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THE BRAIN GOES TO SCHOOL: STRENGTHENING THE EDUCATION-NEUROSCIENCE CONNECTION

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Many recent technological advances, such as functional Magnetic Resonance Imaging (fMRI), have provided unprecedented insights into the workings of the human brain. These methods allow researchers to observe the brain while research participants are, for example, reading text, solving arithmetic problems, recalling previously learned information, or reasoning about social situations. Such investigations have led to the creation of a new field of research that bridges the gap between cognitive psychology and neuroscience: *cognitive neuroscience*. Within this new field, studies examining the processes of learning and development are beginning to reveal the complex relationship between neural processes and environmental input as children develop into their socio-cultural environments.

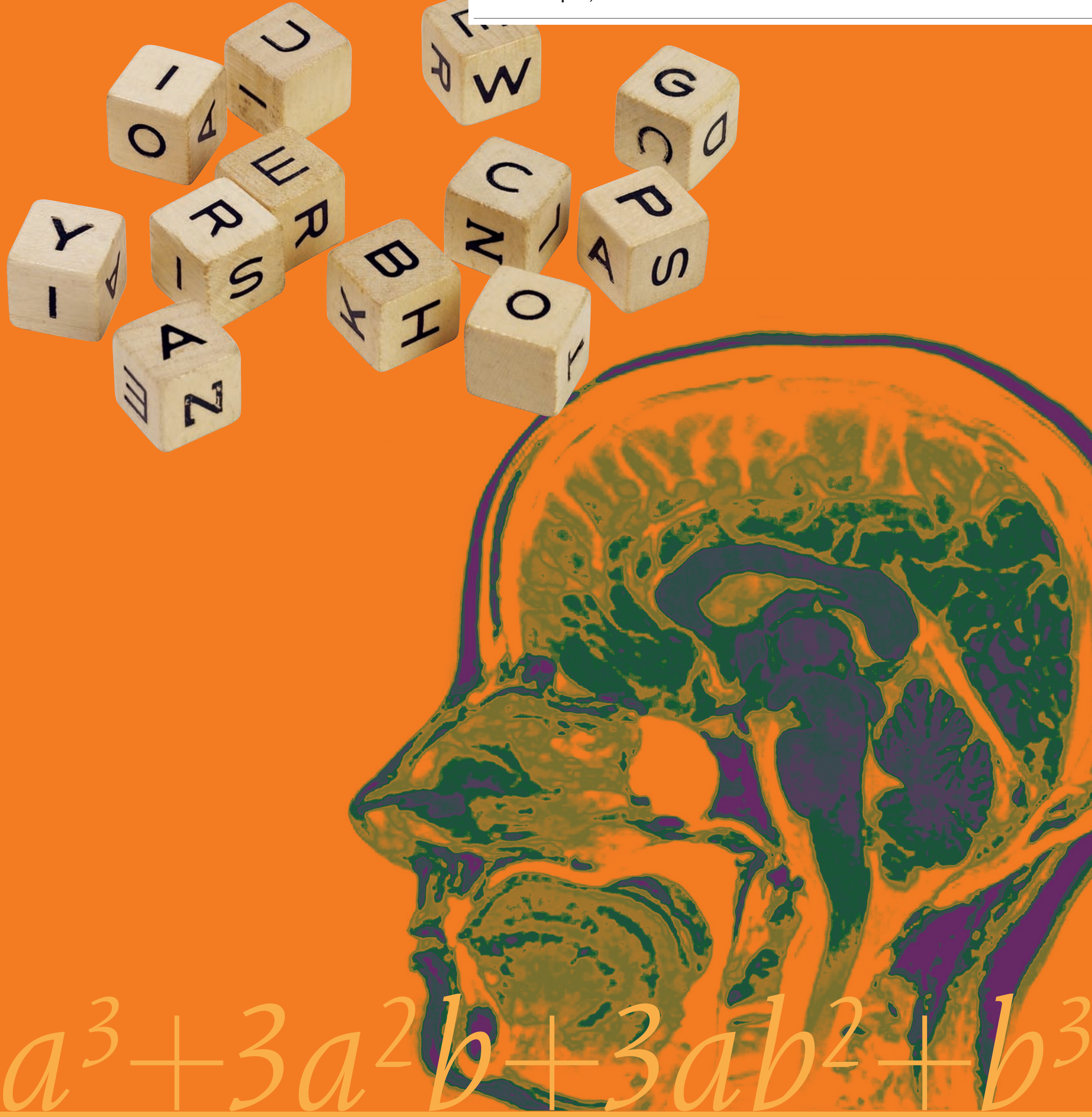
For example, significant progress has been made in advancing our understanding of the 'reading brain'. Studies have shown that there exists a set of brain regions that are activated when both children and adults read.[1] Some of these regions are particularly involved in phonological processing, while others appear to support the representation of orthographic information. In addition, it has been shown that children and adults with reading difficulties, such as developmental dyslexia, show atypical activation profiles of the brain regions known to be involved in normal reading. Most interesting is a recent set of studies showing that the aberrant brain activation profiles in individuals with dsylexia normalize following structured reading remediation programs.[2]

