A BRIEF HISTORY OF THE SCIENCE OF LEARNING:

Part 2 (1970s-present)

Abstract

The history of how we teach is fascinating. By understanding not only how people learn but also how we have learned how to teach, we can become better professionals. In this article we review the history of human learning and the progress of teaching over the past 5,500 years.

The following is an excerpt from Mind, Brain, and Education Science: A comprehensive guide to the new brain-based teaching (W.W. Norton) a book based on over 4,500 studies and with contributions from the world's leaders in MBE Science.

Neuroimaging Boosts Knowledge about the Brain

Technology funding was given a boost in response to the first modern computer developments in the 1970s. The use of automated robots on assembly lines in Japan in the 1970s triggered new discoveries in other fields, such as medicine. In the 1980s improvements in neuroimaging and eventually the development of in vivo imaging techniques enabled observation of the learning brain, providing insights into the brain’s perceptual, cognitive, and emotional functions, with clear relevance for education. Despite the existence of electroencephalographs (EEGs) since 1929 and early computerized axial tomography (CAT) scans and magnetic resonance imaging (MRI) (both 1973), neuroimaging did not reach broad use until the introduction of positron emission tomography (PET) scans in 1979, transcranial magnetic stimulation (TMS) in 1985, and functional magnetic resonance imaging (fMRI) in 1990, when there was an explosion of studies. With more refined neuroimaging tools, more and more work was done on healthy patients, not only those who had suffered traumas or lesions. Much of the earlier work with brain imaging techniques on healthy patients focused on the areas of language and attention. The excitement over increased empirical evidence on learning mechanisms triggered further interest from teacher practitioners in education.

Writings and Early Attempts at MBE Science
The first dissertation on MBE science was written in 1981 (O'Dell, 1981), entitled *Neuroeducation: Brain Compatible Learning Strategies*. O'Dell was ahead of his time and probably unaware that his visionary view of the teaching and learning process would become the norm 30 years later. Speculation about neural mechanisms involved with cognition and consideration of applications to education began in earnest in the early 1980s. The implications of selective brain research on the philosophy of education also hinted at the first considerations of what is known today as *neuroethics*: how choices are made with new knowledge about brain functions. The link to educational practice was encouraged further by the attempt to label the emerging learning science as “applied educational psychology” in the early 1980s. It can be speculated that the reason this title did not enjoy popular support is due to the lack of neuroscientific backing used to support claims.

“Education is discovering the brain and that’s about the best news there could be. … Anyone who does not have a thorough, holistic grasp of the brain’s architecture, purposes, and main ways of operating is as far behind the times as an automobile designer without a full understanding of engines.”


Two popular books for educators that were published at this time were Howard Gardner’s *Frames of Mind* (1983) and Leslie Hart’s *Human Brain, Human Learning* (1983). These two books are considered influential in educational circles because they marked the start of interest in the brain–learning connection in the teaching profession. Though Gardner was inspired by his work with “shattered brains” at Boston Veteran’s Hospital in the 1970s, he did not claim that his *theory of multiple intelligences* related to specific brain areas, nor that it was supported by neuroscience, though he has clearly documented that at least some of the intelligences (language, music, arithmetic) can be isolated by a neuronal lesion. Gardner’s work struck a cord with teachers, parents, and educational psychologists because he challenged the accepted view of “intelligence” and, in doing so, Gardner invited a general questioning of what we believe to be true about all educational measurements. In contrast, Hart’s work was, indeed, focused on how the brain learns. Hart was one of the first to call attention to the *lack of attention* given to the brain in educational practice. Hart said that designing educational experiences without an understanding of the brain was like designing a glove without an

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1 See Posner (1981).
2 See McDon nell (1981).
3 Gaddes (1983).
4 See Gardner’s first book (1974), *The Shattered Brain*, for a better understanding of how his theory evolved. Also see Battro and Denham’s work (2007) on digital intelligence (*La inteligencia digital*), which gives a good overview of the definition of intelligence in this broader perspective.
understanding of the human hand (1983), and he called on teachers to become savvier in their practice. Hart’s work was monumental in emphasizing the “why” as well as the “how” of teaching. If there is one book that likely laid the groundwork for a new genre in writing about the brain and learning, it was most likely Hart’s.

