A PEDAGOGICAL DECALOGUE: DISCERNING THE PRACTICAL IMPLICATIONS OF BRAIN-BASED LEARNING RESEARCH ON PEDAGOGICAL PRACTICE IN CATHOLIC SCHOOLS

DAN WHITE

Executive Director of Catholic Schools, Archdiocese of Sydney

Dr Dan White is currently the Executive Director of Catholic Schools for the Archdiocese of Sydney. Before his appointment, Dr White was the Director of Catholic Education for the Archdiocese of Hobart for six years. He previously served in senior leadership roles in the dioceses of Parramatta and Bathurst.

Academically, Dr White completed his Bachelor of Arts and Diploma of Education at Macquarie University, followed by a postgraduate diploma of religious studies and two masters degrees in leadership and religious education. He concluded a doctoral program with the Australian Catholic University in 2005.

Dr White's research interests have included investigations into brain-based learning theory and its practical implications for classroom pedagogy, especially in the field of religious education. Dr White is the co-author of seven educational resource books focusing particularly on higher order learning and thinking strategies.

Dr White is a member of the Australian College of Education and the Australian Council of Educational Leaders. Dr White is currently the Executive Officer of the Sydney Archdiocesan Catholic Schools (SACS) Board and represents Sydney on the New South Wales Catholic Education Commission. In 2010 he was appointed to the New South Wales Board of Studies. Dr White is also a member of the Board of Governors for the University of Notre Dame, and a member of the New South Wales Chapter and Senate of the Australian Catholic University.

ABSTRACT

In an era where professional standards and the quality of the teaching profession are increasingly being brought into the public spotlight, it behoves educational leaders and policy makers to carefully analyse research from a number of interrelated disciplines to discern more precisely what 'effective teaching' actually looks like within a classroom setting.

Many teachers have a very eclectic approach to pedagogy and, by and large, their pedagogical processes are based on intuitive judgements and the wisdom of experience. While in no way devaluing the experience of teachers, research indicates that teachers have a tendency to emphasise the overt and pragmatic aspects of the pedagogical process – such as capturing the attention of students – over other more subtle, but equally important, dimensions of learning that include personalising learning and having students construct their own insights and meaning.

The purpose of this paper is to explore a 'decalogue' of insights generated by research into brain-based learning theory, and discern their practical implications for pedagogical practice in the classroom. In particular, the paper will highlight how brain-based research has helped to inform and shape the development of the 'DEEP' pedagogical framework that has positively influenced classroom practice in Catholic schools in Tasmania and Sydney.

INTRODUCTION

Over recent decades, advances in neurological science have intrigued and inspired educators in their perpetual quest to enhance the learning outcomes of their students. Brain-based learning involves drawing insights and connections from the field of neurological research and applying them to an educational context. The emerging learning theory attempts to conceptualise and integrate 'traditional' understandings of learning, arising from psychology and sociology, with 'new' insights emerging from neurological research (Jensen, 2005; Sousa, 2006; Wolfe, 2010). In essence, brain-based education involves 'designing and orchestrating lifelike, enriching and appropriate experiences for learners' and ensuring that 'students process experience in such a way as to increase the extraction of meaning' (Caine & Caine, 1994, p. 8).

The focus on neurological research was brought to prominence most recently by President Barack Obama's announcement of an initiative to unlock the mysteries of the brain:

> *Now, as humans, we can identify galaxies light years away. We can study particles smaller than an atom, but we still haven't unlocked the mystery of the three pounds of matter that sits between our ears. (Obama, 2013)*

By pledging to devote over $100 million to a range of research projects, the President challenged neuroscientists to more comprehensively map the human brain so as to create pathways that may lead to 'the cure of diseases like Alzheimer's or autism'. While initially having a public health focus, the potential implication of this initiative for education is readily apparent.

