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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.

"Knowing how something originated often is the best clue to how it works."

Some questions have faced teachers for centuries. What is important to know? Who is prepared to teach? Who should be taught and how? Hints at answers to these questions can be found throughout history, and these answers point repeatedly to key concepts that are the cornerstones of the new science of teaching and learning.

From the Egyptians to the Greeks to the 1100s: The Roots of Formal Education

Humans are a complicated species, and exact records of many aspects of our common development are not so well known. The development of writing systems around 3500 B.C.E. aided in recording these lessons and served as a
concrete record, replacing reliance on purely oral history. Some of the earliest written records show that formal education, in which basic communication skills, language, trading customs, and agricultural and religious practices were taught, began in Egypt some time between 3000 and 500 B.C.E. The earliest library known to man, in Babylonia, was built by Ashurbanipal, the king of the Neo-Assyrian Empire (685–627 B.C.E.). Texts in this library documented advances in math, reading, and writing, as well as common practices of warfare and hunting.

During the Zhou Dynasty (551–479 B.C.E.), Confucius, the famed Chinese philosopher, greatly impacted the overall curriculum focus of formal education and shaped educational values even through present-day systems. Though known better for moral and spiritual teachings, Confucius’s focus on personal values determined what was important to teach as well as how this teaching was achieved in formal education settings. For example, self-control and respect were incorporated as aspects of the development of logical thinking. Additionally, Confucius was perhaps one of the first to think of differentiated instruction: “Teach according to the student’s ability” (as cited in Chin, 2007, p. 1). This means that 2,500 years ago Confucius knew about the value of differentiated instruction and its worth not only to the individual but also to society.

The content of formal education shifted with the Greeks, who sought to balance utilitarian skills with loftier contemplations about the origins of thought. Hippocrates (c. 460–370 B.C.E.), Socrates (c. 470–399 B.C.E.), and Aristotle (c. 384–322 B.C.E.) all speculated about what drives human will, motivation, and learning. While educators since the Greeks have contemplated how to influence human actions through formal education, it is relatively recent in human history that the focus has turned to brain functions that can be manipulated to enhance the teaching and learning process. According to modern educational theorist Howard Gardner, “Greek philosophers may have been the first to raise questions about the nature of matter, living entities, knowledge, will, truth, beauty, and goodness. In recent centuries, however, philosophy has steadily been yielding ground, enthusiastically or reluctantly, to empirical science” (Gardner, 2000, p. 1).

**The 10th–17th Centuries: The Senses and Learning**
Starting in the 10th century, humanity gained a fundamental understanding about how sensorimotor perceptions are interpreted in the brain and translated into thought. Alhazen (or Al-Haytham; 965–1039 C.E.) was perhaps one of the greatest physicists of all times and a product of the Islamic Golden Age or Islamic Renaissance (7th–13th centuries). He made significant contributions to anatomy, astronomy, engineering, mathematics, medicine, ophthalmology, philosophy, physics, psychology, and visual perception and is primarily attributed as the inventor of the scientific method, for which author Bradley Steffens (2006) describes him as the "first scientist." Alhazen recorded some of the first ideas about experimental psychology and optical illusions and could be considered a Middle Eastern da Vinci. Alhazen’s work helped move philosophical ponderings about intelligence to the realm of hard science. Alhazen established that learning is generated by our sensory perceptions of the world (even if only through memories of those perceptions and not actual perceptions themselves). Our senses feed information to our memory, and we compare new with old, detect patterns and novelty, and base new learning on past associations; new information is learned based on our past experiences.

From the Physical Body to the Learning Brain

Renaissance researchers posed similar philosophical questions to the Greeks, but sought answers based in physical evidence. Italy’s Leonardo da Vinci’s rendition of the human brain (1508) and Belgium’s Andreas Vesalius’s (1543) subsequent anatomical drawings not only created precise visual records, but they also began to name specific areas of the brain, creating consistent references and a shared vocabulary for future research. Da Vinci knew what current researchers today still struggle with: Without common terms of reference and vocabulary, it is impossible to compare findings (see Figures 4.1 and 4.2).

