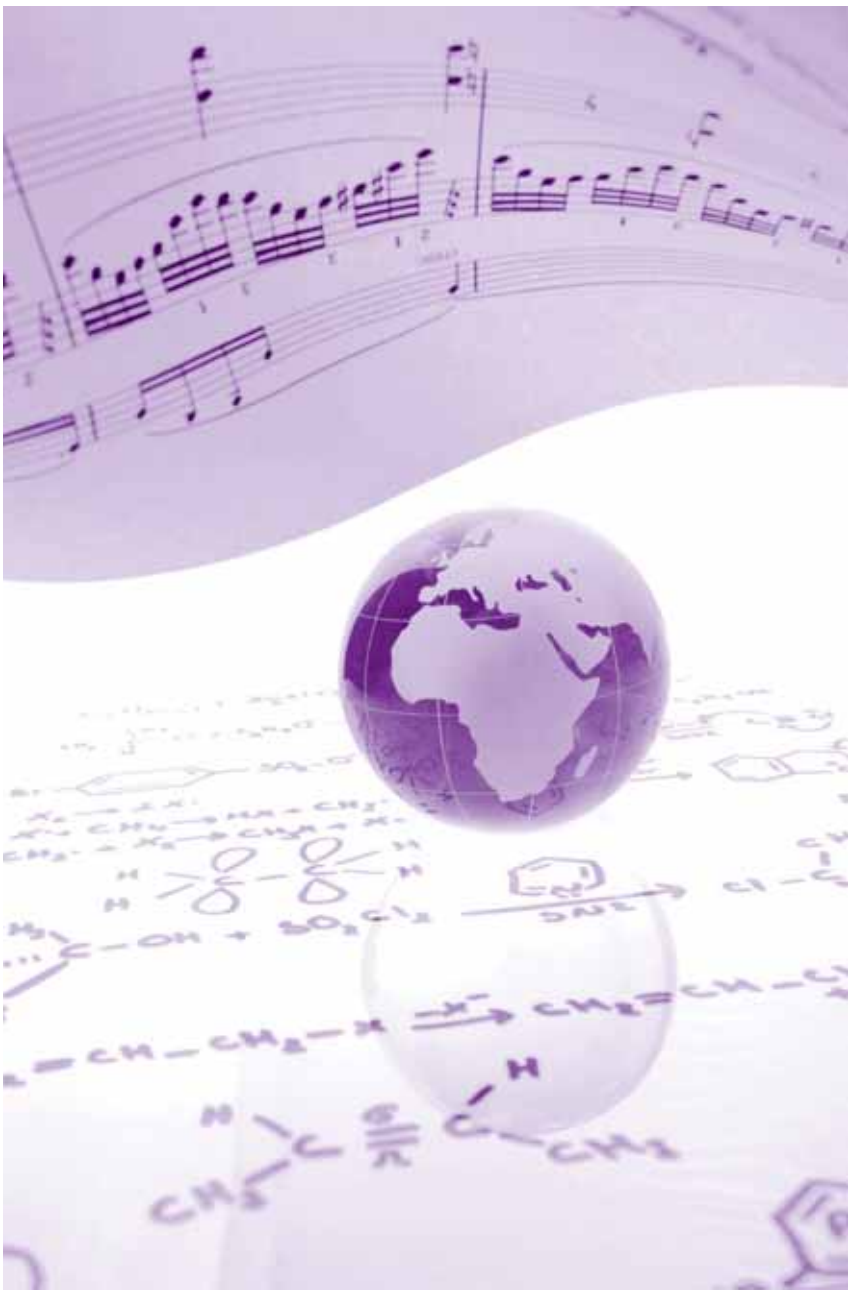
Mozart, juggling and dominoes

a new paradigm in chemistry teaching

BY **BILL ESMAN**

Thanks to the concept of brain-based learning, the works of some classical composers have been welcomed into the classroom of a Melbourne secondary science teacher.



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After attending the IUPAC conference in Melbourne last year, I was impressed with the various strategies employed in chemistry education throughout the world today but surprised at how little was mentioned about the latest neuroscientific findings that have such enormous implications for the advancement of all forms of teaching practice.

My own exposure to the works and theories of John G. Geake, Eric Jensen, Dr Norman Doidge, Dr Kathleen Lawson, Professor Ian Gibbons, Glen Pearsall and others who are investigating how the brain actually learns has led me to the decision to share how chemistry is currently delivered at Padua College Mornington, a school with over 2000 students located on the Mornington Peninsula in Victoria.

I do not profess to be an expert on best teaching practice, just

someone who has been diligently following the differing research that has come to light in the last 30 years, sometimes surprised at what has been said, but always willing to apply what I have thought to be best practice for my students. Along the way, I have frequently discovered that despite the published research, and encouragement from those who should know, the results have often been disappointing with marginal effect on improving student understanding or competence, until now.

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'Intelligence is context-appropriate cognitive activity involving abstraction, reasoning, learning and memory', says Professor John G. Geake in his 2009 book *The brain at school* (Open University Press). It has given me much to think about. Chemistry is all about life, and in my many years of teaching I have made an effort to demonstrate this connection with all my students. I now have a neuroscientifically based platform to extend and consolidate my efforts to engage, excite and challenge my students as never before!

