

Grey matter matters

Teaching strategies for the brain compatible classroom

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The brain is extremely complex. The brain has the amazing ability to reshape and reorganise its neural networks, depending on increased or decreased use, making it malleable or 'plastic'. This plasticity allows for incredible changes to take place, which were once thought impossible. This article explores current research in this area and offers brain compatible strategies that teachers can employ in the classroom to make learning more efficient, to raise student achievement, and to facilitate a healthy learning environment.

Christians have long agreed with the Psalmist that humans are “so wonderfully complex” (Psalm 139:4 NLT), yet it is only comparatively recently that advances in neuroscience have allowed researchers to observe how complex the human brain actually is. The intricacies of the brain point to a super intelligence far and above ours, who with knowledge beyond human understanding, created us with astonishing brains. Brains that can love, feel, respond, reason, compute, remember and worship the One who created us. Does anything else compare with the complexity of the brain? Humanity was created in the image of God, and consequently possesses an intricate mind. We are creative, intelligent, able to think morally, and respond appropriately. We are “fearfully and wonderfully made” (Psalm 139:14 NIV).

How the brain works

The brain is made up of a complex 'wiring' system that involves hundreds of billions of nerve cells, called neurons. Neurons carry electrical signals through the brain, and to the rest of the body by 'firing' their own electrical signal to the next neuron. “Each neuron typically will make 1,000 to 50,000 connections with other neurons, and it is the development of these new connections that represents brain growth due to plasticity” (Trachtenberg et al., 2002, as cited in Willis, 2009, p. 2). According to MacDonald (2008), there are tens of trillions of connections between neurons. “It's for this reason that the human brain is sometimes described as the most complex object we've ever

discovered in our universe” (MacDonald, 2008, p. 18). When we remember that “God's intelligence is the basis of human intelligence” (Sire, 1977, p. 35), the complexity of the brain is not surprising.

The brain's ability to rewire

Our brain has been designed by a loving God, with the ability to change its own wiring to make it more efficient. Neuroplasticity is the word that describes the brain's ability to rewire and can be defined as the “genetically driven overproduction of synapses and the environmentally driven maintenance and pruning of synaptic connections” (Cicchetti and Curtis, 2006, as cited by Willis and Kappan, 2008, p. 4). The brain's plasticity allows it to reshape and reorganise networks, depending on increased or decreased use. This makes the brain malleable and able to change. “When unused memory circuits break down, the brain becomes more efficient as it no longer metabolically sustains the pruned cells” (Willis and Kappan, 2008, p. 4). When learning occurs, the structure of the brain itself is changed. Our brain is constantly learning how to learn, and is not just a vessel to be filled up as was once thought (Doidge, 2007). Several studies with language impaired children (Doidge, 2007) have demonstrated the plasticity of the brain, and its power to change itself. This suggests that God is a God of restoration. He designed bodies to heal and rejuvenate, imaging God's desire for sin damaged humans to be restored to a responsive loving relationship with Him.

Research and implications for classroom practice

As research unlocks more about the brain's operating system, educators can adjust classroom learning environments to be more brain compatible. This article chooses some salient points from research and suggests tested strategies to help provide a quality learning environment.

Rewiring the brain in the school setting

Technology can be used to train the brain so as to 'rewire' itself. Computer-based software has been developed that exercises brain function related to language. Other programs target cognitive thinking

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applications such as spatial working memory and visual attention through the use of computer games (see Table 1—*Fast ForWord* and *The Luminosity brain fitness program*).

Exercise

When it comes to the brain operating efficiently, exercise is an extremely important factor. Medina describes physical activity as “cognitive candy”. One study found that when physically inactive people engage in aerobic activities “all kinds of mental abilities begin to come back online” (Medina, 2008, p. 14). Nedley (2011) and Erlauer (2003), also report studies where the benefits of regular exercise include observable cognitive improvement in both adults and children. Some ways to incorporate exercise into the school day include:

- Increase daily physical activity, possibly a regular morning fitness program where, ideally, the whole school gets involved to increase motivation. This could be a running or skipping program, or any activities where the children are improving their cardio-vascular fitness. Thirty minutes of fitness activities just two or three times a week improves cognitive performance.
- Implement a “Run around Australia” program in which classes run laps of a set course. Laps are converted to kilometres, and a school wide map kept up to date with the combined number of kilometres run by the school. Celebrating milestones once certain cities have been reached can provide motivation, with a grand celebration upon completion.
- Provide students with pedometers to record how many steps they have made over the course of a day, with totals being tallied, and posted on a website.