Figure 4.1. Leonardo da Vinci’s rendition of the human brain, 1508
Source: http://www.drawingsofleonardo.org

Figure 4.2. Andreas Vesalius’ depictions of the human brain 1543
These creative scientists lived in an exciting era in Europe. “The first half of the seventeenth century saw the emergence of scientific groups whose members gathered to promote discussion and to disseminate the ‘new’ philosophy,” (Becker 2006, para. 1), which included study of learning and the human brain. In 1664, one of the most complete early versions of the brain was drawn by Christopher Wren (Willis, 1664), who later designed St. Paul’s Cathedral in London (Figure 4.3). It is poignant that the supreme example of human design, the brain, required a world-renowned architect to do justice to its form.

Figure 4.3. Christopher Wren’s rendition of the human brain, 1664
René Descartes’ proclamation “Cogito, ergo sum” (I think, therefore I am) in 1637 triggered a new reflection about the role of the individual and his or her mind and understanding of a worldview that has forever influenced Western concepts of education. Thinking, not just being, constituted the definition of one’s purpose in the world. This idea implied that maximizing one’s individual potential to think, create, and produce intellectually justified one’s existence. In 1693, John Locke’s Some Thoughts Concerning Education established the link between developmental psychology and human development. Locke made calls for a philosophy of education that encouraged a deeper self-regulation of metacognition and learning and that continues to impact the way students are taught and how we observe what is learned even today. Locke suggested that a key to good teaching is to help students reflect more about their own thinking processes. By articulating their own mental steps in solving a problem, for example, Locke believed that learners would become better thinkers. This reflective process is a modern cornerstone of critical
thinking in which certain habits of mind help students rehearse such reflective processes are basics of modern quality education.

**The 18th and 19th Centuries: Widespread Formal Education**

With the exception of the Islamic world, which had distinct academic institutions as early as the 10th century, a common phenomenon around the world was the use of religious institutions as locations for formal education. For the most part, churches and temples served as the first classrooms and, with few exceptions, generally only catered to the elite. Catholic schools were the first formal educational institutions in Norway around 1152, for example, and the Third Lateran Council (1179) officially mandated free education for the poor in England, though the classes were primarily devoted to religious readings. It wasn’t until the 1500s, however, that widespread education began; some religious schools were converted into Latin schools (as in Norway and Denmark), and each market town was required to have a school.

Beginning in the late 1600s the trend toward the universalization of education became more democratically available, albeit with several shortcomings. Throughout the 17th century Zen Buddhist temples served as the educational structures in Japan. Similarly, in India in the 18th century, schools and temples were physically one and the same. reading, writing, arithmetic, theology, law, astronomy, metaphysics, ethics, medical science, and religion were taught to students of all classes in these institutions. Most educational institutions in the United States that were founded between 1640 and 1750 were started by religious denominations. However, beginning in the 1600s, many religious institutions gave way to nondenominational formal education around the world.

In 1633 the Parliament of Scotland approved a tax to provide for public education. Across the Atlantic in the late 1700s, Thomas Paine promoted the idea of free public education, though it wasn’t until 1837 that Horace Mann managed to successfully create a tax to support public schools in the United States. In the 1880s public education became the norm in France, and by 1890 Japan also had full compulsory education. In 1919 compulsory and free education became standard in Imperial Russian and the current Soviet Union. Since 1950 China has had 9 years of compulsory education. Latin America began reforms in the 1960s to require between 6 and 9 years of basic
education. In Africa, in 2009, less than 60% of all students were currently enrolled in formal education, despite its growing value in local communities and many countries' commitment to the “Millennium Development Goals” for education, which include compulsory primary school completion as a minimum.

Put in this context it is easy to see how pedagogy, or the art of teaching, has had a relatively short history. The concept of creating formal education and the modern needs that have arisen due to the now varied student body are enormous. Whereas only a few hundred years ago few of our relatives were literate, it is now the norm that students of all socioeconomic and cultural backgrounds attend school. To make the setting more complex, it can be ventured that a wider variety of learning potentials (brains) also enters the modern classroom. When education became the norm, no longer were schools filled with obedient and religiously driven, wealthy students, as in the Middle Ages, but rather, they are now filled with students who are simply “normal” or even those with special needs who never would have been attended school a hundred years ago. The evolution of widespread educational access was paralleled by discoveries in neuroscience that formed new beliefs about learning that impacted in these more widely diverse classrooms.