**Connectivity, Cognitivism, and Constructivist Models**

In parallel with the new view of the brain and learning offered by Hart, and the new understanding of intelligence proposed by Gardner, the mid-1980s marked the beginning of discussion on the *connectivist model* in psychology. These models began to offer a more sophisticated view of the brain as a complex integration of various systems (thus the connectivist idea), rather than just the simple localization theories of the past (which believed that X function was located in Y spot of all brains). The 1980s also noted a shift from behavioral studies in educational psychology to those of *cognitivism* and constructivist theories. The general idea of cognitivism is that mental functions can and should be explained by evidence of brain activities that can be measured through experimentation. On the other hand, the *constructivist* model of learning, often attributed to Piaget, suggests that people construct their own knowledge based on their experiences. Viewed together, cognitivism and constructivist models of learning pointed to the increasingly complex understanding of how human mental capacity grows over the course of one’s lifetime, and how this growth can be measured both in relative and absolute terms. Since this early movement away from *behaviorism* (the belief that all things organisms do can and should be regarded as behaviors) toward cognitivism, psychology took a turn toward the hard, rather than soft, social sciences. The interdisciplinary view of learning and its natural counterpart of teaching were firmly established in the 1980s.

**New Organizations**

The interdisciplinary nature of MBE science was reflected in the mission statements of many new organizations in the 1980s. In 1983 the Economic and Social Research Council (ESRC) in the United Kingdom and the Medical Research Council (MRC) were founded to encourage “innovative and multidisciplinary research proposals that link basic or health-related neuroscience to social factors and social behaviour.” The ESRC focuses on “links between the mind, brain, innate traits, society, culture and behaviour, whether normal or abnormal.” The social research angle promoted by these groups was complemented by a return to an appreciation of the natural sciences in the mid-1980s. The influence of genetics and

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6 See the ESRC Society Today website (http://www.esrcsocietytoday.ac.uk/ESRCInfoCentre/about/CI/CP/Social_Sciences/issue63/neuroscience.aspx).
7 Ibid.
heritability on general intelligence refocused attention on the roles that both nature and nurture play in learning,\(^8\) maintaining a firm spotlight on the link between biology and pedagogy.

**The Birth of Neuroscience**

Between 1984 and 1989 the birth of neuroscience began with the projection of the new field,\(^9\) and then books about neuroscience itself.\(^10\) For some, neuroscience, rather than educational neuropsychology, is the true birth mother of MBE science. Neuroscience was one of the first truly transdisciplinary fields, and some authors, such as Gardner (1987), included fields as obvious as psychology and as distant as linguistics, artificial intelligence, and philosophy. Neuroscience gave theorists a large conceptual umbrella under which they could posit hypotheses about the biological foundations of thinking at all levels. The emergence of neuroscience was not lost on educators, who quickly unified around the new information.

**Education’s Interest in the Brain**

Whereas education had been discussed in social–political terms during the greater part of the 1960s and 1970s, in the 1980s the focus changed from “equity” to “excellence,”\(^11\) and in doing so, there was a stronger emphasis on learning mechanisms in the brain more than on legislation. The Brain, Neurosciences, and Education Special Interest Group (SIG) of the American Educational Research Association (AERA) was formed in 1988. This SIG of the AERA was originally formed as the Psychophysiology and Education SIG and is the oldest organizational entity specifically dedicated to linking research in the neurosciences and education in the United States. It was once the only organizational group in the world that hosted an annual peer-reviewed venue for authors to present papers linking research and theory in the neurosciences and education. The purpose of the current SIG remains to promote an understanding of neuroscience research within the educational community, and it achieves this goal by promoting neuroscience research that has implications for educational practice and by providing a forum for the issues and controversies connecting these fields.\(^12\) In many ways the AERA’s established focus on the psychophysiology of learning was slightly ahead of its time when founded. Shortly after the SIG’s founding, an avalanche of findings marked the Decade of the Brain.