In the past decade in Australia there has been a renewed community focus on the quality of educational outcomes. The performance of Australian students as gauged by international testing regimens suggests that, in relative terms, the Australian cohort has declined in performance levels relative to comparable OECD countries (Masters, 2012). Political leaders from both sides of the spectrum have emphasised the importance of strengthening curriculum expectations via the Australian Curriculum, and of enhancing teacher quality with special reference to Australian Institute for Teaching and School Leadership (AITSL) teaching standards as key components of a sustained school improvement process linked to the proposed Gonski (Commonwealth government) funding reforms. In essence, educational leaders are being challenged to carefully examine the pedagogical practice of classroom teachers with a view to delivering quantifiable and qualitative improvements to student learning outcomes.

The purpose of this paper is to explore and critically reflect upon a 'decalogue' of pedagogical insights gleaned from brain-based research by the author both as a researcher and teacher educator in Catholic schools in Australia over the past decade. The paper draws upon an iterative series of action research projects conducted in Tasmanian Catholic primary schools (White, 2005) and extensive dialogue and feedback from educators in association with presentation of workshops on the pedagogical resource books *Deep thinking* (White, White & O'Brien, 2006) and *Desert wisdom* (O'Brien & White, 2010).

LESSON ONE – 'THINK TIME': SO SIMPLE AND SO EFFECTIVE!

Tracking the evaluations of teachers from more than 100 professional learning workshops linking pedagogy and brain-based learning theory revealed an interesting recurring theme. While participants valued the scientific insights into the neurological functioning of the brain, the simple concept of 'think time' was one of their 'top three' pedagogical 'learnings' from the day. First introduced as 'wait time' by Rowe (1987) and further refined as 'think time' by Stahl (1994) the concept of think time resonated with the instinctive awareness of teachers who freely admitted they often overlooked the practice within the complexity of a teaching day.

From the perspective of brain-based learning principles, placing an emphasis on think time is compelling. Given (2000) noted that the main difficulty the brain experiences when thinking is confusion. In order to undertake neural encoding processes, people need opportunities for reflection in order for the brain to transfer learning and construct meaning. By slowing down and focusing the thought process, more effective learning takes place. Caine and Caine (1995) observed such learning does not just occur in fixed, structured time periods: rather, the brain needs 'actual' time to explore a point of view or master a specific skill. Reflective practice is crucial to the learning process: it allows the brain to make learning personal, purposeful, meaningful and relevant (Fogarty, 1998).

Hence the brain needs 'wait time' to think and make connections. Pattern-seeking processes strive to make sense out of chaos. Pedagogically it is important to give the brain some down-time in order to play around with the information, which is essential to detect patterns. Ben-Hur (1998) asserted that the average teacher only pauses for two to three seconds after asking a question before seeking a response. If no answer is forthcoming, teachers reframe the question at a lower level of intellectual functioning. Recent research by Holt (2012) demonstrated that explicitly providing think time improved the reading comprehension levels of primary school students. Teachers need to be patient and allow wait time for answers, while students need to be encouraged to 'think aloud' without necessarily having the complete answer.

LESSON TWO – ENGAGEMENT: THE BRAIN DOESN'T ENGAGE WITHOUT A PROBLEM TO SOLVE!

A major, though unsurprising, research finding from an investigation into the pedagogical practice of primary school teachers in Tasmania (White, 2005) was the overwhelming desire of teachers to use strategies that would maximise the engagement of their students. In identifying the criteria that would underpin a high-quality 'thinking strategy', teachers were twice as likely to nominate items specifically designed to foster student engagement (for example, problem based, relevance, non-threatening) in contrast to meaning making, differentiation or collaborative learning.

In essence, this simply validates the fundamental premise of a brain-based approach: the brain won't engage without have a real problem to solve. Jensen (1998) claimed the acquisition of knowledge is directly related to the formation of new synaptic connections. These connections are formed when the experiences are novel, challenging and coherent. Alternatively, he suggested, if the experiences are incoherent, it is possible that no learning will result.

