Evidence-based thinking skills program improves students' attainment: An AUS-CASE project

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The development of 'thinking' in students is often implicit in curriculum documents, locally, interstate and overseas. For teachers, though, it is not always clear what is included in the hierarchy of thinking skills, how they can be delivered and evaluated or even how they impact students' learning. Recent research shows that some intervention programs in thinking skills do improve the performance of students on cognitive and curriculum tests (Higgins, Baumfield and Hall, 2007), but it is important to consider how this performance is measured. The purpose of this article is to consider the evidence for claims about various thinking skills, to describe one evidence-based thinking skills program, CASE, originally developed in the UK and, finally, to raise awareness of a proposed AUS-CASE project in Western Australia.

Where is the evidence for thinking skills programs?

Renowned educators such as De Bono, Gardner and Lane Clarke have contributed to the general discussion about raising awareness of the need for critical thinkers and of the role schools play in facilitating change and development in student thinking. Teachers are urged to encourage their students to use 'thinking hats' to solve problems, spiral different 'thinking types' and ensure that various different intelligences are addressed in students through the design of the curriculum. However strong the claims may initially appear, there is no or little evidence for many of the popular approaches used by teachers to encourage students to think in the classroom. For example, Crossland (2008) explains that only two of the twelve statements below are supported by empirical evidence. Can you guess which ones? See the end of this article for the answer.

1. *Students are right or left brain thinkers*
2. *Students need an enriched environment in their early years*
3. *There are critical periods of learning*
4. *If we don't use our brain cells we lose them*
5. *We only use 10% of our brain's capacity*
6. *The influence of the amygdalae ensures that everything has an emotional context associated with it*
7. *Students are visual (V), auditory (A) of kinaesthetic (K) type learners*
8. *Brain Gym stimulates neural mechanisms*
9. *Our working memory limits our capacity to learn*
10. *Caffeine acts as "pick me up" and improves alertness*
11. *An adult working memory can hold about 7 facts*
12. *"fMRi" scanners shows neurons firing and therefore thinking and learning*

(Adapted from Crossland, 2008)

Strong evidence for Cognitive Acceleration through Science Education (CASE) program impact on student achievement

Systematic reviews of data, called meta analyses, are used to determine policy and practice in medicine. The same approach of reviewing available evidence has been used to identify the effectiveness of thinking skills in schools (General Teaching Council for England, 2001; Higgins, Baumfield and Hall, 2007). For much of the data, evidence does not support the claims made that a particular approach or use of thinking skills has much, or any, measurable impact on student achievement: the 'feel good' factor does not translate into improved cognition. The same meta analysis of data on thinking skills does show, however, that the cognitive acceleration through science education (CASE) program, developed in the UK at King's College, London, has a demonstrable impact on student cognition. This effect is persistent and cross-curricular, leading to improved performance in school examinations long after the intervention program. If 'thinking' lessons can be taught and if they have such far-reaching consequences in terms of raising the achievement of students across the curriculum, then it seems reasonable to suggest that some long-term improvement to intelligence has occurred.