**The Early 1990s: The Decade of the Brain**

\(^8\) See Fancher (1985) for details.
\(^12\) AERA Brain, Neurosciences, and Education (2008).
The Decade of the Brain (1990–1999) spurred the development of thousands of new findings and dozens of theories about the brain and learning. Two basic types of learning theories were strengthened at this time: modular, domain specific versus global theories.

Modular, domain-specific theories mainly focus on explaining the neural mechanisms of skills such as mathematics, reading, attention, and memory. These studies tend to be very precise studies of very specific skills, such as how the brain perceives phonemes, or how a specific aspect of the brain is responsible for human face memories. These are discussed in further detail in Chapter 6 on Topics in MBE Science.

Global theories of learning provide overarching beliefs about how the brain learns best. Kurt Fischer and others, for example, recognized the value of neuroscience research in education and began to envision an independent field at this time. Cognitive neuroscientists such as Bruce McCandliss and Sally Shaywitz and researchers at the U.S. National Institutes of Health (NIH) and the U.S. National Institute of Child Health and Human Development (NICHD) began doing experiments in neuroscience labs that had more direct applications to education based on global theories of how the brain worked in terms of teaching and learning experiences.

The 1990s were also the beginning of the move to bring more accountability to American education. Who was responsible for good (or bad) educational efforts? Were the states individually responsible for the country as a whole? How about teachers? Accountability measures put a great deal of pressure on local educational systems to find the root causes of success or failure in their school system. What began as finger-pointing from the macro-level eventually reached the most micro-level possible: the individual student and his or her brain. Many states began taking a hard look at their local populations and considered how certain characteristics, such as low socioeconomic status, poverty, poor nutrition, and lack of early educational support impacted the general learning levels achieved by their students.

Even well-off states realized that, once again, the chain was only as strong as its weakest link. Educational interventions moved from the state level to the individual, which created the demand for increasingly personalized measures.

Early attempts by scientists to move closer to teacher-friendly information and products began to escalate in the early 1990s. Experimental psychologist Paula Tallal, originally at Cambridge University (now at Rutgers), and neurophysiologist Michael Merzenich, originally from Johns Hopkins University (now at University of California at San Francisco), began organizing brain-based conferences for educators through their Scientific Learning Corporation (best known for the Fast ForWord language program). These meetings resonated well with teachers and

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13 For good examples, see Dehaene (1999a, 1999b).
15 For exemplary work, see Posner & Rothbart (1998a); Posner & Rothbart (1998b).
16 For an example, see Anderson (1995).
school districts alike who clamored for interventions that were closer to their realm—that of the individual student. Teacher enthusiasm led to more innovations in the classroom. Though some of this work was of high quality, in some cases “innovation” was not tempered by reality checks in research, and in others it meant promoting neuromyths.

International Cooperation in MBE Science and New Institutions

The early 1990s also saw international, interdisciplinary cooperation in the discipline increase. In 1990 the James S. McDonnell Foundation, based in St. Louis, and the Pew Charitable Trusts of Philadelphia, helped found the Centre for Neuroscience at the University of Oxford. The Centre “encourages work in all areas of neuroscience across all relevant disciplines and embraces research on experimental, theoretical, and clinical studies of perceptual analysis, memory, language, and motor control, including philosophical approaches to cognition.”17 In 1994 The Max Planck Institute for Human Cognitive and Brain Science (MPI CBS) in Germany was founded and “revolves around human cognitive abilities and cerebral processes, with a focus on language, music, and action.”18 According to the MPI website: “In 1917, the first interdisciplinary brain research institute in the world was established in Munich, the 'Deutsche Forschungsanstalt für Psychiatrie' (German Research Institute of Psychiatry).” Both of these centers are pioneers in the study of neuroscience and its application in education. For the first time there was significant funding available to focus on the brain in educational settings. However, with increased research and formalization of the discipline came doubts about the lofty goal to link education and neuroscience, and along with these doubts, a good deal of skepticism.