The brain hasn't evolved by simply absorbing a whole array of disjointed data: it needs to process and make sense of the experiences it is encountering. As Walsh (2000) suggested, the brain requires the challenge of figuring out patterns and discerning meaning if real learning is to occur. Hence it is no surprise that inquiry-based pedagogies, supported by brain research, feature prominently in any contemporary approach to student learning.

LESSON THREE: THE LIMBIC SYSTEM: THE BRAIN'S CENTRE FOR 'SNAKES AND LADDERS'

An area of particular interest to many teachers in the workshop sessions was the role the limbic system performs in the learning process. From a pedagogical perspective, the articulation of simplified physiological models of the brain in a professional learning context helped educators to develop a rudimentary understanding of the role of emotion in brain functioning. The presentation of basic physiological models, such as MacLean's (1978) Triune Brain, that illustrate the three main evolutionary levels of the brain ('reptilian' brain stem, limbic, neocortex) was helpful in assisting teachers to appreciate that the initial reception point for most sensory data was the limbic system of the brain. Focus group discussions revealed teachers generally believed that effective learning (for example, data sifting, critical and lateral thinking, meaning making) occurred primarily within the cerebral cortex, without appreciating the crucial filtering role played by the initial receptor, the limbic system, which deals with emotion, form and sequence. As Goleman (1996) noted, the limbic area is the major 'gating' system that allows the brain to discern any perceived emotional threats before upshifting (the 'ladders') to any form of high-level thinking activity or downshifting (the 'snakes') to a 'fight or flight' survival response.

It was illustrated in the 2005 research project that most experienced teachers are aware of the positive impact emotional stimuli could have on learning, as well as how the personal emotional state of the learner could inhibit the learning experience. Brain-based learning theory both validates and explains this intuitive insight. For example, Given (2000) emphasised the capacity of the limbic system to produce serotonin and opioids: 'feel good' chemical and neurotransmitters. When the brain is in a state of relaxed alertness, these chemicals generate positive energy and orient the learner to constructive engagement. Alternatively, when confronted with emotional trauma, learning experiences beyond the proximal zone and negative feelings of self-worth, the chemical balance of the limbic system is altered and learning is inhibited.

Similarly Tomlinson and Kalbfleisch (1998) reported that emotional stress results in an overproduction of noradrenaline that leads the brain to focus attention on self-protection in preference to learning. Learners develop either a 'fight or flight' response resulting in misbehaviour or withdrawal from the learning context. Hence, a pedagogical response should acknowledge that tasks need to be structured in a manner that allows the more emotionally vulnerable students to be able to make a start, while allowing the more secure and capable learners the flexibility and freedom to pursue the upper limits of learning.

LESSON FOUR – DIFFERENTIATION: THE 'HOLY GRAIL' OF BRAIN-BASED LEARNING THEORY?

Since the original concept of a model of the bicameral brain (Sperry, 1968), a diverse range of progressively more sophisticated brain-based learning frameworks has emerged: for example, whole brain thinking (Herrmann, 1988); the visual, auditory, kinaesthetic (VAK) model (Ward & Daley, 1993); multiple intelligences (Gardner, 1999); integral learning (Atkin, 2000). Each model has endeavoured to incorporate insights from brain-based learning research and use it to assist educators to find the holy grail of education: the capacity to cater for the unique learning needs of every student in a complex and diverse classroom environment.

While various brain-based learning style theories have the potential to support differentiation, simplistic allegiance and an over-reliance on any one paradigm has exposed the inherent limitations of any theory that seeks to simplify the enormous complexity of the human brain. From the iterative dialogue across a range of professional workshops, it is apparent that a significant limitation of educational interventions based on learning or cognitive styles has been the inability of practitioners to accurately identify the individual learning preferences of students and precisely match instructional regimens to their learning needs. Similarly, the notion that focusing on individual students' preferred learning modality (for example, spatial intelligence, musical intelligence) is innately advantageous to learning, is at best questionable and at worst significantly curtails the learner's capacity to adapt to the learning demands that will confront them beyond the security of the classroom. A more holistic notion that learning is best accessed via one's cognitive preference and reinforced by challenging students to consolidate their learning through other modalities has emerged from the brain-based theory as an idea that is worthy of consideration. Similarly, helping teachers to realise that often they subconsciously structure their lesson strategies in a manner that reflects their personal thinking style, without appreciating that more than three-quarters of their class may benefit from accessing the content of the lesson by using alternative modalities of learning, has major implications for curriculum planning and pedagogical development (O'Brien & White, 2010).