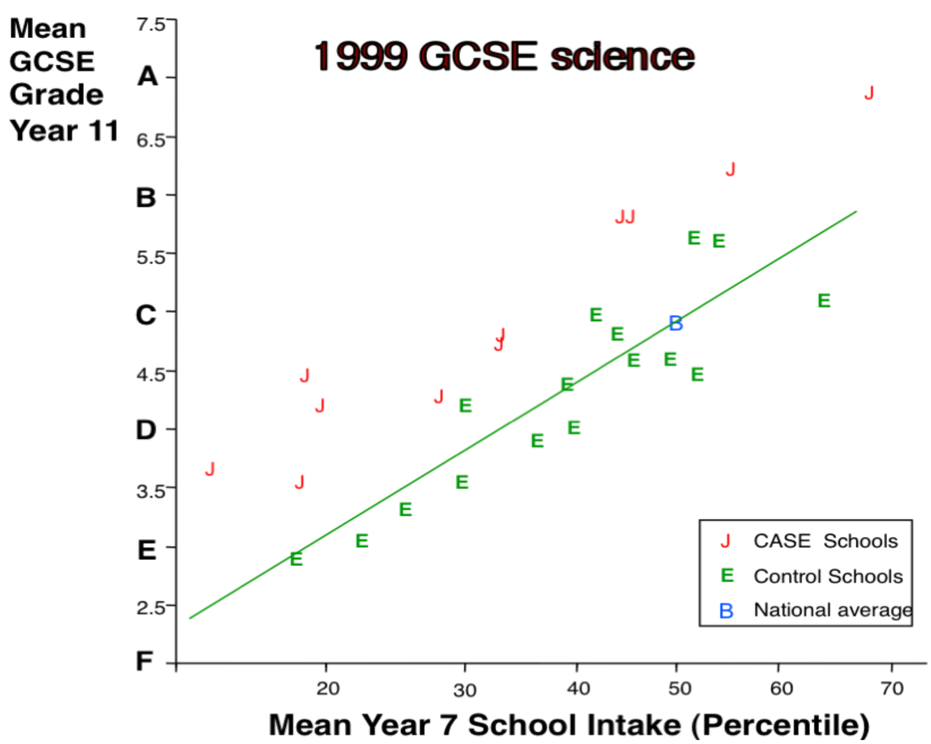

Figure 1 (provided by Philip Adey, King's College London) shows the results from the larger CASE research project (Shayer, 1999) in graphical form. The horizontal axis is the mean student score on a cognitive development test when students entered the school in Year 7. The vertical axis represents the mean science grade for the same students for GCSE, three years after participating in CASE. The CASE schools' value-added can be seen as the vertical distance between the school's point and the regression line for the control schools which runs through the national average.

The evidence of the effect of the CASE program on students' cognitive growth and academic achievement has been published in a number of forms over the years. The original CASE experiment, with only about 130 students (Adey & Shayer, 1994), as well as more recent work, with over 2000 students from 11 schools (Shayer, 1999; Shayer & Adey, 2002), both demonstrated that students participating in the CASE program during Year 7 and Year 8 showed improved cognition on Piagetian-based reasoning tasks compared with students in control schools. Moreover, the improvement was sustained and impacted on performance at the (UK) General Certificate of Secondary Education (GCSE) results three years after the intervention program had ended, not only in science, but also in mathematics and English. The value-added effect translated into an average whole grade improvement in science at GCSE (1.05 grades; 0.6 standard deviations) and similar improvements in mathematics (0.95 grades; 0.5 standard deviations) and English (0.90 grades; 0.57 standard deviations) (Adey & Shayer, 1994).

So, what is CASE?

The cognitive acceleration through science education intervention program, CASE, is carried out in 30 science lessons over a two-year period (ideally in Years 7 and 8). The program was designed to accelerate students' level of thinking so they would be better able to cope with the demands of the curriculum. CASE runs parallel to, but does not replace, other science lessons which give curriculum coverage. CASE was developed into a package for schools, *Thinking Science* (Adey, Shayer & Yates, 1989). Once the early research on cognitive acceleration through science education (CASE) had been completed a particular methodology and set of curriculum materials were developed and applied to other programs. Currently there are several programs under the auspices of cognitive acceleration including Cognitive Acceleration Through Mathematics Education (CAME) and Cognitive Acceleration Through Technology Education (CATE) as well as programs for younger children in the early childhood and middle primary years (Shayer & Adey, 2002).

The theory underpinning the cognitive acceleration programs embraces both Piagetian and Vygotskian schools of thought in detailing the stages of cognitive development and specifically targeting problems and requiring 'thinking' to problem-solve in the 'zone of proximal development' so learning as a result of cognitive conflict occurs. Reasoning patterns specifically addressed through the CASE activities include: *controlling variables, ratio and proportionality, compensation and equilibrium to analyse process, using correlation, probability, determining criteria for classification, using formal models of thinking and understanding compound variables.* The CASE program *Thinking Science* is structured in such a way that the lessons spiral through increasing levels of complexity of these reasoning patterns.

The CASE program has at its core 5 principles or pillars. The first pillar is *concrete preparation* that involves the teacher establishing a problem for the students to consider and to negotiate any associated ideas and terminology needed to understand the problem. The second pillar, *cognitive conflict* is a process whereby students are encouraged to think about the problem in a way that challenges their conventional ways of thinking. Students are encouraged to consider a range of possible explanations for the problem. The third pillar, *social construction* is the shared development of explanations of and understandings about the problem and potential solutions. Teachers play a role in asking probing questions of students but not offering solutions. Active participation by all students is required, as all are expected to negotiate explanations and solve problems. These processes resonate well with the current interest by educators in pedagogy: group work, problem-solving and challenging teaching.

The fourth pillar, *metacognition,* involves students reflecting on their thinking and articulating their approaches taken to problem solving thus enabling other students to access other ways of thinking and evaluating. Finally, the fifth pillar, *bridging,* involves applying the ideas developed to other problems in the real world. Associated science lessons can be used to help reinforce and remind students about the range of problem-solving strategies and ways of thinking they develop during CASE lessons.

