Institution: King's College London

Unit of Assessment: UoA25 (Education)

Title of case study: Cognitive Acceleration

1. Summary of the impact

Research on cognitive acceleration at King's has helped change pedagogy in science and mathematics education in the UK and around the world. Rooted in the cognitive psychology of Jean Piaget and Lev Vygotsky, cognitive acceleration is a research-based teaching approach that enables teachers to challenge how students think and to encourage metacognition. This approach has been shown to have substantial, positive effects on students' cognitive development and hence on their academic achievement. As a result, schools around the world have been attracted to the approach and now teach using cognitive acceleration methods in science and mathematics. In the UK cognitive acceleration is also used in English teaching.

2. Underpinning research [Numbers in brackets refer to references in Section 3.]

The cognitive acceleration research programme dates back more than 20 years. It was originally developed by Michael Shayer, Philip Adey and colleagues through a series of applied experimental studies in science education in secondary schools. Since 1993, the approach has been consolidated in science education and shown to have long-lasting effects on attainment. Subsequently, the approach has been extended both to younger students and to other school subjects, particularly mathematics and English.

Drawing on Piagetian and neo-Piagetian theory, cognitive acceleration is based on a typology of reasoning patterns, which are then specifically addressed through teaching activities. Although based on a general approach to cognitive development, these reasoning patterns are articulated in ways that are specific to the different school subjects. Hence, in science, the reasoning patterns include controlling variables, ratio and proportionality, and determining criteria for classification. In contrast, for English, the patterns include symbolic representation and genre modelling. The teaching approach and lesson structure are informed mainly by Vygotskian theory. Lessons are designed to spiral through increasing levels of complexity within the reasoning patterns and consist of several phases: concrete preparation, construction, cognitive conflict and reflection (or metacognition).

Over the past 20 years the research team has:

1. Shown Cognitive Acceleration in Science Education (CASE) to have statistically and practically significant effects on GCSE grades three years after the intervention. These effects extended beyond science to mathematics and English, thus showing a 'far transfer' effect. [6]

2. Defined and articulated the key principles of the CASE teaching intervention and the professional development approach, enabling CASE training to be carried out by third parties. [7]

3. Described the process of dissemination and identified the key factors that convince teachers and schools to take up interventions such as cognitive acceleration. The research found that direct communication to subject teachers is a crucial factor. [7]

4. Extended the cognitive acceleration programme to school subjects beyond science, most notably mathematics [5], but also technology, the arts [8] and most recently English. The Cognitive Acceleration in Mathematics Education (CAME) programme was shown to increase both the overall intellectual capacity of students (as measured by cognitive tests) and their school GCSE results three years after the intervention [9]. This longitudinal study

demonstrated a 0.8 of a grade difference in GCSE outcomes for mathematics in CAME schools (effect size 0.44). Moreover, the effect transfers to science and English results, with an average of 0.51 grade (effect size 0.30) improvement in science and a 0.52 grade (effect size 0.32) improvement in English.

5. Extended the programme to primary schools through intervention studies focused on science and mathematics in the early years [8], on science at Key Stage 2 [2], and on mathematics at Key Stage 2 [8] and at Key Stage 1 [11]. For example, a study of Year 1 pupils [10] demonstrated that the effect of cognitive acceleration can be seen among children as young as five and six. In this study a group of 300 inner city children, paired with an age-matched control group, showed greater cognitive gains in both the subjects taught using cognitive acceleration methods (effect size 0.47) and in all other subjects (effect size 0.43).

6. Replicated the results internationally. Early examples of research studies in Finland, the US and elsewhere, led by local or regional teams with Adey and/or Shayer as co-investigators or consultants, which indicate that the approach can be replicated elsewhere, are reported and summarised in Adey *et al*. (2004) [7]. More recently, cognitive acceleration has been shown to be effective in Australia [10] and in the high attaining context of China [12]. For example, supported by Adey, Chinese academics from the Ministry of Education and Shaanxi Normal University implemented cognitive acceleration using randomised allocation of participants. First and second grade students showed effects of the programme on thinking ability (effect size, d= .78-1.45), on Chinese (d= .68-1.07), and on mathematics (d=.58-.87). Grade 3 students showed effects from six months after their start on thinking ability (d=.90-1.37), on Chinese (d=.77-1.32), and on mathematics (d=.65-1.29). Hence, the study demonstrated that, in the Chinese context, the cognitive acceleration approach for teaching thinking based on a structured theoretical model has long-term far transfer effects on students' thinking ability and academic achievement.