LESSON FIVE – CRITICAL PERIODS: WINDOWS OF OPPORTUNITY OR A PSEUDOSCIENTIFIC FAD?

Another field of neurological research that has aroused the interest of educators in professional learning sessions surrounds the concept of 'Critical Periods'. Alferink and Farmer-Dougan (2010) reported that a prominent theme in the neurobiological research over the past 30 years has been investigations into neural sculpting and the critical periods of development for sensory, language and motor skills. Early researchers postulated that animals must have certain kinds of experience at specific times in order to fully develop particular skills. By applying this reasoning to an educational setting, it is theorised that a child's peak learning occurs just as the synapses are forming (Diamond, 1998; Wolfe & Brandt, 1998). The ability to adapt and reorganise relevant stimulation was seen as crucial. Peterson (2000) spoke of a 'sensitive period' for learning. He noted children between the ages of three and 12 are capable of developing an incredible vocabulary of upwards of 100 000 words, thereby suggesting children learn about 50 new words every day.

Adding to the theoretical base, Wolfe (2010) postulated there is a critical period of neural sculpting in children between six and 12 years of age – a 'state of developmental grace' – when children learn faster, more easily and with more meaning than at other times in their lives. She suggested the critical periods are 'windows of opportunity' when the brain 'demands' certain types of input to create and consolidate neural networks. Sousa (1995) agreed and also contended that, while later learning is possible, what is learned during the 'window period' significantly affects what may be efficiently learned after the window closes. Bruer (1998) observed critical periods exist for different specific functions. For example, the critical period for phonology (learning to speak without an accent) ends in early childhood, while the acquisition of grammatical functions does not end until 16 years of age. Other commentators (Diamond, 1998) have made similar links with the teaching of music, fine motor skills and the learning of a second language.

In light of the above research, teachers were interested in workshop sessions to debate the implications of critical periods, especially with respect to the potential benefits of teaching foreign languages in early years classrooms. At this stage it appears the jury is still out on the issue of critical periods. More recently Alferink and Farmer-Dougan (2010) have argued that while there is no doubt that significant changes occur in the brain during early childhood and that young children appear to learn quickly, there is little evidence to suggest that this period is the *most critical*. They suggested early learning is important because it sets the basis for later learning, not because the window of opportunity has closed. Furthermore they cited research that indicates the development of critical and analytical skills appears to have its own critical periods as the pruning of neurological connections become more prominent.

LESSON SIX – LESS IS BETTER: THE BRAIN NEEDS A REST!

Over recent years, educators across Australia have been engaged in a series of consultations on the Australian Curriculum. A recurring theme of the workshop sessions is the view that most of the draft curriculum documents are 'top heavy' in content with respect to suggested time allocations, thereby emphasising surface learning at the expense of deeper, inquiry-based conceptual experiences.

Insights from brain theory validate the professional judgements of educators. The brain has not evolved by simply absorbing a whole array of disjointed data; it needs time to process and make sense of the experiences it is encountering (Wolfe & Brandt, 1998). While the acquisition of knowledge is directly related to the formation of new synaptic connections, 99 per cent of all sensory information is discarded almost immediately upon entering the brain, many synaptic connections are often temporary and the brain only builds and maintains the pathways that are relevant to its ongoing 'survival' (Wolfe, 2010).