Late 1990s: Healthy Skepticism of the Emerging Discipline of MBE Science

Healthy skepticism of the discipline was flamed by John T. Bruer's article “Education and the Brain: A Bridge Too Far” (1997), which was followed by a discussion of the educational relevance of research in neuroscience by James Byrnes and Nathan Fox in two seminal articles: “The Educational Relevance of Research in Cognitive Neuroscience” (1998a) and “Minds, Brains, and Education: Part II. Responding to the Commentaries” (1998b). Byrnes and Fox's articles and the peer commentary that followed stimulated the beginning of a vibrant debate about what could and should link neuroscience and education. Educators who agreed with Bruer (1997) noted that teachers could not translate neuroscience research directly into practice. Many of those in agreement with Bruer believed that teachers should rather embrace cognitive psychology to enhance their understanding of learning or other preexisting fields.19 Calls for “making neuroscience educationally relevant”20

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17 Oxford Centre for Cognitive Neuroscience website (www.cogneuro.ox.ac.uk/centre/about.html).
18 Max Planck Institute website (www.cbs.mpg.de/).
19 For an example, see Caine, Nummela-Caine, & Crowell (1999).
Educational Use of MBE Tools

In 1998 the Education Commission of the States published a consideration of how neuroscience could have educational policy implications. There was a boom in pedagogical rethinking at the end of the 1990s, including attempts to unite teachers around a set of accepted best-practice teaching elements and curriculum/lesson planning. While these methods were not the product of neuroscientific research, they knowingly or not applied MBE standards, thus giving them credibility beyond the field of education. This point is very important because it makes the distinction between information produced by the new MBE discipline and information that is used in the field of education that adheres to MBE principles. For example, it is important to note, that curriculum planning in Wiggins and McTighe’s Understanding by Design is structured around attention spans and memory, two aspects that are fundamental to MBE science, though the authors do not claim to base their theory on MBE principles.

Some teachers began hearing certain messages from neuroscience, such as the belief that there are no two brains alike, and began formulating their practice around these neuroscientific findings. For example, there was a movement to differentiate instruction based on the recognition of individual learning abilities and needs. One of the most influential books related to learning was sponsored by the National Research Council and updated in 2003 by Bransford, Brown, and Cocking. Their How People Learn (2003) remains an invaluable reference for teachers. Other high-quality research was also produced at this time, resulting in teaching interventions that were proven in the lab and applied in classrooms and homes around the United States. For example, new neuroscientifically based reading curricula, such as the Fast ForWord, and RAVE-O (retrieval, automaticity,
were developed by neuroscientists and have been applied in the classroom successfully since the late 1990s (see Chapter 7). The initial evaluations of these programs indicated very favorable results, demonstrating that collaborative endeavors between neuroscientists and educators can, indeed, prove fruitful. By the late 1990s global learning theories sought to offer an overarching explanation of the human teaching–learning process. One such concept was the universal design for learning (UDL), which is “defined by research on diversity, brain-based research, multiple intelligences, and the flexibility of digital media,” (Gray Smith, 2008, p. vii). UDL is meant to guide the creation of “flexible learning environments” that are conducive to differentiated learning structures in the classroom. UDL not only joins neuroscience and education but also integrated technology as well as having an eye toward the psychological well-being of all students in the classroom.

**Popular Press Tries to Fill the Void with Varying Degrees of Success**

Teacher interest in the brain grew, but few professional programs in universities offered courses in this discipline, and thus popular-press books about brain-based learning flourished to fill the void at the end of the 1990s. One of the best selling books of all time aimed at teachers, *Teaching with the Brain in Mind*, was published in its first edition at this time. In 1999 the first Learning Brain EXPO in San Diego gathered over 700 teachers and scientists, attesting to the popularity of anything labeled "brain-based" at the time.

