

## Pedagogy Meets Neuroscience

**H**aving acknowledged the social and economic value of education, modern societies are increasingly making concerted efforts to improve schooling at all age levels. Today, policy-makers and practitioners responsible for educational reform and improving classroom practice seek to base their decisions on empirical evidence rather than on opinions, fashions, and ideologies, as was too often the case in the past. This desire for “evidence-based” education has coincided with a period of tremendous progress in the field of neuroscience and enormous public interest in its findings, leading to an ongoing debate about the potential of neuroscience to inform education reform. Although the value of neuroscience research on this front is seemingly promising, collaboration with educators is doomed to failure if the public is not correctly informed and if the research is not considered in an interdisciplinary context.

It has become dangerously fashionable to label general—even trivial—pedagogical advice that is not grounded in scientific fact as “brain-based learning.” For instance, findings about rapid synaptic proliferation in young children’s brains have nurtured hopes that cognitive capabilities can be increased by teaching infants vocabularies and basic facts with audiovisual material. But proponents of these early education programs have conveniently overlooked the lack of direct empirical evidence linking neurological and learning processes. It is far from clear whether children who are encouraged to memorize isolated facts early in life show better long-term retention than their peers.

As a scientist specializing in school-related learning, I am open to the educational implications of neuroscience. However, we need to scale down unrealistic expectations. Otherwise, there is a danger that new efforts to incorporate research in this area into education could be stymied by falsely raising the hopes of the public and policy-makers. There is the further danger that people will ignore the importance of empirical research in the fields of educational and instructional science, psychology, and information technology—work that can continue to teach us about good schooling. Thanks to these more traditional areas of research, we understand a great deal about what has gone wrong in learning environments when otherwise competent students fail to learn. Research on learning and instruction has provided precise and applicable knowledge about how to design powerful learning environments in many content areas. What we now know about the conditions under which pictorial representations aid in teaching advanced concepts goes far beyond the recommendations of so-called brain-based learning.

Nevertheless, certain groups of learners do not benefit sufficiently from educational environments developed in accordance with state-of-the-art research on learning and instruction, and here is where collaboration among traditional research disciplines and neuroscience may be promising. Looking into the brain during problem solving might help to clarify what impedes learning. For instance, there is an ongoing debate on whether male students outperform female students in mathematics and science because of their greater ability to use visual-spatial representations as reasoning tools. As yet, however, the implications of achievement data and behavioral observations remain ambiguous in this respect. Neuroimaging techniques have elucidated areas of the brain that are especially involved in visual-spatial processing, so we may be able to find out whether differences in achievement can be traced back to the use of visual-spatial representations in reasoning. Similarly, neuroimaging may help to clarify whether visual or phonological processing is impaired in people with dyslexia.

Neuroscience may also be able to show how prior experiences can improve learning, going beyond psychological explanations. Although many studies have found evidence for the overwhelming impact of prior knowledge of skills, procedures, or concepts on learning, there may be other ways of improving learning besides such knowledge transfer. Cognitive activities can stimulate certain neuronal processes by triggering electrical impulses and the release of neurotransmitters in particular brain areas. Concurrently, other cognitive activities that are processed in similar brain areas may be enhanced, even if the two cognitive activities involve completely different knowledge structures.

Neuroscience alone cannot provide the specific knowledge required to design powerful learning environments in particular school content areas. But by providing insights into the abilities and constraints of the learning brain, neuroscience can help to explain why some learning environments work while others fail. As part of interdisciplinary collaborations, neuroscience is poised to help structure the future classroom. This would be “evidence-based” reform worth supporting.

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10.1126/science.1121139