Effective pedagogy requires the brain to be focused on the information that is being accessed at any particular moment. Perry (2000) drew attention to the fact that the neural system fatigues relatively quickly. Three to five minutes of sustained activity will result in the neurons becoming less responsive. He contended that, when a neuronal pathway is stimulated in a continuous, sustained manner, it is not as efficient as when it is receiving patterned, repetitive stimuli over a series of intervals. Perry furthermore noted the recovery period for neurons is also relatively brief. Consequently, if, after a short period of time, the learning is directed down an alternative pathway, more effective learning will occur. It is the interrelationship between neural systems that is vital. Students are seen to learn more completely (that is, create meaning and memory) if they weave backwards and forwards between the neural systems. If the experiences are simply familiar or repetitive, existing individual connections may be strengthened without developing new interconnections across the neuronal network that would facilitate deeper learning and understanding.

Jensen (1998) highlighted the importance of variety in the acquisition process. When a student is in a familiar, emotionally safe environment, such as the classroom, the brain will seek 'novelty' after about four to eight minutes. If variety is not provided by the nature of the learning encounter, the brain will seek alternative stimuli elsewhere. While explicit instruction is vital for learning, an over-reliance on constantly holding a student's attention with direct input negates the fact that much learning comes from indirect acquisition, notably peer discussion, structured thinking activities and environmental stimuli. The brain 'needs a rest' from formal input and drill and practice activities. In a brain-compatible classroom, teachers should only engage the learner's direct attention for 20 to 40 per cent of the time (Jensen, 1998). Specific explicit instructional processes should only occur in short bursts, relative to the age of the learner. Learning sessions should incorporate instruction, processing, encoding and, most importantly, neural rest.

LESSON SEVEN – ELABORATION: DISTINGUISHING BETWEEN PRACTICE AND REHEARSAL

Another of the 'top three' learning insights that emerged from the professional learning workshops was the concept of 'elaboration'. In brain-based learning theory, elaboration plays a crucial role in the functional development of the brain and ultimately in retention and memory. It involves the process of sorting, shifting, analysing and testing data that deepens the learning experience by strengthening the contact between the new data and the knowledge already stored in the various systems of the brain. Elaboration is an interactive process that requires feedback from a multitude of sources, notably collaboration with the peer group, digital and social media, structured thinking activities, personal reflection and teacher reaction.

In terms of pedagogical practice, elaboration distinguishes between 'practice' and 'rehearsals' in developing synaptic connections (Lowery, 1998). Practice involves the repetition of the same conceptual item over and over again, such as learning the times tables. Rehearsal, on the other hand, involves building on and extending concepts by doing something similar but not in an identical manner (for example, applying the tables in problem-solving settings or expanding the difficulty level: 22 × 2). Rehearsals reinforce learning while adding something new. Hence, practice strengthens individual neuronal pathways, while rehearsals enable the brain to develop a series of branching, interrelated pathways.

Generating learning experiences that challenge students to elaborate upon a recent learning experience is vital for memory retention. Information is easier to remember if it can be explicitly linked to something already stored in the memory bank (Jones, 1996). Each record or 'memory trace' represents a pattern of connections amongst the brain cells that can be reactivated to recreate components of the experience. According to Lowery (1998), reactivation links material involved in the experience with other characteristics of the event. When learners place an image in their mind, they store its components in many different places (for example, shapes in one place, colour in another, scent in a third). Pathways are constructed between the different storage areas and are activated when the brain endeavours to recall an experience. Elaboration activities or rehearsals of learning are required to connect the differing storage areas together in order to reconstruct the memory when it is required at a future stage. Indeed, if a concept cannot be reconstructed it cannot be said to have been learned. In terms of pedagogy, students need frequent opportunities to explicitly reconstruct and elaborate upon their learning in contrast to simply reiterating the teacher's perception of the world.

LESSON EIGHT – DISCERNING MEANING: AN ENDANGERED SPECIES OF THE LEARNING PROCESS?

