THE DEVELOPMENT OF MEMORY: IMPLICATIONS FOR LEARNING AND EDUCATION

Pieter Rossouw

School of Psychology, School of Nursing, Midwifery and Social Work
The University of Queensland
p.rossouw@uq.edu.au

Crisis in Western Education

On 25 October 2014, the *China Daily* ran an in-depth article "Homework seen as damaging to pupils in early years" ("Homework Seen", 2014) in which researchers discussed why teachers should avoid giving homework to students until the last years of primary school. One of my focuses in this discussion is on how relationships between children and parents are compromised as a result of the change in roles when parents become co-teachers, as well as the lack of effective socializing.

On 29 November 2014, the popular Australian newspaper, *The Weekend Australian,* ran a series of in-depth articles on education, leading with the front page article "Writing's on the wall: Kids failing basic literacy" (Ferrari, 2014) followed by "National curriculum railroaded by utilitarian bias" (Donnelly, 2014). The front-page article had a focus on the drop in literacy rates and the mechanics of grammar and writing, while the second focused more on the need for contextual learning.

On face value these three articles have little in common except an indication that something is not well in the domain of schooling—that learning is suffering. The article in the *China Daily* suggested that learning should be the domain of teachers, and that learning is compromised when it is enforced outside of the school domain, where it becomes too much too young. This is a very interesting concept with significant implications. The front-page article in *The Weekend Australian* indicated a problem in technique, with an education expert pointing toward a narrative approach to learning, and the second article pointed to a lack of cultural sensitivity and showed how this compromises learning. All three articles addressed some important issues that may be unrelated—or are they the proverbial tip of the iceberg?

These articles should also be linked to the 5th Programme for International Student Assessment report (PISA 2012) by the Organisation for Economic Co-operation and Development (OECD) and key findings (OECD, 2014). The report is based on results from 510,000 students in 65 countries, aged between 15.3 and 16.2 years, representing 28 million 15-year-olds globally and 80% of the world economy. Demographic information was collected via questionnaires to students and their school principals regarding the student's background, the school, the learning environment, and school systems. The results are not good news for most western countries (like Australia and the USA, for example), where students are found to be slipping further behind in global rankings (Rossouw, 2014). Some of the findings are:

- Shanghai-China had the highest scores in mathematics, with a mean score of 613 points. That is 119 points, or the equivalent of nearly three years of schooling, above the OECD average. Singapore, Hong Kong-China, Chinese Taipei, Korea, Macao-China, Japan, Liechten-

stein, Switzerland, and the Netherlands, in descending order of their scores, rounded out the top 10 performers in mathematics.

- Of the 64 countries and economies with trend data between 2003 and 2012, twenty-five had improved in mathematics performance.
- On average across OECD countries, 13% of students are top performers in mathematics (Level 5 or 6). At these levels, students can develop and work with models for complex situations, and they can work strategically using broad, well developed thinking and reasoning skills. The partner economy Shanghai-China has the largest proportion of students performing at Level 5 or 6 (55%), followed by Singapore (40%), Chinese Taipei (37%), and Hong Kong (34%). At the same time, 23% of students in OECD countries and 32% of students in all participating countries and economies did not reach the baseline Level 2 in the PISA mathematics assessment. At this level, students should be able to extract relevant information from a single source and use basic algorithms, formulae, procedures, and conventions to solve problems involving whole numbers.
- Between 2003 and 2012, Italy, Poland, and Portugal increased their share of top performers and simultaneously reduced their share of low performers in mathematics.
- Boys performed better than girls in mathematics in 38 of the 65 countries and economies that participated in PISA 2012, and girls outperformed boys in five countries.
- Shanghai-China, Hong Kong-China, Singapore, Japan, and Korea were the five highest-performing countries and economies in reading in PISA 2012.
- Of the 64 countries and economies with comparable data throughout their participation in PISA, 32 improved their reading performance.
- On average across OECD countries, 8% of students are top performers in reading (Level 5 or 6). These students can handle texts that are unfamiliar in either form or content and can conduct fine-grained analyses of texts. Shanghai-China has the largest proportion of top performers (25%) among all participating countries and economies. More than 15% of students in Hong Kong, Japan, and Singapore are top performers in reading, as are more than 10% of students in Australia, Belgium, Canada, Finland, France, Ireland, Korea, Liechtenstein, New Zealand, Norway, Poland, and Chinese Taipei.
- Between the 2000 and 2012 PISA assessments, Albania, Israel, and Poland increased their share of top performers and simultaneously reduced their share of low performers in reading.
- Between 2000 and 2012 the gender gap in reading performance (favouring girls) widened in 11 countries.
- Shanghai-China, Hong Kong-China, Singapore, Japan, and Finland were the top five performers in science in PISA 2012.
- Between 2006 and 2012, Italy, Poland, and Qatar, and between 2009 and 2012, Estonia, Israel, and Singapore increased their share of top performers and simultaneously reduced their share of low performers in science.
- Across OECD countries, 8% of students were top performers in science (Level 5 or 6). These students can identify, explain, and apply scientific knowledge, and knowledge about science, in a variety of complex life situations. (OECD, 2014; Rossouw, 2014).

