# THE LONG-TERM EFFECTS FROM THE USE OF CAME (*COGNITIVE ACCELERATION IN MATHEMATICS EDUCATION*), SOME EFFECTS FROM THE USE OF THE SAME PRINCIPLES IN Y1&2, AND THE MATHS TEACHING OF THE FUTURE

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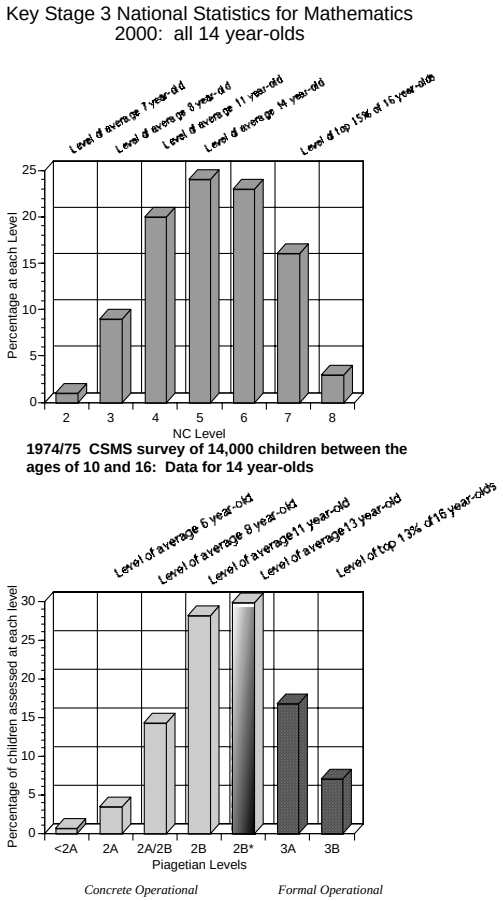
*The CAME*[1] *project was inaugurated in 1993 as an intervention delivered in the context of mathematics with the intention of accelerating the cognitive development of students in the first two years of secondary education. This paper reports substantial post-test and long-term National examination effects of the intervention. The RCPCM project*[2]*, an intervention for the first two years of Primary education, doubled the proportion of 7 year-olds at the mature concrete level to 40%, with a mean effect-size of 0.38 S.D. on Key Stage 1 Maths. Yet, instead of the intervention intention, it is now suggested that a better view is to regard CAME as a constructive criticism of normal instructional teaching, with implications for the role of mathematics teachers and university staff in future professional development.*

## BACKGROUND TO CAME AND RCPCM

In the mid-70s CSMS[3] survey 14,000 children aged 10 to 16 were given three Piagetian tests to assess the range of thinking levels at each year. Figure 2 shows the findings.




By 14 only 20% were showing formal operational thinking (3A&3B). This mattered at the time because current O-level science and maths courses, designed for grammar-school children in the top 20% of the ability range, required this level from the end of Y8. In the 80s the *Graded Assessment in Maths* scheme for the ILEA found that by the age of 12 the children's mathematics competence had a 12-year developmental gap between the above-average and those at what would later be National Curriculum Levels 1 and 2.

In 2002 the Government's own Key Stage 3 statistics for maths showed the same spread, as can be seen in Figure 1. When RCPCM conducted their first Pre-tests on 5 year-olds' classes they found

comparable wide spreads in cognitive development.

The intention of both Projects was to increase the proportion of children able to benefit from good instructional teaching.