**Localizationism**

Localizationism is the belief that X skill is located in Y part of the brain. This idea is rooted in early studies, mainly in the 1700–1800s, which sought an association between certain parts of the brain and brain functions, as in language being in the left hemisphere. Localizationism implies that if, for some reason, X is damaged, then Y is lost forever. We now know that this is not necessarily true. However, in the 19th century the focus was on deciphering the map of brain functions; where patterns were found, generalizations about the brain were made. This had some good and other dubious results.

The 18th and 19th centuries were riddled with false convictions about the brain, for example. These included the belief in phrenology, in which the bumps and crevices of the skull were measured to determine strengths and weaknesses of both academic prowess and personality traits. When it was found that external traits of the brain did not reflect intellect, neuroscientists
turned to the inner workings of the brain. In the mid-19th and early 20th centuries significant and highly credible new findings about the brain’s functionality emerged.

Discoveries related to specific domain functions, such as language by Paul Broca (1862) and Carl Wernicke (1874), a general charting of the brain areas by Korbinian Brodmann (1909), and findings about the role of individual synapses or links between neurons in the brain by Santiago Ramón y Cajal (1911) generated a new and lasting excitement in the field. Broca and Wernicke established that most people (95% of right-handed people and 70% of left-handed people) have two main language areas in their left frontal (Broca) and parietal (Wernicke) lobes (Figure 4.4). Brodmann devised an elegant system for charting primary visual motor and auditory pathways in the brain (Figure 4.5). Brodmann’s contemporary, Ramón y Cajal, made a lasting impact by showing that the neuron was the basic functional and structural unit in the brain. Each of these discoveries contributed to new definitions of the physical nature of learning and the brain. The turn of the 19th century brought a flood of new scientific theories of learning, including the now famous “nature versus nurture” debate.

*Figure 4.4 Broca and Wernicke’s Areas*

*Source: Bramwell for Tokuhama-Espinosa*
The Biology of Learning and the Nature versus Nurture Debate

Just as formal education was getting underway around the world in the late 1800s, Francis Galton, the father of eugenics (1869), sparked the original debate on the nature versus nurture influence on learning and intelligence. Are you who you are, and as intelligent as you are, based on the genes you
received from your parents, or based on how you were raised? This question
continues to be asked today and is at the root of many educational policy
decisions. Are schools obliged to support all children, no matter how bright or
dull (because it is not their fault, it’s their genes; or because it is morally right
to do so), and therefore required to invest resources into special education and
programs for all learning differences (disabled, challenged, or gifted)? Galton
was instrumental in calling attention to the role of biology in learning—a role
that remains a major part of MBE science.

The theories of evolutionary psychology and sociobiology were given
prominence by Mark Baldwin in the late 1800s in a theory that is known
today as the Baldwin Effect, a proposed mechanism for specific evolutionary
selection for general learning ability (Baldwin, 1896). The Baldwin Effect
basically suggested that when learning occurs that is beneficial to the survival
of a species, then it would be remembered in the genes passed on to the future
descendants. This theory had profound influence on the belief that both
biology and experience mutually impact learning outcomes. For example, in
her eloquent book Proust and the Squid, Maryanne Wolf (2007) illustrates
how reading has changed the human brain through dramatic evolutionary
processes, a concept that is reinforced by Stanislaus Dehaene’s (2009) belief in
neuronal recycling, or the reuse of evolutionarily older areas of the brain for
new needs (as in reading, which has only been required for the past 5000
years or so). By the start of the 1900s there was a rush to link behavior to
biology at every turn—for example, in studies of emotion and developmental
psychology.