Reaction and Solutions

The reaction to the report and solutions offered are also of interest. Notably, all western countries responded with a similar outcry—that the drop in performance was due to funding cuts, and therefore more funds were needed, both to get more effective and highly trained teachers in the early education system and to have more high quality facilities available to more students. Almost no focus was placed on understanding the neuroscience of development, memory, and learning—that neural development provides a fundamental basis of education, not just for more effective learning (doing it better) but for doing it right.

Memory and Learning

To understand education at its core is to understand the neuroscience of memory. Since Eric Kandel demonstrated the neuromolecular pathways of memory (Kandel, 1998, 2005; Kandel, Schwartz, Jessell, Siegelbaum, & Hudspeth, 2013) it has become clear that memory formation is not a mere pro-

cess of repetition and/or conditioning. In its essence, memory is synaptic connection: When synapses are formed, memory is established; when synaptic connections change, memory changes. As Joseph LeDoux showed, we are our synapses (LeDoux, 2005). Who we are and what defines us are the multitude of neural connections and the intricate interactions between these connections. The complexity of these connections (where increasing complexity equates to cognitive reserve) points toward high levels of capacity, and lesser connectivity points toward lower levels of capacity. And there is more: Neural activation is also reliant on effective neural highways and effective neural pruning. Ineffective neural pruning leads to chaotic (albeit complex) communication—a typical example is the autistic brain where neural communication is complex but due to ineffective neural pruning is not well structured.

However, there is more to add before we can consider aspects of the solution for more effective education. This is an aspect mostly forgotten when education is discussed.

Education and Neural Development

The concepts of development and education are closely aligned in modern education theory—the developmental stages of giants like Jean Piaget appear in almost every text on childhood development and education. And yet, while the development of the brain is well described in every neuroscience textbook on paediatrics and developmental neuroscience, what is of interest is how little attention is paid to the development of the brain—or the significant implications of neural development for memory formation—in discussions about effective education.

Some of the key aspects that need to be investigated to maximize learning from a brain-based perspective are

- an overview of brain development with specific links to memory formation and learning;
- the function of primitive survival memories and learning (fear-based learning);
- emotional wellbeing and basic needs and implications to memory formation;
- the development of higher order memory systems that define the development of self;
- memories of self in relation to others—the neuroscience of relationships; and
- education and learning as needs-based activity.

A Brave New Education System

To maximise learning through the development of strong, healthy neural networks, well aligned on social levels, is one of the cornerstones of a well developing society. Neuroscience should play a pivotal role in this endeavour.

References

Donnelly, J. (2014, November 29). National curriculum railroaded by utilitarian bias. *The Weekend Australian*. Retrieved from http://www.theaustralian.com.au/national-affairs/opinion/national-curriculum-railroaded-by-utilitarian-bias/story-e6frgdox-1227138823814

Ferrari, J. (2014, November 29). Writing's on the wall: Kids failing basic literacy. *The Weekend Australian.* Retrieved from http://www.theaustralian.com.au/national-affairs/education/writings-on-the-wall-kids-failing-basic-literacy/story-fn59nlz9-1227138940282

Homework seen as damaging to pupils in early years (2014, October 25). *China Daily*. Retrieved from http://www.chinadaily.com.cn/hkedition/2015-02/26/hk.html Kandel, E. R. (1998). A new intellectual framework for psychiatry. *American Journal of Psychiatry, 155*, 457–469.

Kandel, E. R. (2005). *Psychiatry, psychoanalysis and the new biology of mind*. Washington, DC: American Psychiatric Publishing.

Kandel, E. R., Schwartz, J. H., Jessell, T. M., Siegelbaum, S. A., & Hudspeth, A. J. (Eds.) (2013). *Principles of neural science* (5th ed.). New York, NY: McGraw-Hill.

LeDoux, J. (2005). *Synaptic self: How our brains become who we are.* New York, NY: Penguin.

Organisation for Economic Co-operation and Development (2014). *PISA 2012 Results in focus. What 15-year-olds know and what they can do with what they know*. Retrieved from http://www.oecd.org/pisa/keyfindings/pisa-2012-results-overview.pdf

Rossouw, P. J. (2014, January/February). The social brain and education. *Neuropsychotherapy in Australia, 25*, 4–11. Retrieved from http://www.mediros.com.au/wp-content/uploads/2014/03/e-Journal-Neuropsychotherapy-in-Australia-Edition-25.pdf