Thus we now know which brain regions are involved in reading, how differently they respond in individuals who have trouble reading, and that their response properties can be altered through systematic intervention. Reading is just one example of a learning process whose neural basis is becoming increasingly well understood. Significant progress has also been made in the fields of mathematics learning, memory, language development, and music, among others.[3]

At the same time as we gain more insights into the neuroarchitecture supporting various domains of learning, studies are also revealing how learning changes both the function and the structure of the brain. For example, studies have shown that learning how to juggle leads to changes in the structure of brain regions that are typically associated with the processing of visual motion.[4] Moreover, once individuals stop juggling, the increased brain volumes decrease back towards their pre-learning size. Similar changes in brain structure have been observed among medical students before and after an intense period of studying for a major examination.[5] These studies demonstrate that the brain is changeable and adapts itself to the particular demands set by the individuals' environment.

These tantalizing findings have led to great enthusiasm for the possibility of connecting findings in neuroscience with education and widespread hope that new understandings about the workings of the brain can inform the way we

EN BREF Le nouveau domaine de la neuroscience cognitive donnera sans doute lieu à des avantages tangibles, tant dans les salles de classe qu'en recherche fondamentale, en favorisant des interactions fluides entre la recherche et la pratique. Les éducateurs devraient apprendre les éléments de base de la neuroscience lors de la formation des maîtres et devraient penser aux processus neurobiologiques qui restreignent l'acquisition de compétences pertinentes sur le plan éducatif. Par ailleurs, les chercheurs qui étudient les processus neurologiques devraient acquérir plus de connaissances sur l'éducation, les contraintes d'une salle de classe et les questions pédagogiques. Nous devons penser au-delà des simples liens laboratoire-classe et constituer une nouvelle discipline « esprit-cerveau-éducation » regroupant des scientifiques, des éducateurs et des décideurs.



teach and structure our educational environments. Since each formed memory leads to biochemical changes in the brain, teaching is a process of altering the function and structure of the brain. In view of this, it is somewhat puzzling that until recently there have been few attempts to connect education and neuroscience. One such attempt has been the creation of the International Society for Mind, Brain and Education (http://www.imbes.org/), with a peer-reviewed journal and a series of publications.

Although attempts to connect neuroscience and education have been scarce, there has recently been a wave of enthusiasm for making greater links between learning sciences (including neuroscience, psychology, anthropology and computer science) and education. If we can harness this enthusiasm, it promises to improve the education of children and adults alike. At the same time, we must exert caution and think carefully about how to proceed in order to avoid turning the role of neuroscience in education into just another 'educational fad'.

HOW SHOULD NEUROSCIENCE AND EDUCATION INTERACT?