**The 1900–1950s: Neurons That Fire Together, Wire Together**

Donald Hebb made a daring link between brain science and learning through
his groundbreaking book *The Organization of Behavior* (1949). In this book,
Hebb wrote about how brain organization relates to behavior and posited the
now-famous Hebbian synapse rule, a core of modern neuroscience: Neurons
that fire together, wire together. This finding explained in biological terms
what psychologists had witnessed for decades in behavior. In classical
conditioning, associative learning results when a neutral stimulus is associated
with conditioned stimulus, a concept first demonstrated by Ivan Pavlov (who
won the 1904 Nobel prize in physiology and medicine for his work on the
digestive system) when he discovered the basic principles of conditioning by
the simple act of feeding his dogs: He typically rang a bell calling dogs to their food; he realized that soon after the first few rings of a bell, the dogs would begin salivating merely at the sound of the bell, without the food. In Hebb’s terms, this was explained by the fact that the stimulus of the bell and the usual delivery of food created neuronal firings linking bell and food. The Hebbian synapse concept is fundamental to our current understanding of plasticity and learning as a whole.

The Hebbian synapse concept also explains anxieties related to learning. For example, if a student relates a negative emotion to a teacher of certain subject, such as math, he or she may experience math anxiety, independent of the teacher, in the future due to the “wiring” of the negative experience with the subject matter. Although some teachers have begun to experiment with some of these concepts based on psychological models, widespread knowledge and use of the Hebbian synapse concept is still foreign to most teacher training programs. Other psychological theories of cognitive development were more successful in making their way into the classroom, however.

**Stages of Cognitive Development**

Jean Piaget, a contemporary of Hebb, also made profound contributions to the conceptualization of the new science of teaching and learning found today. Piaget was one of the most renowned developmental psychologists of the 1900s and is still recognized as one of its main figures today. Piaget was “originally trained in the areas of biology and philosophy and considered himself a ‘genetic epistemologist’.” Throughout his career, Piaget strongly grounded his work in biology and tied it to education. Piaget’s research was instrumental in defining four stages of cognitive development (sensory–motor stage, preoperational period, concrete operational stage, and formal operational stage) and also recognized the individual differences in reaching these milestones.

To understand Piaget’s contributions, it is important to grasp the way in which he envisioned human development. Piaget perceived human development as a continuum with several sub-elements in each stage. The first of the four stages of development, the sensory–motor stage (0–2 years old), has six sub-stages: (1) simple reflexes; (2) first habits and primary circular reactions; (3) secondary circular reactions; (4) coordination of secondary circular reactions;
(5) tertiary circular reactions, novelty, and curiosity; and (6) internalization of schemes. The meticulous division and description of each of these stages can now be correlated to specific changes in the nervous system and particularly in brain development.

In the second stage of cognitive development Piaget acknowledged two sub-stages: the emergence of a symbolic function (about 2–4 years old) and intuitive thought (about 4–7 years old). These are more complex to correlate to specific neuroscientific findings, but there is growing evidence of the maturation of certain brain areas related to complex thought (forebrain mechanisms) that experience a large amount of growth during these years. In the third of Piaget's stages (the concrete operational stage), there are several processes, but no sub-stages. The complexity of human thought and development become evident in this stage, and many a neuroscientist has grappled with the implications of this division to date. These processes include:

- **Seriation**, or the ability to sort objects in an order according to size, shape, or any other characteristic;
- **Transitivity**, or the ability to recognize logical relationships or the relative relationship between objects;
- **Classification**, or the ability to name and identify sets of objects in terms of their varying characteristics;
- **Decentering**, in which the child approaches the problem from several angles in order to find the right solution;
- **Eversibility**, in which the maturing child comes to understand that numbers or objects can be changed, then returned to their original state;
- **Conservation**, in which the child grasps the idea that quantity, length, or number of items is unrelated to the arrangement or appearance of the object or items (as when water is poured from a short fat cup into a tall slim glass); and,
- The elimination of egocentrism and the possibility of becoming empathic (i.e., the ability to view the world from others' perspectives).
The beauty of Piaget’s work is that we now know that all of these processes, which a child normally develops before the age of 12, relate to different mental tasks that can, indeed, be isolated in the human brain. That is, the systems needed to conduct seriation, transitivity, classification, etc., are all different (though sometimes overlapping) neural circuits in the brain. This means that they pose individual challenges for students as they develop.