The first “Learning & the Brain Conference” took place on the Harvard University and MIT campuses in 1997 and sought to elevate the caliber of teacher–neuroscientist encounters and began formal meetings at the end of the 1990s. The 26th conference in this series took place in May 2010 and drew over 2,000 people in attendance, mostly educators, pointing to an increasing interest by teachers in the emerging discipline. The current conference series is cosponsored by the Mind, Brain, and Education Program at Harvard Graduate School of Education, the School of Education at Johns Hopkins University, the Comer School Development Program (Yale University School of Medicine), the Neuroscience Research Institute (University of California, Santa Barbara), the School of Education at Stanford University, the Center for the Study of Learning at Georgetown University, the Dana Alliance for Brain Initiatives, the Cognitive Control and Development Lab (University of California, Berkeley), the National Association of Elementary School Principals, the National Association of Secondary School Principals, and others. The wide range of high-quality sponsors of this conference series demonstrates a deep interest by learning institutions to incorporate more neuroscience understanding into their teacher education.

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28 See Wolf (2008) for a complete explanation.

The growth in publications during the 1990s shows the impact that the Decade of the Brain had on encouraging research in the discipline, as well as the great impact that technology has played in providing continually improved means of observing healthy, functioning healthy, human brains. By 2010 the number of important work directly related to MBE science—rather than that derived from the parent fields of neuroscience, psychology, or pedagogy—was numerous signaling growing interest, research, and application of concepts in the emerging discipline. However, many questioned the quality of the information to which teachers were being exposed.

**New Academic Programs in MBE Science**

In the late 1990s many formal associations were launched around the emerging discipline in order to try and put parameters on quality-control questions. Cornell University’s Sackler Institute for Developmental Psychobiology was founded in 1998 and has increasingly focused on educational neuroscience. Across the Atlantic, the Belgian Society for Neuroscience was founded in the same year, showing that the interest in the brain and learning was, indeed, an international phenomenon. Academic programs also began to grow at this time. After several years of planning (1997-2001) Harvard University launched its Master’s Program in Mind, Brain, and Education in 2001–2002. In a like fashion, the University of Cambridge’s Program in Psychology and Neuroscience in Education started in 2004. The Transfer Centre for Neuroscience and Learning in Ulm, Germany (2004), Bristol University’s Centre for Neuroscience and Education (2005), and the start of The Learning Lab in Denmark (2005) were all landmark beginnings in an attempt to structure the emerging discipline. Other programs available in MBE science by 2005 included those at the University of Texas at Arlington, the University of Southern California, Beijing Normal University, and Southeast University in Nanjing.

**The 2000s: (Mis)Interpretations of Neuroscience in Education**

From 2000 to 2005 there was a refinement of knowledge about the developmental processes of learning,\(^30\) which led to a proliferation of neuroscientific information written for and by educators.\(^31\) While some educators shared measured, quality advice to teachers, some popular press writers promoted commercially attractive but neuroscientifically inaccurate claims. For example, discussions about “right-brained children in a left-brained world,”\(^32\) or guides on how to use “right-brain styles for conquering clutter, mastering time, and reaching your goals,”\(^33\) which were popular in the 1990s, continued to be bought in the thousands,
as in the case of *Boost Your Brain Power Week by Week: 52 Techniques to Make You Smarter*.\(^{34}\) This easy acceptance of false information earned many teachers a bad reputation in hard science circles. Teachers were accused of looking for “quick fixes” rather than respected as quality researchers themselves. This poor reputation led to the rejection of the label “brain-based education” because it was associated with many false claims about the brain and learning.