Recent literature on the relevance of neuroscience for education frequently implies that, since the brain is the organ of learning, scientific research on the brain should lead to direct application in the classroom. In other words, if you know how the brain acquires a particular body of knowledge, this should empower you to deduce teaching methods that would facilitate the appropriate learning process. This hope for silver bullets, for quick and easy educational solutions and direct applications of research for practice, is shortsighted. A long history of applied research shows us that the path from research to application is never straightforward and often very indirect indeed.[6]

While educators are often disappointed that results from neuroscience research are unlikely to lead to direct and straightforward applications, no such direct application of basic research exists in other fields. Take medicine and health care, for example. Although basic research is crucial, it exerts its effects only indirectly through the design of tools or pharmaceuticals and by means of educating practitioners. Furthermore, in modern medicine, research and practice interact dynamically with one another – an interaction that leads to tangible and bi-directional benefits. Doctors' observations can spur on new research, the results of which can, in turn, change their practice. In many university hospitals, medical doctors are both practitioners and researchers.

Scientific information is empowering. Few would argue that medical doctors' knowledge about genetics and molecular biology directly informs their everyday practice, but no one would question their need to understand them. Similarly, while teachers who know about brain structure and function will not be able to use this knowledge as a recipe for their next lesson, it will enable them to interpret children's behaviours, their strengths and weaknesses, from a scientific point of view, and this will in turn influence their pedagogy.

It is my contention that fluid interactions between research and practice are as needed in education as they are in medicine. Educators should become literate in basic neuroscience during teacher training and should think about the neurobiological processes that constrain the development of educationally relevant skills. This does not apply only to neuroscience; teachers need more exposure to up-to-date research in all the learning sciences.

At the same time, those researchers who investigate educationally relevant brain processes (such as the learning of mathematics or the role of sleep in consolidating memories) should become more familiar with education, the constraints of the classroom, and pedagogical issues. This would encourage the generation of common questions and a shared language, thereby facilitating a mutually beneficial information exchange and generating new scientist-practitioners. Indeed, literacy in basic research methodology encourages teachers to conduct action research, which is now actively supported by Ministries of Education across the country. If they want to play an important role in shaping the emerging field of 'Mind, Brain and Education', educators cannot be simply passive recipients of knowledge; they must be active participants in knowledge generation and application.

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PRACTICAL IMPLICATIONS

Of course, for the above to become reality, many changes will have to take place.

First, education faculties will need to lessen their aversion to scientific research. Educators have often been resistant to the influence of empirical, quantitative research.[7] However, the study of children's learning and development is a multidisciplinary research enterprise that is growing and actively supported by governments worldwide. It seems unwise not to think about the ways in which the cutting edge science of learning (which includes neuroscience) could exert its effects on education. We owe it to our children to find the best ways to teach and to systematically compare educational approaches, rather than simply going with what seems to work.

I have often been told that, since teachers need to learn how to teach and to learn pedagogical approaches specific to their content areas, it is not feasible for teacher education programs to include more instructional components that help teachers understand the development of the brain and mind. Yet, would it not make sense for educators to know more about the workings of the organ that supports their students' learning? Would this not facilitate their understanding and guard them against preconceptions and scientifically unfounded assumptions about the brain and learning?

It is also frequently put to me that there is not enough time to include neuroscience in the teacher preservice curriculum. If such instruction can improve teaching, then the additional time should be invested.

Neuroscience training also needs to change. Undergraduate and graduate students should be encouraged to think about links between basic science and its application. Many scientists resist thinking about application. For example, Educational and Applied Psychology sometimes get a bad reputation among academics for being soft sciences. This is just as unhelpful as the rejection of scientific research in education settings. It creates artificial boundaries and a hierarchical system that leads to a growing gap between research on learning and research on instruction.

Eventually, it is funding agencies that can make a difference here. While continuing to fund basic science, such agencies should also encourage greater attention to potential for application and the creation of multidisciplinary research involving both educators and neuroscientists. Such teams would give students exposure to a multitude of perspectives, which would inform their future research and teaching careers.