The fourth stage of Piaget’s conception of cognitive development is called the formal operational stage. This stage normally occurs as children move into adolescence (on average, around 13 years old or so) and begin to think more abstractly, which is related to their ability to reason logically and draw on existing information to develop hypothetical suppositions about situations. Piaget noted that an adolescent’s verbal problem-solving ability was paralleled by the logical quality of his or her thought at this stage (as opposed to earlier stages when children work by a trial-and-error method). In the formal operations stage, humans begin to use a greater amount of hypothetical–deductive reasoning and systematically deduce, or conclude, choices as opposed to random guessing. In an interesting example, Piaget suggested that many “first loves” occur during early adolescence principally because teenagers are now able to contemplate possibilities beyond their immediate moment. The formal operations stage begins in adolescence, which explains teenagers’ fascination not only with where they came from, but also with what they can possibly be in the future. In the 1960s Piaget was actually closer to the reality of the teenage brain than many modern theories (which suggest that hormones are to blame for their fickle behavior).

Both the theory of the stages of cognitive development as well as the individual variation with which students go through the stages are core elements of modern MBE science (Figure 4.6). Piaget’s keen observations allowed him to envision how developmentally observable behaviors are linked to changes in the brain over time. Through Piaget’s experiments were based on observable behavior, his theories, like Freud’s, presumed analogous physical changes in the brain that reflected the changes.

*Figure 4.6 Piaget’s Stages of Development*
Social-Historical Psychology and Child Development

Another key contributor to the MBE science discipline was Lev Vygotsky, whose novel ideas on cognitive development and learning concepts (e.g., the Zone of Proximal Development, in which within a group there will always be someone who knows just a bit more than the others and through a scaffolding teaching-learning structure they will instruct one another) were fundamental in shaping modern pedagogy as well as subsequent theories of child development. Two of Vygotsky’s core contributions, still being debated today, are related to cultural mediation and internalization as related to an individual’s “inner voice” (Vygotsky, 1934). Cultural mediation begs the question as to whether there are “universals” related to human learning, versus the concept that all learning is filtered through one’s culture (and therefore unique to each). Vygotsky’s inner voice concept questions whether or not thinking is based on the words we know—that is, can we think without words? Both ideas are still points of contention in modern educational theory. Vygotsky’s work was translated into curricula structure for school-age children by Vasili Davidov, whose work is also noted as influential in the emerging discipline related to its contributions of social attributes and learning.

One of Vygotsky’s disciples, Alexander Luria (1924), made breakthrourghs in
his writings related to “cultural–historical psychology” and its influences on thought. While short lived as a sub-discipline of psychology, the conceptual framework devised by these early thought leaders established the foundations for understanding how culture, especially as mediated through language, influenced thinking. Luria’s second large contribution was documentation of The Mind of a Mnemonist: A Little Book about a Vast Memory (Luria, 1968), which was the catalyst for a great number of studies related to the human memory system and questions on how memory impacts learning. Luria’s work was important because by documenting the “curse of a flawless, synaesthetic memory” he was able to demonstrate that there are various memory systems in the brain, not just a single entity called “memory.” In this work, Luria documents the case of a man who was unable to forget, causing terrible difficulties in his life, such as the inevitable association of random concepts, which distracted him for “normal” exchanges with the people around him. Luria’s documentation of memory led to a breakthrough concept for teachers, who began to understand that information could be recorded in different “formats” via distinct neural pathways and that memory is a vast and multilayered system, which can have many different types of flaws.

