new discipline of Mind, Brain, and Education science. Maximizing the potential of each student means clearly detecting individual strengths and weaknesses, problems, and gifts, as well as the need for remediations *and* celebrations. This is not a simple task by any means (see Figure P.2).

FIGURE PREFACE. 2

## **Core Knowledge in Mind, Brain, and Education Science**



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