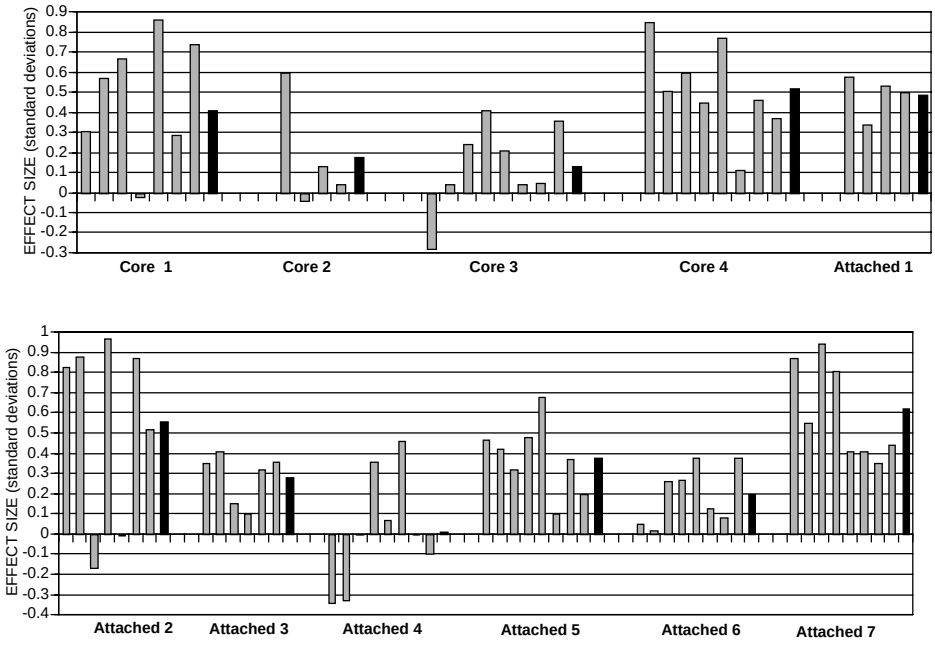
## INTRODUCTION

The theory and practise of the CAME project is discussed in detail in Shayer & Adhami (2006). Essentially it takes a cognitive approach to the learning of mathematics, but integrates this with collaborative learning challenging the students initially in the Thinking Maths lessons (Adhami, Johnson & Shayer, 1998), with the teachers then using some of the same teaching skills in their other maths lessons. Space allows only for the results to be reported here.

## EFFECTS OF CAME

The CAME project used the Thessaloniki Maths test (Demetriou, et al.1991) as a Pre-test in Y7, and as a Post-test at the end of Y8. Figure 3 presents the effect-sizes of each class, in relation to the test norms as controls, shown by the test. The black bars are the schools' mean effects. The Core schools were those which Shayer and Adhami were able to visit frequently: the Attached schools received only PD at King's.

**Figure 3: CLASS GAINS ABOVE EXPECTED GAIN OVER TWO YEARS**




No-one used to working with whole school departments will be surprised by the individual variations in classes within each school, or indeed, between school and school! It is however noteworthy that Attached school 2, having the largest mean effect-size, had one class with an effect-size near 1 S.D, and another with a zero effect. They were both taken by the same teacher: the one with the zero effect was a remedial class. The interpretation suggested is that for collaborative learning to work in a Vygotskian way, the remedial class lacked any pupils of intermediate ability that

might provide for them the higher level insights enabling them to complete their individual zones of proximal development (ZPD).

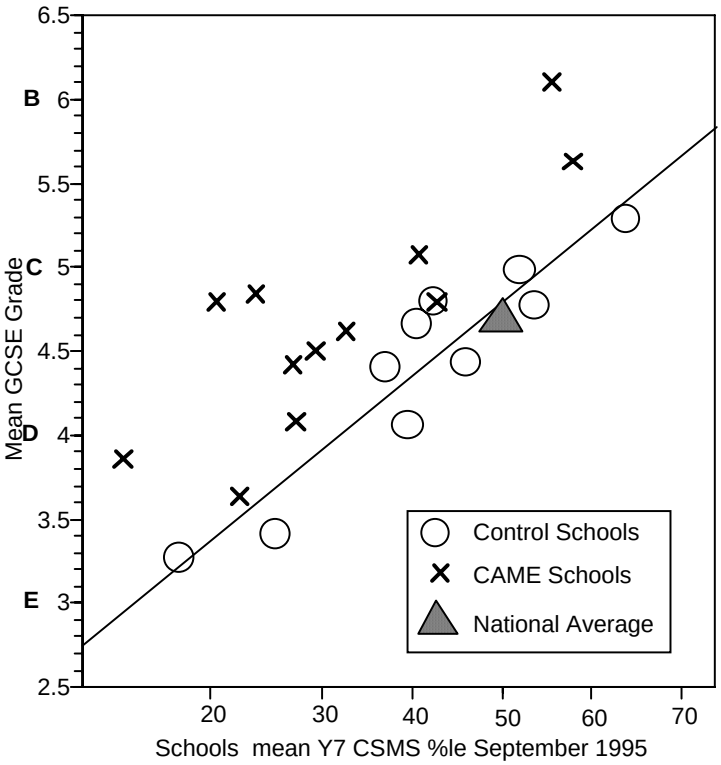



Figure 4 shows the long-term effects on GCSE 2000. The Control schools had either the Thessaloniki Maths test, standardised to the CSMS norms, or another CSMS test, as Pre-tests in Y7. It can be seen that the regression line for the Controls passes very close to the National average.

Comparable effects were found in both GCSE Science and English, as shown in Table 1. This provides the evidence that the general learning ability of the pupils was affected by the CAME intervention, as well as their maths achievement.

Table 1: Effects of the CAME Project.

| | Mean Effect-sizes |
|---|---|
| Thessaloniki Maths Post-test | 0.34 S.D. |
| GCSE Maths (2000) | 0.44 S.D |
| GCSE Science | 0.30 S.D. |
| GCSE English | 0.32 S.D. |

Finally, Figure 5 shows the correlation between the 1997 Post-test effects, and the GCSE 2000 effects. This is the evidence that the long-term GCSE achievement of the students is related directly to the intervention in Y7/8.

