Brain-Based Education

The overall goal of brain-based education is to attempt to bring insights from brain research into the arena of education to enhance teaching and learning. The area of science often referred to as "brain research"; typically includes neuroscience studies that probe the patterns of cellular development in various brain areas; and brain imaging techniques, with the latter including functional MRI (fMRI) scans and positron-emission tomography (PET) scans that allow scientists to examine patterns of activity in the awake, thinking, human brain. These brain imaging techniques allow scientists to examine activity within various areas of the brain as a person engages in mental actions such as attending, learning, and remembering. Proponents of brain-based education espouse a diverse group of educational practices and approaches, and they generally attempt to ground claims about effective practice in recently discovered facts about the human brain. They argue that there has been an unprecedented explosion of new findings related to the development and organization of the human brain and that the current state of this work can inform educational practice in meaningful ways. Indeed, advances in brain science led brain-based educator David A. Sousa to proclaim that "no longer is teaching just an art form, it is a science" (1998, p. 35).

Summary Principles of Brain-Based Research

Although brain-based education has no seminal source or centrally recognized leader, examples of commonly cited works include special issues of education journals and popular books such as *How the Brain Learns: A Classroom Teacher's Guide, * by Sousa; *Teaching with the Brain and Mind,* by Eric Jensen; *Making Connections: Teaching and the Human Brain,* by Renate Nummela Caine and Geoffrey Caine; *A Celebration of Neurons: An Educator's Guide to the Human Brain,* by Robert Sylwester; and *Teaching for the Two-Sided Mind: A Guide to Right Brain/Left Brain Education,* by Linda VerLee Williams. Such works, invariably written by education writers rather than brain researchers, claim to help teachers turn research on brain function into practical lessons and activities that will enhance student learning. A common step in many brain-based education efforts involves disseminating findings from brain science in the form of basic summary principles that are designed to be accessible to educators. For example, Caine and Caine (1994) claim to have deduced twelve principles from brain science that hold strong implications for education and that can be linked to specific educational practices:

- "The brain is a complex adaptive system."
- "The brain is a social brain."
- "The search for meaning is innate."
- "The search for meaning occurs through patterning."
- "Emotions are critical to patterning."
- "The brain processes parts and wholes simultaneously."
- "Learning involves both focused attention and peripheral perception."
- "Learning always involves conscious and unconscious processes."
- "We have at least two different types of memory: a spatial memory system and a set of systems for rote learning."
- "We understand and remember best when facts and skills are embedded in natural, spatial memory."
- "Learning is enhanced by challenge and inhibited by threat." (pp. 88-95)

There are three problems with such summary principles. First, they are not necessarily endorsed by brain scientists as appropriate summaries of the research. Second, they are exceedingly global statements that could potentially encompass a wide variety of educational practices that are not necessarily compatible with one another. Third, few of the practices that are deemed “brain based” have been evaluated for their relative effectiveness. These problems make it difficult to evaluate the merits and usefulness of the kind of global claims offered by brain-based education writers, as exemplified by Caine and Caine.

Nevertheless, brain-based education proponents typically argue that a particular educational approach or practice *is* warranted by these kinds of basic summary principles and the related supporting evidence from brain research. Given that such links between brain research and education practice are initially speculative in nature and are often not subjected to evaluations that demonstrate their effectiveness, the label of “brain-based education”; does not necessarily imply that the recommended educational approach or practice is “evidence based.” The brain science evidence merely provides a rationale for speculating about potentially useful educational practices.

Often proponents of brain-based education use collections of claims (as above) to promote a rationale for doing away with traditional forms of education in favor of educational reforms based on constructivist learning principles and more active engagement in individualized learning and group problem solving. For example, Susan Kovalik, developer of the Integrated Thematic Instruction model argued, “disciplines have to go; the textbooks have to go; the worksheets have to go because they have nothing to do with how the brain works” (Cohen, p. 1). Along these lines, brain-based education is often cited as a mandate for “orchestrated immersion,” such as having children work through problems in curriculum by engaging in activities that simulate real-world problem solving or by engaging in group cooperative learning.