3. References to the research

Supporting Grants

[1] Shayer (PI), Brown, Adey (2001-2004). *Realising the Cognitive Potential of children 5 to 7 with a Mathematics focus*. ESRC (R000239451): £380,822.

[2] Dillon, Adey (Co-PIs) (2000-2003). *Cognitive Acceleration in Science Education (CASE) at Key Stage 2 Research & Development*. AstraZenica: £148,317.

[3] Adey (PI) (1998-2001). *CASE*. London Borough of Hammersmith and Fulham, Single Regeneration Budget: £250,000.

[4] Johnson (PI), Adhami, Shayer, Hafeez, Hodgen (1997-2002). *Focus 5: CAME Primary. Accelerating progress in numeracy by improving general intellectual performance*. The Leverhulme Trust: £150,414.

[5] Johnson (PI), Shayer, Adhami (1993-98). *Cognitive Acceleration in Mathematics Education Projects I&II*. Leverhulme Trust 1993-95; Esmee Fairbairn Trust 1995-97; ESRC (R000221898) 1996-98: £33,175.

Key peer-reviewed publications: [hard copies are available on request]

[6] Adey, P., & Shayer, M. (1993). An exploration of long-term far-transfer effects following an extended intervention program in the High School Curriculum. *Cognition and Instruction*, 11(1), 1-29. Doi: 10.1207/s1532690xci1101_1

[7] Adey, P., Hewitt, G., Hewitt, J., & Landau, N. (2004). *The professional development of teachers: Practice and theory*. Dordrecht: Kluwer.

[8] Shayer, M., & Adey, P. S. (Eds.). (2002). *Learning intelligence*. Buckingham: Open University Press.

[9] Shayer, M., & Adhami, M. (2007). Fostering cognitive development through the context of Mathematics: Results of the CAME Project. *Educational Studies in Mathematics. 64*(3): 265-291. Doi: 10.1007/s10649-006-9037-1

[10] Adey, P., Robertson, A., Venville, G. (2002) Effects of a cognitive acceleration programme on Year 1 pupils*, British Journal of Educational Psychology,* 72(1), 1-25.

[11] Shayer, M., & Adhami, M. (2010). Realizing the cognitive potential of children 5–7 with a mathematics focus: Post-test and long-term effects of a 2-year intervention. *British Journal of Educational Psychology, 80*(3), 363-379. Doi: 10.1348/000709909X482363

[12] Hu, W., Adey, P., Jia, X., Liu, J., Zhang, L., Li, J., & Dong, X. (2011). Effects of a 'Learn to Think' intervention programme on primary school students. *British Journal of Educational Psychology, 81*(4), 531-557. Doi: 10.1348/2044-8279.002007

4. Details of the impact [Numbers in brackets refer to references and sources in Sections 3 & 5.]

In the UK the uptake of Cognitive Acceleration in Mathematics Education (CAME) and Science Education (CASE) is widespread in primary and secondary schools as a result of extensive dissemination of the research through a mixture of: teaching materials produced by the research team; professional networks; and professional development programmes for teachers. The cognitive acceleration-based *Let's Think* materials for teachers in primary and secondary schools have sold over 6000 units in the 2008-13 period. In 2010 the King's researchers established the organisation, the 'Let's Think Forum' out of a merger between two organisations formed in the previous decade to provide training and support for schools wishing to use cognitive acceleration approaches (the Cognitive Acceleration Network, established in 2002 to support a group of around 20 trainers, and Cognitive Acceleration Associates, established in 2003 to provide training and support for schools). Since its establishment in 2010, Let's Think has delivered cognitive acceleration-based professional development in 18 local authorities in the UK based on the original King's research [17]. As a result, over 2000 mathematics, science and primary teachers from more than 1000 schools have been trained to use cognitive acceleration concepts and techniques in these 18 'clusters' over the last five years. In addition, a number of advisors have created their own programmes based on the published materials (e.g., in East Riding), whilst many of the 1500+ schools trained prior to 2008 have now integrated CASE and/or CAME into their schemes of work [see source 14 for an example]. In addition, 'Let's Think' is currently conducting an independently evaluated randomised control trial of the CASE approach with an intervention group of 25 schools in the Midlands and the North of England funded by the Education Endowment Foundation.

The research has also had impact on guidance on best practice to schools. CAME, for example, is the only research-based intervention cited in the two most recent OFSTED subject reports on calculation in primary mathematics [13] and on school mathematics [14]. The primary report [13] was commissioned by the Department for Education to support the increased emphasis on calculation in the proposed revised National Curriculum for primary schools. CASE is cited in the 2008 OFSTED report on Science [15] and is one of only two research-based approaches recommended in the Royal Society's 2010 '*State of the Nation*' report on 5-14 education [16].