**Cutting-Edge Technology**

Brain imaging technology took a leap at the turn of the century with Hideaki Koizumi’s development of Optical Topography™, which was announced in 1995 and commercialized by Hitachi Medical Corporation in 2001 as “a safe, patient-friendly brain imaging technique that uses light to measure hemodynamic changes in the brain.”\(^{35}\) This technology was revolutionary in that “there is no need for a special measuring environment or patient restraint during examinations, [so] brain functions can be measured in a natural state.”\(^{36}\) This technology made it possible to image brain functions of babies, for example, previously thought impossible, which opened a myriad of possible “application[s] in studies of learning and education.”\(^{37}\) This technological advance was a huge steppingstone along the path toward better links between the laboratory and the classroom. Koizumi’s invention is a great move towards moving laboratory accuracy into realistic classroom settings.

Figure 3.8 Hideaki Koizumi and Hitachi’s new Brain Imaging Technology: Optical Topography

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\(^{34}\) Lucas (2006).

\(^{35}\) Hitachi (2008).

\(^{36}\) Hitachi (2008).

\(^{37}\) Ibid.
The Birth of a New Discipline: MBE Science

It can be said that the MBE discipline was "born" in several different places at once, all across the globe. At the turn of the 21st century formal attempts to unify interdisciplinary concepts in learning and teaching were numerous. In 2000 the Australian National Neuroscience Facility was founded to synthesize and integrate various institutional findings in order to elevate the level of neuroscience and education research. In 2000 the Neurosciences India Group was also founded with the mission to “empower through education” by pursuing cutting-edge research on learning. Both realized the usefulness of MBE research for classroom purposes. Many universities, such as the University of Melbourne in its Mind, Brain and Behaviour forum series, led global reflection on the relationship between intelligence and education from a neuroscientific perspective.38

38 For a more complete history on this entity, see Geake (2000).
Some of the earliest formal organizations promoting MBE beliefs around the world included INSERM’s (French National Institute of Health and Medical Research) Cognitive Neuroimaging Unit in France (2001), and the Oxford Neuroscience Education Forum (2001) in the United Kingdom. But perhaps the greatest leader in this movement was the consorted effort of the Organisation for Economic Co-operation and Development (OECD), which conducted three international conferences at this time to synthesize opinions and concerns and to design agendas for research in the emerging discipline at the intersection of neuroscience, psychology, and education. These conferences took place in New York (2000), Granada, Spain (2001), and Tokyo (2001) and served to identify leaders, as well as the major challenges facing them. The 400th anniversary meeting of the Pontifical Academy of Sciences in November 2003 also focused on mind, brain, and education and provided historical context for understanding the significant changes in education that would result from the birth of this new learning science.

**Government Efforts to Unite the Brain and Learning Initiatives**

Several government programs related to the emerging discipline started in the early 2000s as well. The Japan Research Institute of Science and Technology (2001) and the subsequent creation of the RIKEN Institute in Japan (2002) emphasized flexible, interdisciplinary research about the brain and learning. At the end of 2002, the Dutch Science Council, in consultation with the Dutch Ministry of Education, Culture and Science, set up the Brain and Learning Committee. The Dutch Science Council undertook initiatives to stimulate an active exchange among brain scientists, cognitive scientists, and educational scientists about educational practices. This exchange culminated in a book of state-of-the-art findings, *Learning to Know the Brain* (Dutch Science Council, 2005). The trend toward applying neuroscientific concepts in educational settings was paralleled by an increasingly receptive society, eager for new tools to combat problems in education.