- Schedule regular movement breaks throughout the day. Some schools opt for three half hour breaks instead of the traditional shorter recess and longer lunch period.
- Schedule movement breaks during lessons. Standing, stretching and moving help pump the blood around the body to deliver much needed oxygen to the brain.
- Provide children with equipment at playtimes to further develop fine and gross motor skills through play.
- Model an active lifestyle.
(See Table 1—*The Perceptual Motor Program*).

Sleep

The eyes may be shut but the brain is “displaying greater rhythmical activity during sleep, actually, than when it is wide awake” (Medina, 2008, p. 152). It is only during the non-REM stages of sleep, 20% of the sleep cycle, that the brain is consuming less energy than during a similar awake period. The rest of the time, the brain’s neurons are firing electrical commands to one another maintaining normal energy consumption rates.

Adequate sleep is vital for the brain to function effectively. One study clearly indicated that sleep significantly shortened the time taken to solve mathematical problems. “Sleep has been shown to enhance tasks that involve visual texture discrimination, motor adaptations, and motor sequencing” (Medina, 2008 p. 161). Conversely, a loss of sleep has adverse effects on attention, immediate and working memory, moods, reasoning skills and general mathematical knowledge (Medina, 2008). Sleep loss also diminishes the body’s ability to extract glucose from the bloodstream, resulting in a lack of energy, with the brain’s prefrontal cortex, which is responsible for executive functioning, suffering the most (Bronson and Merryman, 2009).

“The benefits of regular exercise include observable cognitive improvement in both adults and children”

Table 1: Programs contributing to enhanced brain function

Program	Purpose/comment	Web address
<i>Fast ForWord</i>	Operates as a kind of “cerebral cross-training” (Doidge, 2007, p. 70)	http://www.blcspeech.com.au/programs/fast_forword
<i>The Luminosity brain fitness program</i>	Based on cognitive research that shows the brain is malleable	http://www.lumosity.com/app/v4/personalization
<i>The Perceptual Motor Program (PMP)</i>	Develops children’s physical motor skills	http://www.movingsmart.co.nz/home/schools/pmp/
<i>Stop Think Do</i>	Children’s social skills training	http://www.stopthinkdo.com/

The executive functions include the organising of thoughts to fulfill a goal, predicting outcomes, and perceiving consequences of actions, all of which have implications for behaviour, and therefore learning.

It is interesting to note research by Dr Matthew Walker, as cited by Bronson and Merryman, (2009). Walker explains that during sleep, the brain shifts what it has learned that day, to more efficient storage areas in the brain. Each stage of sleep has a role to play in securing memories. Learning a foreign language, for example, requires learning new vocabulary, auditory memory of new sounds, and motor skills to enunciate the new word. The vocabulary is stored early in the night during slow wave sleep; motor skills are processed during stage 2 non-REM (rapid eye movement) sleep, and memories that are emotionally charged are processed during REM sleep. It is claimed that, “The more you learn during the day, the more you need to sleep at night” (Bronson and Merryman, 2009, p. 34). According to Walker, during sleep, certain genes appear to be activated, to reconsolidate memories. One of these genes is essential for synaptic plasticity, which is the strengthening of neural connections. Memories are enhanced and “concretised during the night, and new inferences and associations are drawn, leading to insights the next day” (Bronson and Merryman, 2009, p. 35). Willis (2006) cites Frank, Issa, & Stryker (2001) who note that, “This recognition of the need for sleep has led researchers to test and confirm their predictions that increasing sleep time from six or less to eight hours can increase memory and alertness up to 25 percent” (par. 135).

“*Increasing sleep time from six or less to eight hours can increase memory and alertness up to 25%*”

While sleep occurs outside of the school day, the following strategies may help highlight its importance to students and their parents:

- Educate parents as to the importance of sleep via school newsletters, handouts, parent information evenings or the school website.
- Encourage parents to set technology curfews for week nights.
- Construct class graphs of student bed times. Use a wiki page to record the number of hours of sleep that each student has, then graph the results. Parents could access the site and see progress, as could other classes. Incentives could be offered for the class with the most number of sleep hours per night or for reaching an ‘optimum target’.

Nutrition

Eating a healthy well-balanced diet provides the brain with valuable amino acids, which in turn provides the neurons with neurotransmitters. Omega-3 fats

provide the brain with an essential fatty acid that is required for memory. Studies of animals have shown that omega-3 fats influence the function of genes in the brain within the hippocampus (Innis, 2007), which controls learning, attentiveness, verbal and declarative memory. Omega-3 has also been shown to increase the production of transthyretin, which is vital for long-term brain health (Needly, 2011). Another essential brain-food is calpain (Erlauer, 2003, p. 42) which both cleans dendrites and synapses and keeps them working efficiently. Calpain can be sourced from green vegetables and dairy products (Jensen, cited by Erlauer, 2003).