Using brain-based learning strategies, I now have my students listening to music that is 60 beats a minute, without words. Much of the music is from Baroque composers such as Bach, Handel, Vivaldi and Pachebel, but students find Mozart, from the Classical period, a particular favourite when completing classroom activities. I restrict single-focus tasks to 20 minutes. I get my students up and moving and doing left–right brain gymnastics. A particularly good one involves them making their own juggling balls and then teaching each other to juggle, a great left-right brain connection activity. Playing mole dominoes and teaching them about nutrition and hydration has also become part of their overall classroom experience. I have lined up Year 12 students outside the back of the lab, eye closed and facing the sun while I have moved along the line, asking questions or posing problems. Why? Well we are now told we are mal illuminated, lacking appropriate levels of vitamin D. Having students up and moving around increases blood flow and oxygen to the brain. It also turns out that exercise and variety stimulates emotion and emotional learning facilitates long-term memory.

A major component of chemistry has always been the necessity to commit large amounts of material to memory. The subject is almost like a new language to students – terminology, formulas and processing equations. Students have so much to learn, to remember – everything is critical for examination success and subsequent learning. To make it more accessible, I encourage them to break it down into smaller chunks of information and write it down on sticky notes. Pictures are drawn, students turn s, p, d and f subshells that contain 1, 3, 5 and 7 orbitals into 'Smart people don't forget 1, 3, 5, 7' and draw pictures of a ute driving into a lake, to help them remember that the sol**ute** dissolves in the solvent (the lake). Playing mole dominoes reinforces stoichiometry. A drawing of an oil rig sits on the top of the white board as a way of remembering that **o**xidation **i**s **l**oss of electrons and **r**eduction **i**s **g**ain of electrons. A red cat adorns the right side of the board, signifying that **red**uction is at the **cat**hode. Both are visible for the whole year and it is fun to observe the 'light globe' moments when they suddenly realise what they have been looking at for so long. Pairs of students will construct mind maps, which are then assessed by peers and graded. Prizes are awarded of rolls of Fizzers, a sweet containing sodium bicarbonate, tartaric acid and sugar, giving students a glucose hit and tang on the tongue. I encourage them to place sticky notes all over their walls at home with snippets of theory and, when ready, stick them on their foreheads, walk up to their parents and say 'Test me!'

Lessons begin with students being given a card at the door. This card may be a playing card requiring a match that is situated at a particular point in the classroom, or a theory card, which needs to be paired with an appropriate answer card (some cards are student generated). This results in them constantly changing their positions in the classroom. Although it eliminates sitting with their friends, it does create greater classroom cohesion. It also results in a more diverse range of partnership groupings for practical work and a

greater appreciation of each others' strengths and weaknesses.

If students cannot find their matching theory cards, they are encouraged to ask each other for help. This approach allows for consolidation of knowledge and students are more focused at the beginning of a lesson. The best way for any student to learn is by teaching others, so students are frequently encouraged to write solutions for particularly difficult questions on the white board for the rest of the class.

Assessment is varied – one task requires students to complete a pro forma for a test requiring five true/false questions, five multiple-choice and five short-answer questions. They need to write the questions and answers. When they are finished, students circulate around the classroom and vote on the best test. I print it up and all the students get to attempt it.

The point of this exercise is to allow students ownership of the material and the task. They get to see what other students regard as important and what they may have forgotten to include. This can have a much greater influence on long-term memory than being lectured to by me, or completing a revision sheet! Which, incidentally they may already have been given in the form of a summary sheet where the information has been turned into a page of Wingdings symbols that they need to decipher before they have the information.

One task for Unit 4 Chemistry requires students to write an A4 page (with picture) on an alternative energy source, with the advantages and disadvantages of, for example, solar energy. When they are submitted, I laminate them and hand

them back in groups of three to pairs of students who need to allocate a rank order for the different sources of energy. Each group then justifies the order to the rest of the class and writes the order on the white board. The final component of the exercise is when the students form a circle, throw all the cards in the centre and as a whole class rank all the cards. It is amazing to see the class argue and rank, changing the order over and over until consensus is achieved. When they sift, order and analyse the information, I feel far more confident that deeper understanding results. They are also developing patterns of thinking that will aid them in other tasks and hopefully improve their own learning processes.

I could go on about other aspects of my classes and the fact that even my Year 7 students are following a similar structure. Suffice to say I am also learning as I apply the three basic principles of brain-based learning – orchestrated immersion, relaxed alertness and active processing.

Finally, why play music at 60 beats per minute, with no words? Well it turns out that when our brains are in alpha mode (8–12 cycles per second), we are calm and relaxed – reflection, problem-solving activities and access to long-term memory are enhanced. The music I play has been shown to bring us to this state. Students listening to their MP3 players, or constantly social networking on their mobile phones, tend to spend most of their time in beta mode (13–25+ cycles per second), a state where our five senses are strongly engaged, something that might be needed for a debater, or someone playing sport. These waves are associated with short-term memory, alertness and concentration and, at excessive levels, anxiety. By playing music during class time students become more focused and after a while they do not even notice it is on, but their brains do and the learning process is enhanced.

I encourage my peers to apply these principles and have explained what I am doing at last year's STAVCON and other conferences. I would like all teachers to feel the satisfaction that comes from engaged, motivated and enthusiastic students not only mastering the principles of chemistry, but also gaining the tools to become lifelong learners – something that goes way beyond the old 'chalk and talk' model that most of us grew up with.

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