## EFFECTS OF THE RCPCM PROJECT

The theory and practice of RCPCM is fully presented in Shayer & Adhami (2003).

The RCPCM project was designed to build on the expertise already developed in the research project CASE@KS1.H&F[4] (1997-2000). Children in Y1, in groups of 6 were given, for about half an hour every week, interactive and collaborative learning focused on the major concrete operational schemata described by Piaget.

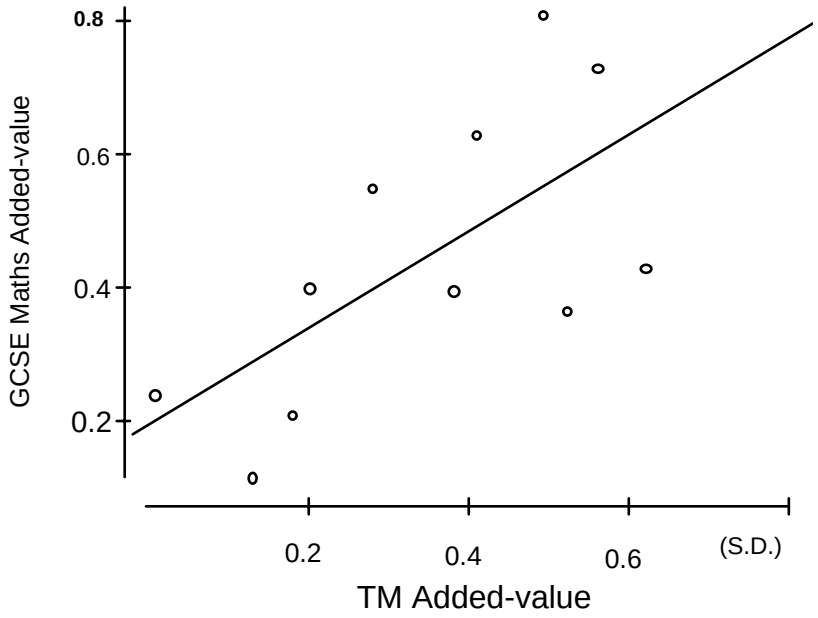
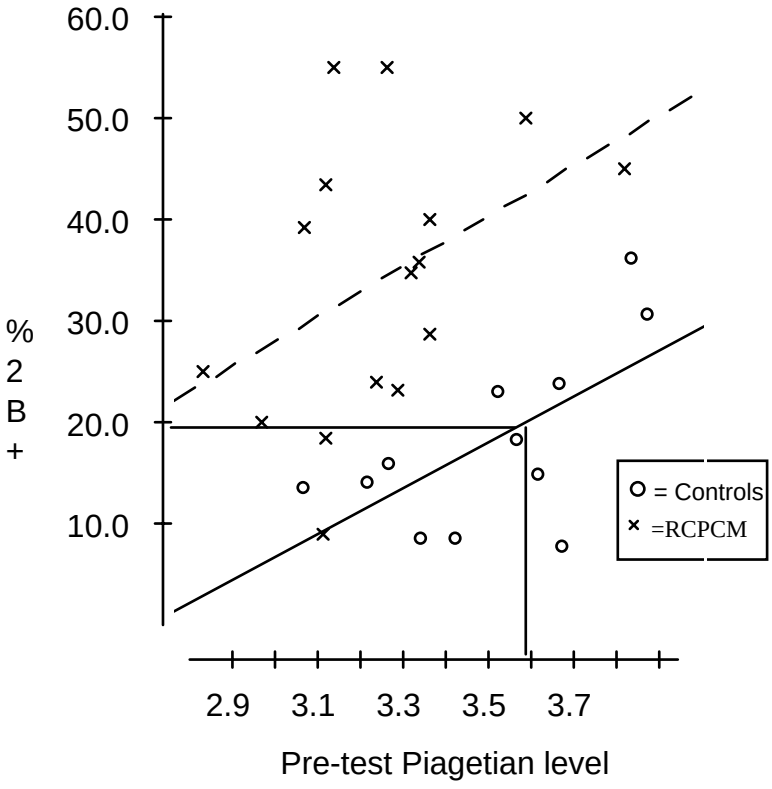



Figure 5: Correlation between gain scores of GCSE 2000 Maths and Thessaloniki -Post test 1997 both in relation to Thessaloniki Pre-test 1995

By Friday each week all the children in the class would have participated in the week's task. Unlike the original CASE project for Y7/8 the activities were not placed within the context of any particular school subjects. The effects of this one year intervention are reported in Adey (2001). Using Piagetian Pre- and Post-tests, effect-sizes, in relation to Control schools, of 0.47 and 0.43 standard deviations were obtained. The lessons and materials used have now been published as *Let's Think* (Adey et al. 2001).