In contemporary Australia, where political rhetoric, comparative school report cards and international league tables can cloud, and in some cases dominate, the educational landscape, it is crucial that teachers are constantly reminded of the main game: education is fundamentally about learning to construct meaning in its deepest and fullest sense. With the growing emphasis on objective, measurable and electronically marked test results, there is a grave danger that the importance of discerning meaning, with all of its ambiguity and subjectivity, will become a lost art, an endangered species within modern educational paradigms.

A review of the brain-based literature makes it apparent that the dominant function of the brain is to discern meaning for each individual. Concepts such as patterning, elaboration, engagement and relevance are all crucial to the learning process. Research has identified a number of key notions surrounding the manner in which the brain functions. These reveal that the brain has not evolved by absorbing meaningless data; it needs opportunities to make sense out of what it encounters; it is essentially curious and must remain so in order to survive and to function effectively; and it seeks constantly to find connections between the new and the known. In essence, brain-based theory is premised upon the innate desire of each human being to search for meaning.

Yet notwithstanding the above, when teachers in Tasmania (White, 2005) were asked to identify the criteria that should underpin and guide their pedagogical practice, only 16 per cent of workshop responses suggested processes that would nurture meaning-making (for example, connected knowing, reflection, elaboration, critical and intuitive thinking). It was apparent that, in an outcomes-based learning environment with an increasing emphasis on external testing regimens, discerning meaning may have ultimately become an endangered species in the learning cycle.

Further there is also a real danger in the contemporary standards-based environment of teacher assessment that the importance of meaning making may be underestimated. If evaluative judgements focus on the explicitly observable dimensions of teacher performance – such as the capacity to engage students and differentiate for their learning needs – in contrast to identifying the more subtle but crucially important dimension of their craft, the discernment of meaning, then supervisors may inadvertently direct teacher attention away from the most crucial element of the learning process.

One significant by-product of an interest in brain-based learning theory has been the development of a number of pedagogical frameworks that have drawn heavily, while not exclusively, from the research. The action research project in Tasmania was designed to explicitly critique one such model, the DEEP Framework (White, O'Brien & Todd, 2003). After exposure to brain-based learning theory over a three-day workshop program and its incorporation within a pedagogical model, teachers were asked to use and critically evaluate a range of high-order thinking activities in their classrooms over a period of two terms. The increased awareness and importance of meaning-making experiences were reflected in more than 75 per cent of respondents citing criteria from the 'discernment' dimension of the framework as part of their reflections upon practice, in contrast to only 16 per cent at the commencement of the study. This demonstrates that, although endangered, the importance of meaning making in pedagogical practice can be brought back from the edge of extinction through the use of frameworks that focus teacher attention on the primary goals of the learning experience.

LESSON NINE – NEURAL PLASTICITY: THE LATEST FRONTIER

As the interest in brain-based learning principles has grown around Australia, individual schools and school systems have begun exploring the potential applications of the theory to the field of special education. The concept that has garnered the most attention with teachers involved in supporting children with specific learning difficulties has been that of neural plasticity. A review of the neurological literature before the mid-1990s (Wolfe & Brandt, 1998) tended to suggest that after the initial formation of major neurological pathways in the brain, especially those responsible for connecting the various processing centres, there was little possibility for reshaping brain function in the event of major trauma, environmental deprivation or substance abuse. The theorists contended that, after birth, no further significant neuronal cells are produced and damaged cells cannot be replaced.

Conventionally, brain-based research has highlighted three phases of neuronal development. Initially, genetic coding influences neuronal formation and induces the neurons to send out pathways. As the embryo and the infant become more active, the neurons begin sending electrochemical activity down the 'wires'. Through acquisition, elaboration and encoding a stage is reached when patterned (meaning-making) activity is needed to stimulate neuronal connections and to precisely 'hard wire' the brain's response to the environment (Peterson, 2000). It was argued that the brain had to be stimulated to continually use the synaptic connections that were generated during childhood (for example, foreign language acquisition), otherwise the natural synaptic pruning that occurred during adolescence and early adulthood would discard such pathways and inhibit future learning in the nominated domain. From an educational perspective the mantra that was often invoked was the 'use it or lose it' approach: that is to say, optimal long-term brain functioning was highly dependent on being appropriately stimulated and challenged, especially in the early years, and that a failure to do so would result in an irreversible decline in cognitive functioning ability.