One extremely fascinating view of memory and different memory systems is related to synesthesia, or the ability to relate different types of information to different senses (e.g., something visual can be remembered through smell or texture; a taste can be remembered through a color or sound). Findings of some of the studies that were sparked by Luria’s inspirational work included the acknowledgment that problems with memory can occur during stages of encoding (getting this information into the brain), storage (maintaining links to the encoded information), or retrieval (being able to access and use memories stored in the brain). Other studies noted that different memory systems (e.g., short-term vs. long-term) have different, though often overlapping, neural pathways. Jerome Bruner, one of the 20th century’s leading cognitive psychologists in educational psychology, lent his skills and insight to the foreword of Luria’s work in a reprint in 1987 and helped reinforce the importance of the consideration of memory in all aspects of life and learning (Luria & Brunner, 1987). These contributions from psychology and education were complemented by stunning findings in the neurosciences around the same time.

From the 1960s to the 1980s: Enriched Environments?
In 1958, Mark R. Rosenzweig and colleagues published results of rat experiments that opened a new field of discussion related to the neurobiological basis for behavior and the influence of enriched environments. Building off of Rosenzweig's findings at the University of California, Berkeley, colleague Marian Diamond's work examined differences between rats' brains (dendrites and synaptic growth) based on a comparison of impoverished versus enriched environments. Rosenzweig's and Diamond's work started the discussion of how enriched learning environments could enhance neuronal growth in humans and the subsequent debate as to whether increased synaptic growth translated into better learning (see Figure 4.7). The authors of the original studies now believe that the “enriched” laboratory environments were actually more like “normal” rat environments (i.e., sewers), which does not prove that enriched environments are better, but rather that poor environments are worse than normal environments. Despite this new knowledge, there is a million-dollar industry dedicated to training parents and teachers to design “enriched” environments.

Figure 4.7. Enriched Rat Environments and Synaptic Growth

Source: Barbro B. Johansson and Pavel V. Belichenko (2001) Environmental
Environmental Enrichment on Intact and Postischemic Rat Brain

William Greenough, in turn, built off of Diamond’s work as he explored how experience affects the developing and the mature brain. Greenough understood that plasticity, commonly known in the field today but new a dozen years ago, related to the brain's capacity to change and build new synapses with experience. We know that “synapses form in situations in which animals are learning; synapses typically do not form as a result of non-learning-related neural activity”; therefore, more synaptic activity is an indication of learning. His current work focuses on “upon cellular mechanisms underlying learning and memory and other brain information storage processes” using his knowledge of how plasticity works.

The discussion about what constitutes an “enriched environment” continues today and is accompanied by a vibrant debate as to whether babies and children should or should not be sent to early stimulation classes. As Greenough and others showed, while there is no doubt that enriched environments change the brain and that new learning occurs, the main discussion related to enrichment revolves around the definition of the term: what may be enrichment to one person (or rat) may not be enrichment to another. Enrichment is discussed in the following chapters; what is important to note here is that the excitement in the emerging discipline at the end of the 1960s led to a number of academic initiatives.

The Pre-MBE science Stage

Dartmouth College’s doctorate program in psychological and brain science was started in 1968, and Dartmouth’s undergraduate educational degree in educational neuroscience is also one of the oldest in the nation, founded in 1990. The Dartmouth program continues to grow today as more and more applicants seek academic programs that promote MBE science principles. Both the undergraduate and graduate programs merged knowledge bases from psychology and neuroscience and subsequently education before others recognized the truly complementary nature of the fields. Dartmouth was an early starter; most other programs did not formally begin until the early 2000s.

A number of academic researchers began explicitly linking brain functioning
to learning and education starting in the 1970s. Michael Posner, author of some 280 books and articles on attention and memory, wrote his earliest works beginning in the 1970s. Posner has been a key contributor to the continual evolution of the discipline of MBE science, and his most recent work has been fundamental in bridging psychology and neuroscience for the application in education. The work at Dartmouth and by people such as Michael Posner in the 1970s came principally from developmental neuropsychology and can be called a “pre-MBE stage.”