Are such broad claims warranted by the evidence provided by brain science? In 1996, seventy-four brain scientists and education professionals gathered at a meeting held by the Education Commission of the States and the Charles A. Dana Foundation to explore the extent to which neuroscience had uncovered facts about the brain that educators might apply in the classroom. At the conclusion of this meeting, which was called “Bridging the Gap between Neuroscience and Education,”; neuroscientists warned educators that many brain research findings might be too narrow and isolated to ever provide a detailed plan of action for restructuring schools. Furthermore, some scientists “cautioned educators to resist the temptation to<el3>use neuroscience as a propaganda tool to promote a pet program”; (Taher, p. 5). At this same meeting Joseph LeDoux, a prominent psychologist and neuroscientist, warned that “these ideas are very easy to sell to the public, but it’s too easy to take them beyond their actual basis in science”; (Taher, p. 5).

The specific claims made within brain-based research vary widely but typically take the form of two interrelated assertions: (1) assertions of basic summary principles that are held to be broadly supported by neuroscience research and (2) assertions that particular educational approaches or practices should be promoted on the basis of the stated principles of brain science. Critics of contemporary brain-based education literature, such as John T. Bruer and Paul Grobstein, have raised questions about whether the basic summary principles delivered to teachers might be too overly simplified to capture the most useful information in brain research and have raised concerns about the validity of the inferential leap that takes place between accepting a basic summary principle from brain research and creating a particular recommendation for educational practice. The remainder of this article summarizes the major points raised in critiques of brain-based education in light of evidence available in the early twenty-first century and discusses promising directions for future research that might help the fields of brain science and education to mutually inform one another in productive ways.

Critiques of Brain-Based Education

In some cases, summary principles can oversimplify research to the extent that the most useful level of detail for educational implications is lost. For example, in a 1999 article, Bruer pointed to Sousa's summary claiming that brain research had established that the left hemisphere of the brain is responsible for language processes (including logical processes, coding information verbally, reading, and writing) and the right hemisphere is responsible for spatial processing (and also creativity, intuition, and encoding information via pictures). Sousa had furthermore argued that, based on this insight, teachers should provide time for both left and right hemisphere activities so that children receive a balance of left and right hemisphere activity. Bruer, however, pointed to more recent brain research that demonstrated that the left and right hemispheres do not strictly divide the labor of thought between processing information about space on the right and language on the left, with this research finding instead that both spatial and language processes draw upon the left and right hemispheres and that subcomponents within each of these skills draw differentially on left and right hemispheres. In light of these findings, the related brain-based education claims appear to be invalid. This discussion underscores the dangers of relying on outdated notions of brain organization and function and the importance of making rigorous and detailed links between educational practice and the best available brain science data.

In other cases of brain-based research, summary statements appear to be general enough to have broad appeal to educators, but they are perhaps so broad that they have little or no meaningful connection to brain research and have only vague or perhaps misleading implications for educational practice. To take one example, in 1994 Caine and Caine stated that one basic principle of brain research (already mentioned above) was that wholes and parts are perceived simultaneously. Bruer pointed out that although this is statement is likely to be true, the statement is framed in such a way that it cannot be used to identify any particular brain system, nor can it provide direct and compelling implications for educational practice. Furthermore, Bruer directly challenged the validity of the inference that the Caines made in using this principle to argue that whole-language instruction and cooperative learning are warranted by brain research because such programs encourage students to think about both parts and wholes.