COMMERCIALIZING BRAIN RESEARCH

There now exists a growing industry that is aggressively marketing what might be labelled 'brain-based learning'. Many books published for teachers and parents claim to espouse teaching approaches based on neuroscientific research. Furthermore, conferences designed for teachers (with steep registration fees) promote 'brain-friendly' teaching strategies. These books and conferences (with a few exceptions, of course) tend to oversimplify and misrepresent neuroscientific findings and often proliferate 'neuromyths' – apparent 'facts' about the human brain for which there is no scientific support. For example it is frequently claimed that some learners are more 'right-brained' while others preferentially learn with their left hemisphere. This position has led to the proposal that instruction needs to be differentiated depending on what hemisphere students are using. I have heard from many teachers that they are being encouraged to do certain exercises to stimulate one of the two hemispheres (so-called 'brain gyms'). While it is undoubtedly true that the two hemispheres differ in their functions, there is no evidence to support the claim that some individuals use their right hemisphere more than their left or the other way around. In fact, functional neuroimaging research shows that both hemispheres are involved in most processes and that there is constant communication between the left and right halves of the brain via a thick bundle of white matter called the corpus callosum.

This is just one example of the gross oversimplification and misrepresentation of neuroscience that educators are being exposed to. Another example is the notion of so-called 'learning styles' tied to sensory modalities of the brain. Again, there is no evidence that people can be classified as auditory, visual or kinesthetic learners. These simplistic concepts are appealing, yet fundamentally inaccurate. If, as I propose above, educators received greater training in basic neuroscience, they could evaluate such texts and thereby stop the proliferation of 'neuromyths'.

In this context it should be noted that accurate and reliable resources about cutting edge neuroscience are available without having to trawl through the scientific jargon that is commonplace in many journal articles. Such texts refrain from making seemingly straightforward leaps from brain science to particular pedagogical methods or exercises and instead aim to help teachers become more 'brain literate'.[8]

Another recent troubling development is the growing availability of commercial software packages that purport to be effective in remediating learning difficulties. Often these programs claim to be grounded in neuroscience, and their developers use a few select studies – cited in glossy catalogues – to promote these products to educational psychologists, school districts and school boards. While some of these programs may indeed have led to desired effects and thereby improved students' lives and scholastic achievement, the fact that they are 'for profit' often precludes a systematic comparison to other programs. Often companies request that the results from the intervention programs be sent back to them, and they claim the right to withhold publication of research studies that evaluate such intervention tools. Other programs are available in the public domain without any associated costs or rules set by their producers.[9] Programs released in this way allow for systematic, unbiased assessment and evaluations of efficacy.

Greater training in neuroscience, research methodology, and evaluation of intervention programs would both help educators become critical evaluators and users of such software packages and put pressure on the designers and producers of these tools to increase transparency and allow for better evaluation of their programs.

CONCLUSION

These are exiting times for the prospect of a new science of education. Advances in the understanding of how the human brain learns and develops are transforming our view of the developing child. In light of this, there is currently great hope that this knowledge explosion may have a positive impact on education. The relationship between education and the learning sciences (neuroscience, cognitive psychology, anthropology, computer science) is most likely to lead to tangible benefits by, on the one hand, providing learning scientists with more insights into the classroom and, on the other, enabling educators to be exposed to research results, their limitations and their implications. These mutual benefits will result in more scientist-practitioners, enable educators to become careful consumers of the literature and products they are being exposed to, and help them to form a scientifically-based view of the developing child.

We need to think beyond simple laboratory-to-classroom links and consider a new discipline of 'Mind, Brain and Education' that brings together scientists, educators and policy makers. Such a transdisciplinary field will most certainly benefit the education of both children and adults. It is up to policy makers, funding agencies and university faculties to create the environments for this field to grow.

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Notes

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