Between 1973 and 1979 there was a rise in interest in defining and promoting educational neuropsychology, another forerunner to MBE science. The discipline of educational neuropsychology seeks to merge education, neuroscience, and psychology, but unlike MBE science, emphasizes the study of learning rather than teaching. For teachers, educational neuropsychology was a leap forward in merging the common goals of education with those of developmental psychology in the school setting, but still did not serve teachers’ needs completely (how to teach better). Educational neuropsychology was an improvement over simple developmental psychology because neuroscientific studies were given more prominence. The lack of neuroscientific support for some of the studies in developmental psychology meant than many studies were about the “mind” rather than the “brain,” which some argued detracted from their applicability in teaching. However, educational neuropsychology is quickly giving way to MBE science at the time of this writing for two primary reasons. First, as noted above, MBE science studies teaching, not just learning processes, and second, due to the syntax of the term educational neuropsychology, in which education and neuroscience are considered a subfield of psychology—whereas in MBE science there is equal input from all three parent fields. Several studies in this pre-MBE stage considered life skills, such as the role of motivation or emotions, and how they impact learning.

**Emotions and Learning**

One of the first links between emotions and learning was introduced in the language context in the form of the affective filter hypothesis, which basically suggests that how we feel influences what we are able to learn. That is, emotions impact how, what, and why we learn. Currently this hypothesis is correlated with amygdalar neuroimaging studies that, in some cases, show how stress and emotional states influence learning. What is important for
teachers to accept is that emotions impact decision-making and that decision-making is core to learning.

In the 1960s, American public education went into an existential crisis. Myron Lieberman’s book The Future of Public Education was representative of a general review of core concepts related to educational practice, including teacher education of the basics of learning. The National Education Association, the largest professional organization of teachers in the United States, began to take interest in the application of neuroscience findings to the classroom in the late 1970s. In 1978, Brain Research and Learning (National Education Association, 1978), and Chall and Mirsky’s work Education and the Brain (1978) were both published. These two books were serious and well-researched attempts to integrate neuroscience and education and rode on the heels of many breakthroughs about human learning. This was to be the beginning of a general popularization of information on neuroscientific research for teachers and a general marriage of neuroscience, education, and psychology, and it came at a time when policy makers began to focus on reaching all students in a more equitable way. How can we serve not only the highest-achieving students, but also respond to the needs of the lower-achieving ones? America and many other countries around the world began to realize that a chain is only as strong as its weakest link; public education had to do more to reach all of the members of society.

The 1970s saw a huge surplus of teachers in the United States as budget cuts meant that classes grew larger and only core subject-area teachers were hired. The larger class sizes meant less individualized attention for students, but also drew focus to attention-related difficulties on the whole. Discoveries about neurotransmitters related to attention mechanisms in the brain led to the introduction of Ritalin in 1971, which was meant to "aid to general treatment of minimal brain dysfunction," which manifested itself in the form of hyperkinetic activity. . The end of the 1970s witnessed the crystallization of many concepts about learning related to attention and memory, and to other areas as well. Perhaps two of the most important developments emerged from Michael Gazzaniga’s call to bring functional neuroscience to the forefront of teaching in his text Neuropsychology: Handbook of Behavioral Neurobiology, and Michael Posner’s move toward the integration of neurosciences and psychology for the benefit of understanding learning in a more holistic fashion. Both of these efforts tried to put a more “utilitarian” face on
neuroscientific findings and brought the information out of laboratories and into classroom settings. The back-to-basics approach in public education was mirrored in the emphasis of what was considered important in the science lab; if it could not be applied in authentic settings, there was less funding available for research. Gazzaniga and Posner contributions in the late 1970s to the applicability of science findings for classroom became norms for future studies, and their earlier works remain important for researchers today.

**Some Pioneering Institutions**

Three pioneering neuroscience societies were also formalized in the late 1970s. In 1977, the Japan Neuroscience Society was founded as “an academic organization of scientists who study the brain and nervous system and wish to publish their findings in order to promote the welfare and culture of humans.” Also in 1977, the Centre for Neuroscience (CNS) was established as an institute of Flinders University in Adelaide in South Australia, and was “the first such multidisciplinary centre in the neurosciences to be established in an Australian university.” CNS members were instrumental in establishing the Australian Neuroscience Society later in 1979. These societies promoted new findings about the brain that were fueled by growing information from improved imaging techniques. These Austro–Asian institutions were early leaders; most other such institutions came along in the late 1990s.

*(PART 2 IN NEXT ARTICLE).*

**References**


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