What does a CASE lesson look like?

The early part of a CASE lesson involves introducing the problem and related vocabulary. For example, in the 'Treatments and Effects' lesson from *Thinking Science* (Adey, Shayer & Yates, 1989), correlation reasoning is used to assess the strength of a relationship between two variables. A concrete experience is provided and students examine pictorial data about carrot plants grown in soil and grown in soil with a treatment. Some control group carrots are larger than treated carrots even though a strong positive correlation exists between the treatment and the size of the carrots. The cognitive conflict is then presented: will all carrots be bigger if we use the treatment? Clearly, understanding correlation depends on an understanding of probability. Other activities in the lesson include examples of negative correlations or where no correlation exists at all. Bridging to everyday life can include use of medication for pain relief etc. Much of this lesson involves whole class discussion, with some time for paired or small group discussion to determine the relationships between variables: teacher input is through specific and Socratic questioning such as 'how do I know?'

Establishing CASE in schools

Preparation, delivery and evaluation of thinking lessons need to be well supported. The effective establishment of specific thinking lessons outside the 'normal' curricula depends on a good theoretical understanding and acceptance of the rationale for implementing such lessons into classrooms. For teachers prepared to take on the additional task of delivering lessons which may appear to have little to do with the normal skills, processes and knowledge of everyday curricula, considerable support and 'coaching' in methodology is required. Ideally, this has to be a whole-school agreement, whereby teachers, managers in schools, technical support and parents are included in the decision to promote thinking in students. To be able to successfully incorporate a program like CASE into a school curriculum requires science teachers to be trained in the materials and methodology as well as the underpinning philosophy. At present, we estimate that two days training can successfully cover the underpinning theory as well as address the practical know-how for experienced teachers.

Thinking lessons in Western Australia

There has been no comprehensive survey of the frequency and types of 'thinking' lessons implemented in Western Australian schools to date. The teaching, learning and development of 'thinking' in schools is assumed and teachers share that responsibility. We feel it is timely to focus on 'thinking' and cognitive acceleration as school restructuring across the state, particularly in middle schools, creates possibilities for curriculum change. Students in Western Australia stand to benefit by access to evidence-based thinking programs, like CASE, not only in science but also in other learning areas. Since the CASE program is a series of stand-alone thinking exercises in developing formal operations, it can be used alongside, although discrete from, an established school science program.

We have already introduced a number of science teachers in the Perth metropolitan area to the methods and materials of the CASE program through presentations at conferences of the Science Teachers of Western Australia (STAWA) and through the Catholic Education Office. Early data from end of performance in Year 8 students in one school has suggested that there is an immediate improvement in attainment in the Investigating Outcome. While these findings have not been formally analysed, the teachers found the students were consistently able to demonstrate their understanding and application of level four on the Investigating Outcome, the average expected level for students in Year 9. For example, all students were able to identify variables, distinguish between dependent and independent variables, explain and evaluate data. We might expect to see this higher attainment in cognitive function translated into improved performance on the MSE9 tests.

AUS-CASE: A cognitive acceleration project for Western Australian Schools

The three authors of this paper, Mary Oliver, Grady Venville and Ant Meczes have all been involved in various ways with the cognitive acceleration programs in the UK. Our experiences running professional development courses, workshops and giving lectures on cognitive acceleration suggest that there is considerable interest in this topic from teachers in Western Australia. The notion of being able to realistically improve student thinking and academic performance is alluring indeed. We feel it is timely to establish a community of educators committed to cognitive acceleration in Western Australia and are initiating such a group called AUS-CASE. We have the full support and collaboration of the initiators of the cognitive acceleration program in the UK including Professor Philip Adey at King's College London.

The goal of AUS-CASE will be to implement a program of thinking skills, based on the UK CASE program, for students in Year 7 and Year 8 in WA schools in 2009. There will be a financial cost to schools that choose to participate in the AUS-CASE program to cover materials and professional development. We are also seeking research grant funding to investigate adaptation of the UK-based cognitive acceleration material for the Australian context and to evaluate the impact on student cognition.

If you are interested in participating in AUS-CASE, and/or attending the information session please get in touch with Mary Oliver at UWA by phone, 6488 2385 or email on mary.oliver@uwa.edu.au

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All the statements are myths except number 6 concerning the fundamental importance of emotion in learning and number 9, working memory. For more information about these myths see the free download Neuroscience and Education: Issues and Opportunities: www.esrcsocietytoday.ac.uk/ESRCInfoCentre/PO/ESRC_Community/neuromyths.aspx