The new 'Let's Think in English' teaching programme, led by Laurie Smith (a former staff member and a visiting academic in DEPS), is currently being used by 65 secondary schools in London and the South East, with training for 20 additional schools in Liverpool, West Yorkshire, Hampshire, Norfolk and Suffolk commencing in 2013.

The international spread of cognitive acceleration concepts and practices has also grown steadily over the last decade. For example, in the 1990s Shayer toured the major cities of South Africa to talk to around 2000 teachers about cognitive acceleration. One teacher, Ian McLachlan, became heavily involved in using CASE and CAME, driving its wider adoption in South Africa. At Hilton College, McLachlan taught Kgosi Leruo Molotlegi, the present King of the Bafokeng Nation, a province in South Africa. The King was impressed by the quality of the teaching he had received from McLachlan (particularly in cognitive acceleration) and hence, in 2008, asked McLachlan to establish the Royal Bafokeng Institute of Education (RBI) with the aim of improving teaching in all schools in Bafokeng. Accordingly, in 2009, McLachlan and the RBI re-established Lebone II College as a centre of educational excellence which would also provide continuing professional development (CPD) for the teachers across the province's primary and secondary schools [21]. In 2011, Shayer visited Lebone II and RBI to advise on CASE, CAME, Let's Think and the associated CPD interventions. At Lebone II cognitive acceleration is used from Grade R to Grade 12 in all subject areas and is central to the CPD for the province's teachers. As a result, CASE, CAME and the other Let's Think interventions are now used in 10 pre-schools, 29 primary schools, and 20 secondary schools with a total of 25,000 pupils across Bafokeng.

Similar patterns can be identified in other national settings where the research has been replicated by local teams of researchers and teachers supported by Adey or Shayer. For example, in Western Australia, 30 schools are currently using CASE and CAME in a replication intervention programme developed with the support of Adey [18]. The effects on student learning of this extension have been demonstrated by Dr Grady Venville and her colleagues, with Adey acting as an academic adviser [19]. Venville *et al*. found an effect size of 0.47 on a set of standardised science reasoning tasks for students whose teachers had been trained in the CASE approach. Moreover, students were overwhelmingly positive about the cognitive acceleration lessons.

In China cognitive acceleration techniques are used in over 300 schools, reaching more than 200,000 students. In addition to showing that the approach is effective at raising attainment even in the high attaining Chinese context [12], cognitive acceleration has also addressed a significant additional concern amongst Chinese educators and policy-makers: the need for a greater emphasis on the promotion of creativity in school education. In a two-year intervention study, Professor Weiping Hu found that cognitive acceleration enhances scientific creativity, reporting that the approach established 'an open, democratic and positive activity atmosphere', and 'encourag[ed] students to spend more time discussing problems with partners, thinking independently, speaking out their own ideas bravely, and judging others' views' [20].

5. Sources to corroborate the impact

Documents and webpages: [hard copies are available on request]

[13] OFSTED. (2011). *Good Practice in Primary Mathematics: Evidence from 20 successful schools*. London: OFSTED.
[14] OFSTED. (2012). *Mathematics: Made to measure*. London: OFSTED.
[15] OFSTED. (2008). *Success in Science*. London: OFSTED.
[16] The Royal Society. (2010). *Science and Mathematics Education 5-14. A "state of the nation" report*. London: The Royal Society.
[17] http://www.letsthink.org.uk/impact-evidence
[18] http://www.education.uwa.edu.au/tsa
[19] Oliver, M., Venville, G., & Adey, P. (2012). Effects of a Cognitive Acceleration Programme in a Low Socioeconomic High School in Regional Australia', *International Journal of Science Education*, 34, 9, 1393-1410. [Adey acted as an academic adviser expert, but the research was carried out by the local academics led by Venville.]
[20] Hu, W., Wu, B., Jia, X., Yi, X., Duan, C., Meyer, W., & Kaufman, J. C. (2013). Increasing Students' Scientific Creativity: The "Learn to Think" Intervention Program. *The Journal of Creative Behavior, 47*(1), 3-21.
[21] http://bafokenginstitute.org

Individuals:
Head Teacher, Ruislip High School. [Can corroborate impact on a typical school in England.]
Administration and Information Officer and Council Member, the Let's Think Forum. [Impact of the Let's Think programme.]
Dean of Coursework Studies, University of Western Australia. [Use of CA in Western Australia.]
CEO, Royal Bafokeng Institute, South Africa. [Use of cognitive acceleration in Bafokeng.]
Professor, Ministry of Education and Shaanxi Normal University, China. [Use of CA in China.]