Another challenge Bruer posed for many basic summary statements relating to brain science is that the evidence that best supports many such summary statements does not actually come from neuroscience or brain scans but comes, rather, from other disciplines that have been around for decades. For example, in his 1998 article "Is the Fuss about Brain Research Justified?": Sousa listed several claims about how current "brain research"; can influence educational practice. On the topic of memory, he wrote about insights into how previous knowledge and judgments of meaningfulness influence people's ability to store new information. On the topic of timing and learning, he wrote about insights into how breaking learning time up into twenty-minute segments that are spaced over time might be an advantage over massing all that same study time together into one long stretch. One problem with these claims is that these insights were achieved with little or no direct support from brain studies. Instead, these claims are well supported by existing evidence in cognitive psychology, in the form of compelling information-processing studies on the influence of prior knowledge on memory recall and on the benefits of spaced versus massed practice in recall. In this sense, referring to these claims as brain based can be misleading; after all, existing bodies of cognitive psychology may have a great deal more to contribute to educational practice than the currently available brain studies.

Directions for Future Research

This literature on brain-based education that makes summary claims about brain processes and their implications is augmented by a literature that makes much closer ties to emerging research in brain science and that cautiously explores possibilities for enhancing research. For example, Pat Wolfe (2001) made several recommendations to educators related to taking a proactive stance as consumers and users of insights from brain science. These recommendations are for educators to learn the general structures and functions of the brain, to gain some skills in assessing the validity of a study, to exercise caution and restraint when attempting to employ insights from research studies in a classroom, and to intelligently combine insights from brain science with knowledge from cognitive psychology and educational research. To achieve these goals, Sousa argued in 1998, there is a need for professional development opportunities for prospective and current teachers to get firsthand contact with scientists involved in cognitive neuroscience the field of combing cognitive psychology with brain-imaging techniques. Such programs are beginning to become available at a national level and involve some of the nation's top scientists, as evidenced by advanced courses offered by the National Institute of Mental Health, Harvard University, and the University of Washington.

Other brain-based education literature that makes closer ties cwith brain research focuses on brain imaging of particular learning disabilities. Sousa wrote "we are gaining a deeper understanding of learning disabilities, such as autism and dyslexia. Scanning technology is revealing which parts of the brain are involved in these problems, giving hope that new therapies will stimulate their brains and help them learn"; (p. 54). Such direct ties between investigations of brain mechanisms associated with learning problems and intervention attempts provide a promising direction for brain-based educational research. Understanding how brain mechanisms of basic visual and language processes work together in typically and atypically developing readers is of central interest to many brain scientists and educators. Several studies centered on these issues were underway in fMRI laboratories in the early twenty-first century, with many of the studies involving brain scans collected before a particular educational intervention. Such direct interplay between educational intervention and brain-based measurements provides a means of assessing the degree to which a particular educational program impacts brain mechanisms associated with learning within a particular domain, such as reading.

Early mathematical abilities represent another very promising area of research that holds the potential for rigorous interaction between brain science investigation and educational practice. fMRI imaging work has provided insights into brain mechanisms of basic numerical abilities such as symbol recognition, digit naming ability, and estimation of magnitude. Future work that combines educational psychology and cognitive neuroscience may examine how educational programs help to train up these brain mechanisms and how remediation programs might help children with atypically developing mathematical abilities improve the operation and integration of these brain mechanisms for number symbol identification, naming, and magnitude estimation.

The examples of early reading and early mathematics skills have several qualities in common that perhaps make them ideally suited for a new form of brain-based education. In both of these domains, multiple years of brain research have been invested in elucidating the specific brain mechanism that underlie the particular skill; efforts have been made to map out differences in the brain activity patterns between typical and atypically developing learners; and each of these two content domains represent an educational challenge that many students and teachers struggle with.

As mentioned at the 1996 “Bridging the Gap”; meeting, perhaps the best way to pursue this form of brain-based research will involve collaborations between educational researchers and brain science researchers. Such forms of collaboration hold the advantage of combining teachers’; intervention ideas and with techniques for imaging brain areas associated with particular cognitive skills, thereby allowing researchers to track the changes in brain activity patterns that occur over the course of learning. Perhaps by explicitly combining evidence-based investigations of specific educational practices with brain imaging and psychological studies of learning, future research might take a step closer toward the goals of brain-based education and provide empirically validated contributions to enhancing education based on scientific insights into learning.

See also:* Learning, *subentry on* Neurological Foundation.

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