From a pedagogical perspective, this underlying premise has been seriously questioned in recent years. The concept of neuroplasticity, the capacity of the brain to change its structure and chemistry in response to the environment, has been a major focus of research, particularly related to the field of special education. Wolfe (2010), citing studies with visually and hearing-impaired subjects, suggested the neuronal pathways designated for sight or hearing could potentially change their initial functions in order to assist the creation of alternative pathways for auditory or tactile neuronal activity. Recent case studies reported by Doidge (2010) and Arrowsmith-Young (2012) point to the educative potential of 'retraining' the brain through a series of systematic, sustained cognitive exercises.

While research with respect to the Arrowsmith model of brain transformation is still limited, and its methodology strongly contested in the broader neurological field, an Australian-based research and development pilot program has recently been commenced by the Catholic Education Office in Sydney. The project has been designed to ascertain whether a highly intensive, personalised program that explicitly endeavours to rewire neuronal pathways will provide longer term educational and sociological benefits to a target group (initially eleven Year 9 and 10 students) for whom conventional learning paradigms have proved to be inadequate. While being undoubtedly targeted at a specific cohort of students, it is anticipated that the value in exploring this emerging frontier of research may reap significant benefits into the future.

LESSON TEN – BRAIN-BASED LEARNING: A REFLECTION OF SHARED WISDOM

Brain-based learning research, while significant, should never naively suppose that it captures or explains the many nuances of high-quality pedagogy that educational researchers and experienced teachers have discerned over many centuries. While researchers (D'Arcangelo, 1998; Peterson, 2000) have highlighted the notion that a stimulating, interactive, problem-oriented classroom environment will foster the building and pruning of neuronal capacity – regarded as crucial factors in enhancing the brain's ability to learn – educators have instinctively known this for decades. Put simply, in many cases the field of brain-based research reinforces and affirms the shared wisdom of the teaching profession, in contrast to producing major research findings that point to the development of new or enhanced classroom pedagogies.

For example, many of the pedagogical principles of cooperative learning (Johnson & Johnson, 1989; Kagan, 1994), such as the importance of scaffolded learning experiences, the significance of modelling and joint construction, the creation of an appropriate culture for social interaction and the notions of pacing and neural recovery, have all been validated by ongoing brain research. Similarly many of the pedagogical models that have been 'stimulated' by brain-based research such as whole brain thinking (Herrmann, 1988) or multiple intelligences (Gardner, 1999) owe their development to theoretical constructs that have emerged from a rather simplistic modelling of brain functioning in contrast to a sophisticated in-depth understanding of how the brain functions in reality.

The lesson in essence for pedagogical practice is one of caution and common sense. Teaching practitioners need to trust in the shared wisdom of the profession that has evolved over many generations. Brain-based learning theorists have much to offer to the teaching profession but methodologies supposedly premised on neuroscience need to be carefully analysed and rigorously researched in real-life classroom environments before entering into the body of shared knowledge that characterises an authentic learning community.

CONCLUSION

Reflecting upon the 'Decalogue of Lessons' from brain-based learning theory that have emerged from both research and lived practice has exposed some hidden gems, affirmed what many would already recognise as high-quality practice and questioned the assertions of those educators who uncritically embrace populist theories based on only a rudimentary understanding of how the brain operates. As has been revealed by the concept of neural plasticity, the rapid advances in neurological research are liable to render our 'primitive' understandings of the brain as virtually worthless in the foreseeable future. Equally, if educators do not develop a functional understanding of the brain, not only will they miss out on many useful (though not necessarily earth-shattering) pedagogical insights, they will be even more vulnerable to 'pseudoscientific fads, inappropriate generalisations and dubious programs' (Wolfe & Brandt, 1998).

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