**The First International Society Related to MBE Science**

In 2004 the formation of the International Mind, Brain, and Education Society (IMBES) was announced at the conference on Usable Knowledge in Mind, Brain, and Education at Harvard University. Since its inception, IMBES has held increasingly larger society meetings, a fact that speaks to the willingness of members to wear the MBE “hat,” as opposed to remaining solely in their field of formation (as educational psychologists, cognitive neuroscientists, or otherwise). In 2005 the Mexican Society for the Neurosciences was founded, demonstrating the spread of MBE values in places other than Europe, Japan, and the United States. This was followed by an innovative doctorate program in the same year: The Joint International Neuroscience Ph.D. Program united various world perspectives on the emerging discipline and was sponsored by the University of Bologna (Italy), Université Claude Bernard (Lyon, France), University College of London (U.K.), University of Bangor...
The New Challenge: Transdisciplinary Communication

These various initiatives converged to create the global transdisciplinary discipline of MBE science. Between 2004 and 2006 many concrete suggestions circulated about how to improve interdisciplinary communication in the emerging discipline. Activists promoting a formal union called attention to the lack of common vocabulary and the challenges different worldviews placed on advancements in the discipline. This challenge was faced, head on, by a handful of professionals who studied within two, if not all three, of the parent fields (some of their suggestions are found in Chapter 9). An increasing number of individuals who were formally trained in both pedagogy and neuroscience began to publish work that is acceptable to neuroscientists, useful to educators, and with an appeal to psychologists as well. Usha Goswami and Judy Willis are examples of neuroscientists turned educators in the new profession of MBE science. Their expertise on the brain and their clear and coherent friendly writing styles brought many a teacher to the MBE flock. Similarly, Patricia Wolfe and David Sousa went from teacher status to MBE experts. They, too, provide coherent and easy-to-read evidence-based information to teachers and help neuroscientists view learning problems in the more practical light of the classroom setting.

Institutes and organizations devoted exclusively to the goals of the emerging discipline continued to grow, as with the Oxford University Institute for the Future of the Mind (2006), evidence of the continual formalization of the discipline. The short but elegant book, The Birth of a Learning Science (OECD, 2007), added to the global recognition of a new discipline as a shared view by the 30 OECD member countries (Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States). In a landmark event, the new discipline of MBE science launched the first issue of the international Mind, Brain, and Education Journal in March 2007, thanks to efforts by Kurt Fischer and David Daniel. This scholarly journal managed what few publications before had done: Establish a readership that included cognitive neuroscientists, teachers, and educational psychologists all in one.

Uniting the Discipline: Teachers, Psychologists and Neuroscientists Working Together

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39 Some of the most convincing and articulate of these arguments can be found in Ansari (2005); Geake (2005); Goswami (2004); Goswami (2005a); Goswami (2005b); Howard-Jones (2005); Wunderlich, Bell, & Ford (2005).

40 Excellent examples of this interdisciplinary approach can be found in Goswami (2006); Willis (2006).
Starting about 2007 there were many concerted efforts to further integrate teachers into the research process through conferences and society meetings, as with Sue Pickering and Paul Howard-Jones’s *Educator’s Views on the Role of Neuroscience in Education: Findings from a Study of UK and International Perspectives* (2007), and the first International Mind, Brain, and Education Society conference in 2007 in Fort Worth, Texas, organized by Marc Schwartz and the Southwest Center for MBE at the University of Texas at Arlington. Developmental psychology, neuroscience, and learning theory became a more common combination in publications such as *Human Behavior, Learning, and the Developing Brain: Typical Development* (Coch, Fischer, & Dawson, 2007), and *The Jossey-Bass Reader on the Brain and Learning* (Wiley, 2008). The second conference of the International Mind, Brain, and Education Society was held in Philadelphia in May 2009, with membership steadily on the rise. With both publications and society meeting attendance increasing, it seems that MBE professional formation is growing. With increased acceptance, however, comes an increased responsibility. Starting around 2004 questions of neuroethics began to emerge.

**Neuroethics and Self-Criticism in MBE Science**

As the discipline became more established, consequences of its work were considered and there was a growing concern about *neuroethics*.\(^{41}\) Calls for neuroethical decisions began to increase as the proper use of information about individual brains became more publicly available. For example, there are increased calls for position statements on memory-enhancing drugs, the benefits and potential drawbacks of scanning students’ brains for “defects,” and the responsibilities that teachers and parents have for the proper care of children’s brains.\(^{42}\) All of these different ethical areas pose complex challenges to practitioners in the future. The discipline as a whole, as well as each individual professional, will have to reflect upon these issues.