The method proposed in the RCPCM project was twofold. In Y1 'Thinking Maths' lessons (*TM*) would be designed in such a way that the teachers could be led to manage the children's collaborative learning in the context of maths using similar skills they were also using in their *Let's Think* activities. In Y2 the *Let's Think* work would have ceased but the children, already used to the learning strategies practised in the Y1 *TM* lessons, would now receive further *TM* lessons at a rate of about one every 10 days. In addition the teachers would be encouraged, where possible, to use the

Figure 6: Proportion of children per class at the Mature Concrete level at Post-test on Spatial Relations



same teaching skills within the context of their ordinary Numeracy work, and also to establish a link from the children's *TM* insights and the National Curriculum learning objectives. The research design involved using a Piagetian Spatial test early in Y1, and then again at the end of Y2, and also Key Stage 1 results on Maths. Figure 6 shows the effects on the Piagetian test at the end of Y2

The Piagetian Spatial test from the CSMS survey is answered only in terms of the children's drawings. It was modified for 5 year-olds as a Pre-test by asking them only to complete figures, e.g. for water in a jar, the jar was drawn for them: they had only to pencil in where the water was. But for a post-test, after trialling with 7 year-olds, the Spatial test was found usable entirely in terms of the children's own drawings, as previously with 10 year-olds. Although it is cast in the spatial mode, the test in fact acts as a test of fluid intelligence: one assesses, in each drawing made, the number of relations the child was bearing in mind in the act of drawing. In drawing trees on the side of a hill, if they consider one relation (Early Concrete) then they draw them perpendicular to the side: if they can manage two relations (Mature Concrete) then they draw them perpendicular to earth.

As a guide to the Piagetian scale used in Figure 6, '3' is the Early Concrete level (2A), '4' is Middle Concrete (2A/B) and '5' is Mature Concrete (2B).

In the monograph Shayer, Demetriou & Pervez, 1988 surveying 5 to 10 year-olds, it was shown that the proportion of 7 year-old children in Greece, Australia and Pakistan succeeding on a least two-thirds of Piagetian tests at the 2B level was between 15 and 20%. This is similar to the proportion shown in the CSMS survey for 14 year-olds at the Early Formal level ('7' on the Piagetian scale) and also the proportion selected for grammar school education at $11^{+}$ in the 1945 Act. It seems reasonable to assume that it is those children, at 7 years already at the 2B level, who are the future high achievers who would have been selected at 11 for selective education. In Figure 6 it can be seen that all but two of the experimental classes were well below the National average at Pre-test in Y1, yet six of them had over 40% at the 2B level at the end of Y2. Mean effect-sizes were Spatial test, 0.63 S.D. and Key Stage 1 Maths, 0.38 S.D. The expectation is that this will affect the children's learning experience during the rest of their time in Primary school.

## DISCUSSION

Enough evidence has been presented to show that the research has engendered class management skills in the teachers involved that realise Vygotsky's insistence that teaching should foster development as well as subject knowledge: that it should always aim ahead of where students presently are. Yet in achieving this we have had to abandon almost completely the cause-and-effect thinking present in so many Government initiatives. Teachers mediate the collaborative learning through which their pupils mediate each other. For them to gain possession of the underlying theory—both social and cognitive— they need the same mediation of their own collaborative learning as we are asking them to use with their children. This places

the University mediator in an interesting and demanding position: more akin to a sports coach than a knowledge 'expert'. The essential difference between this methodology and all others is the view that both pupils and their learning objectives can be interpreted, as with Rasch analysis, on one and the same Piagetian scale of difficulty. For the theory and practice of maths teaching itself, one can imagine ahead, in the spectrum of teachers' skills a seamless integration of instructional teaching—aimed at increasing children's competence in what they already understand—and interventionist teaching, aimed at enhancing children's cognitive development. This process, only the first word, now needs further development in other people's hands: the authors are only too aware of how much more there is to understand and make explicit than they have hitherto succeeded in expressing.

## NOTES

1 *Cognitive Acceleration in Mathematics Education I* (1993-1995) project funded by the Leverhulme Foundation. *Cognitive Acceleration in Mathematics Education II* (1995-1997) project funded jointly by the Economic and Social Research Council and the Esmée Fairbairn Trust.
2 *Realising the Cognitive Potential of Children 5 to 7 with a Mathematics Focus* (2001-2004). Project funded by the ESRC at King's College.
3 *Concepts in Secondary Mathematics and Science* (1974-1979). Research Programme funded at Chelsea College by the Social Science Research Council
4 CASE@KS1.H&F. Research project based at King's College funded as part of a Single Regeneration Budget granted to the Hammersmith and Fulham LEA by the DfES.

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