There are also foods that have negative brain effects. Junk food and excessively refined foods inhibit optimal brain function (Richardson, 2006). Sugar-laden foods excessively consumed also hinder peak mental performance as the sugar high is followed by a nadir (Needly, 2011). As the brain is composed of a higher percentage of water than other organs, dehydration has a significant impact, usually resulting in lethargy. Further, when water levels decrease, salt levels increase, causing feelings of tenseness and stress (Erlauer, 2003).

While schools cannot mandate healthy eating, the following ideas may be useful:

- Educate the school community regarding brain healthy foods by using posters, handouts, newsletters, and class or school websites.
- Encourage parents to limit the use of junk foods and sugary drinks, and have the benefits of brain friendly foods explained to them.
- Share brain-food recipes with parents, through a student made recipe book that promotes healthy eating.
- Encourage students to eat a healthy breakfast.
- Allow fruit breaks for younger children.
- Allow water bottles in class.

Memory

It was once thought that the brain stored information like a computer system—filed away in a single location to be retrieved later. The brain works differently to this, however. Memories are distributed all over the surface of the cortex, and many regions of the brain are involved in representing a single input, each contributing something different to the memory. To facilitate ease of retrieval, re-exposure to information at regular intervals is important. Learning occurs best when new information is incorporated gradually into the memory store rather than when it is jammed in all at once” (Medina, 2008, p. 133). The environment can act as part of the original learning trace by make the encoding more elaborate, helping to aid retrieval. It is beneficial

for learning and retrieval to take place under the same conditions. Information is also more readily processed if it can be immediately associated with ideas already present in the learner's brain. Information being learnt needs to be interesting and relevant for the brain to remember it and not dismiss it. Choices are an important part of making learning relevant for students. "When some control and choices are provided for students, the content relevance is increased, their interest is heightened, stress is reduced, learning styles and ability levels are better accounted for, and both motivation and effort are enhanced" (Erlauer, 2003, p. 59). To facilitate memory, try some of the following:

- Teach shorter, more frequent lessons where material is reviewed to assist retention.
- Introduce class content gradually, then review at timed intervals.
- Remember that "Memory is not fixed at the moment of learning and repetition provides the fixative" (Medina, 2008, p. 146).
- Recap the previous lesson's content at the beginning of the lesson, and recap throughout the lesson to highlight the main points to strengthen the neural connections that are being formed.
- Allow reflection time after learning new concepts.

Attention

The brain needs to be paying attention before it can learn. "The more attention the brain pays to a given stimulus, the more elaborately the information will be encoded-retained" (Medina, 2008, p. 74). Emotions capture our attention, and play a key part in helping the brain to make memories. The hippocampus is responsible for deciding whether information in the short term memory should be converted to memories in the long term memory—to be stored by the cortex. When emotional responses are evoked, hormones and proteins are released and settle around the synapses, strengthening the connections. As learning occurs, new connections are strengthened. "For students, this means emotionally important content learnt in school is very likely to be permanently remembered." (Erlauer, 2003, p. 13). "Emotionally charged events persist much longer in our memories and are recalled with greater accuracy than neutral memories" (Medina, 2008, p. 80). When the brain detects an emotionally charged event, the amygdala releases dopamine, which aids memory processing. According to Medina, this is like the brain putting a "post-it note" on the event, which reads—"remember this".

Brains are incapable of processing more than one attention rich input at a time. The brain must jump from one task to the next, and focus on one task at a time. Each switch is sequential. People who are good at multi-tasking, have a good working memory, and are good at paying attention to several inputs, but only ever one at a time. "Studies show that a person who is interrupted takes 50% longer to accomplish a task. Not only that, he or she makes up to 50% more errors" (Medina, 2008, p. 87).

To be able to pay attention, the brain needs breaks or reflection time. Thinking or talking about an event also enhances the memory of that event. A final point worth noting is that the brain will not absorb information unless it perceives it to be meaningful and relevant. Some implications of these findings for the classroom are as follows:

- Evoke students' emotions when appropriate.
- Construct learning sequences that pique curiosity, provide big picture connection and relevance, employ memorable narrative, engage students, arouse emotions and allow reflection. An example of this style of teaching can be found in Cobbin's (2011) *Transformational Planning Framework*, utilised in the *Encounter Adventist Curriculum* (Adventist Schools Australia, 2010).
- Allow some choice in process and presentation of material. "Providing choice for student learning provides an increase in motivation for learning. The brain's cortex is more fully functional" (Caine & Caine, 1994, as cited by Erlauer, 2003, p. 59).
- Cater for a variety of learning styles, including those informed by Gardner's Multiple Intelligences (Gardner, 1993).