Linked to ethical concerns were articles that challenged findings in the 1990s related to learning concepts in the developing discipline.\(^{43}\) New self-criticisms are reflective of maturation, which is now old enough to look back at its own research and critique itself. Numerous articles began to appear gave a slap on the wrist to those who dared to promote half-truths and neuromyths about the discipline. This healthy judgment of research in the discipline helped to elevate standards, but it also increased tensions in the relationships formed by professionals in education, psychology, and neuroscience. Pleas from all sides called for improved communication and sharing by the early 2000s. Teachers begged neuroscience to tell them which information was “good” and what was “bad” during the IMBES conferences (2007). Neuroscientists reacted to criticisms that their work related to

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\(^{41}\) Excellent coverage of the neuroethic theme can be found in the Farah (2007); Glannon (2007); Illes (2005); Illes & Raffin (2002).

\(^{42}\) These specific examples are found in Sheridan et al. (2005); Illes (2005).

\(^{43}\) An example can be found in Coles (2004).
laboratory animals, not to teachers and their students, and asked teachers for “real-life” problems upon which to structure future research. Psychologists began to react to educators’ calls to ground theory in more practice.

A Pendulum Swing from the Mind to the Brain and Back Again

By the end of 2007 it became clear that MBE science had experienced a pendulum swing. From the time of the Greeks through the Decade of the Brain in the 1990s there was an demand to ground teaching in science, or more specifically, in information about the brain. Around the start of the 21st century, there was a change, however. Many scientists reminded the discipline that it was “losing its mind in favor of the brain,” and that a move toward “biological determinism” was unbalanced, at best, and dangerous, at worst. These observations returned a more human face to the emerging discipline and demanded a happy medium between research and practice as well as between the laboratory and the classroom. This pendulum swing brings the balance back to the middle and values both the science as well as the art of teaching.

In 2008 an international Delphi panel of 20 experts in the emerging discipline sought to create a framework for standards. The concerted efforts by neuroscientists, psychologists, and educators on this panel brought many key questions from the backburner into the spotlight. Who should teach and how and what should be taught to take advantage of knowledge about the brain became the key issues in education. These issues included the creation of standards and a shared language as well as core topics and themes in the new science of teaching and learning, all of which is discussed in the following chapters.

By the end of the first decade in the new millennium the numbers in MBE science increased from a handful of enthusiasts to thousands. International gatherings such as “Explorations in Learning and the Brain”; “Learning and the Brain”; “The International Mind, Brain, and Education Conference”; “Learning Brain Europe”; “Primary Teacher UK: Learning Brain Europe Conference,” and the “Behavior and Brain Conference” were just a few of the society meetings that took place in the United States and the United Kingdom in 2008. For the first time, books used the “mind, brain, and education” label in their titles: The Developmental Relations between Mind, Brain and Education: Essays in Honor of Robbie Case; Mind, Brain, and Education in Reading Disorders; and The New Science of Teaching and Learning: Using the Best of Mind, Brain, and Education Science in the Classroom were all published between 2009 and 2010.

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44 Siegel (1999, p. xii).
45 Siegel (1999, p. xiii).
46 To see the complete study, see Tokuhama-Espinosa (2008).
47 Ferrari & Vuletic (2010).
49 Tokuhama-Espinosa (2010).
MBE science has its roots in thousands of years of academic reflection. This brief history of MBE science tracks its parallel development around the world in psychology, education, and neuroscience—a development that became an integrated effort in the 1990s and a new academic discipline around 2004–2006. Once unified, the new discipline asked some obvious questions of its membership: Most importantly, what are the goals of the new discipline, and by what standards are members bound? These questions are explored in Mind, Brain, and Education Science (Tokuhama-Espinosa, 2010).

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Supervision and Curriculum Development.


**Books on this topic by Tracey Tokuhama-Espinosa:**