Sensory impacts

The senses are wired to work together. It is the thalamus which serves as the central distribution centre for most of our senses. The more visual an input is, the more likely it is to be recognised and recalled. Vision is the most superior sense. If you hear a piece of information, three days later you'll remember 10% of it. If you add a picture, you'll remember 65% (Medina, 2011). Eighty per cent of all information absorbed by the brain is visual in nature. Colour also has a powerful effect on the brain. In one study students increased IQ test scores by an average of 12 points when testing occurred in a room with a low painted ceiling of light blue, yellow, yellow-green, or orange. Conversely, those placed in rooms painted white, black or brown, made lower scores when given new IQ tests (Wilmes, Harrington, Kohler-Evans, Sumpter, 2008).

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Smell has an unusual ability to evoke memories, especially emotional memories. In some smell-exposed experimental groups, it was found that smell increased an individual's ability to recall memories by between 10–50% (Medina, 2008). Smell bypasses the thalamus and goes directly to the brain, whereas all other sensory information travels to the thalamus before being redirected to the rest of the brain. Smell stimulates the amygdala, which directs emotions. Smell also plays a part in decision-making, because smell signals also travel to the orbitofrontal cortex, which is involved in decision-making.

Our sense of hearing is also important to learning beyond direct instruction. Some studies have shown a significant improvement in reading comprehension when background music is played. Music can also be used to commit facts to memory since the words of songs are easily remembered. “Music appeals to the emotional, cognitive, and psychomotor elements of the brain, and several studies show a link between music and increased learning” (Wilmes, Harrington, Kohler-Evans, Sumpter, 2008, p. 3). Music can be utilised to create a relaxing atmosphere, adding an element of fun, or providing inspiration. Musicians have been found to have a larger planum temporale, which is the region of the brain associated with reading skills. It was also found that musicians had a thicker corpus callosum; the nerve fibres that connect the two halves of the brain (Nedley, 2011). What follows are some ideas for a multi-sensory classroom:

- Include multi-sensory experiences wherever possible. This could include excursions to evoke vivid memories years later.
- Link colour to new information wherever possible, to help the brain recall information.
- Use natural lighting, or soft, full spectrum lighting in classrooms rather than fluorescent lighting.
- Make use of aroma in the classroom. Wilmes, Harrington, Kohler-Evans & Sumpter, (2008), report that the use of smell can be harnessed to evoke memories. Certain aromas have been linked to increased performance. Peppermint and lemon scents can energise. “One study showed that groups exposed to the aroma of peppermint were able to solve puzzles 30% faster than the unexposed control group” (Wilmes, Harrington, Kohler-Evans, Sumpter, 2008, p. 4). Vanilla, chamomile and pine have been found to create a relaxing atmosphere before tests.

- Harness the power of music in the classroom to reap benefits for learning. Playing classical music softly in the background at work times could provide improved cognitive ability. Encouraging students to learn an instrument would also be cognitively beneficial. Music can also add interest to lessons.

Stress

One study showed that adults who were under chronic stress performed 50% worse on certain cognitive tests than adults with low stress. Stress hurts declarative memory and executive functioning, and these skills are needed to excel at school. “In almost every way it can be tested, chronic stress hurts our ability to learn” (Medina, 2008, p. 178).

When the body is under stress, adrenalin is released. Cortisol, which is released to cancel the effects of adrenalin, renders the cells in the hippocampus more vulnerable to other stressors. Cortisol can disconnect neural networks and can stop the brain from making new neurons. Under extreme conditions, cortisol can kill brain cells among the hippocampal cells. “Though the evidence is not as conclusive, a growing body of data suggests that children living in hostile environments are at greater risk for certain psychiatric disorders, such as depression and anxiety disorders. Such disorders can wreak havoc on cognitive processes important to successful academic performance” (Medina, 2008, p. 185). Some suggestions to minimise stress are:

- Provide a learning environment that provides high challenge yet low threat.
 - Encourage the use of diaries to support memory and to learn time management
 - Minimise school generated stress with positive student welfare programs that deal with issues such as cyber-bullying.
 - Be aware of when students may need to speak to a school chaplain or school counselor and facilitate the process.
- (See Table 1—*Stop Think Do*).

The brain, designed by a loving creator God, is an extremely intricate organ. Research is only beginning to understand its true complexity. Neuroscience has educational implications, since brains are malleable and have the amazing ability to rewire, to heal and restore. There are many ways teachers can make classrooms and teaching practice brain compatible. By understanding how brains learn best, teachers can implement best practice in the classroom to impact learning in the most significant way. **TEACH**

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