DOES 'CAME' WORK? (2) REPORT ON KEY STAGE 3 RESULTS FOLLOWING THE USE OF THE COGNITIVE ACCELERATION IN MATHEMATICS EDUCATION, CAME, PROJECT IN YEAR 7 AND 8

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Abstract

The CAME project aims to contribute to pupils' achievements and teachers' professional development by basing classroom practice on research and theory - applicable research. Three major sources are drawn upon: a) research on levels of achievement in mathematics; b) Vygotskian psychology and social constructivism as exemplified in the recent literature on classroom cultures; and c) Piagetian/neo-Piagetian theories on levels of reasoning. These sources have been integrated to provide a theoretical foundation for teacher intervention and pupil-pupU interaction in the early years of secondary school mathematics aimed at increasing pupils' intellectual development. Findings from the research indicate that the intermediate aims have been achieved - an increase in classroom interactions and significant improvements in pupils' attainmentsin mathematics. An interesting feature is that the value-added effects were even larger in science and English.

Background

The CAME project (supported through grants from The Leverhulme Trust, The Esmee Fairbairn Charitable Trust and the ESRC) is based on research and theory in cognitive and social psychology. The focus of the work has been, and is, on challenging pupils to 'think' mathematically. A central feature has been the research in developmental psychology which indicates that the age of 11-14 represents a 'window of opportunity' (Adeyand Shayer, 1994) and as such is critical in terms of pupils reaching their potential. The theory and practice of CAME is discussed in detail in Adhami, Johnson and Shayer (1998a, page 1) and the practicalities of the delivery of the lessons - background, lesson summary and specimen lesson and pupils' Notesheets - are given in Adhami, et al (1998c) ..

In a previous BRSLM paper (Adhami, Johnson and Shayer, 1998(b) we reported pre-post-test data on ten schools who had participated in the CAME 2 project using the *Thessaloniki Maths* test (TSLM) (Demetriou et al, 1991). Pre-post test effect-sizes varied between zero and 0.55 standard deviations for each school overall, and from 0.33- to 0.84 standard deviations for each class. Although these results were promising, we argued then that 'the results of National tests for Key Stage 3 at the end of Y9 will provide a more complete picture as to the potentiallong(er) term effects of the intervention on pupils' achievements - *pupils realising their potential. '* In this paper these results are now reported. There were four schools labelled 'Core' which the researchers visited for the purpose of recording lessons, and a further 7 schools labelled 'Attached' which were visted only occasionally during the two year period of the intervention. All schools received central PD at Kings in eight one-day seSSIOns .

Research Methodology

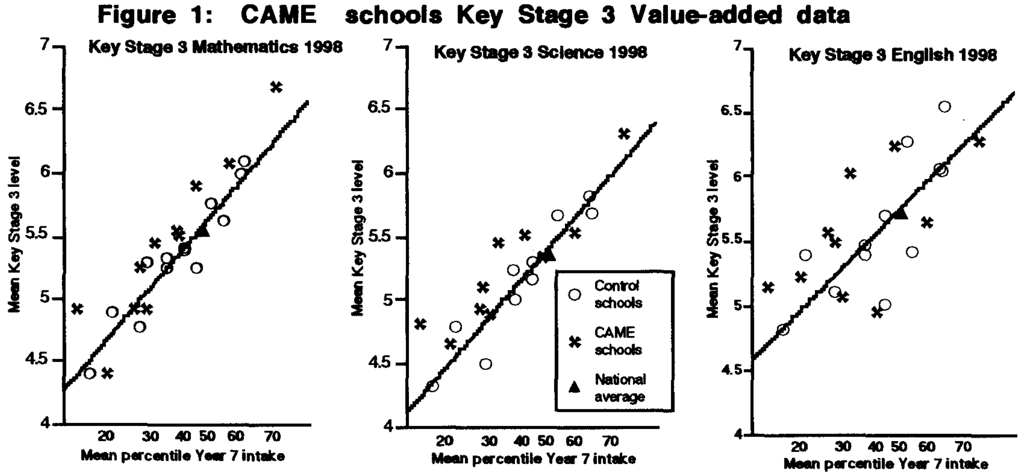
All ten schools administered the *Thessaloniki Maths* test (TSLM) (Demetriou et al, 1991) as Pre-test in the Autumn term 19950. The TSLM test is in three sections: the four operations, the development of algebraic language and ratio and proportion. The test has been standardised to the norms of the CSMS survey (Shayer et al, 1976) so that, for example, scores in the range of 3-7 represent Piagetian levels from early concrete (3) through early formal (7) with a score of 6 corresponding to concrete generalisation. All schools were asked to provide their Key Stage 3 results from summer 1998 in Mathematics, Science and English to test both whether pupils' mathematics achievement had been enhanced, and also whether their cognitive development had been accelerated with a corresponding general rise in their learning ability.

In order to evaluate the 1998 Key Stage results so that they yielded added-value evidence, data from control schools in which the CAME intervention had not been used were needed. These were drawn from a concurrent value-added exercise conducted for the Cognitive Acceleration through Science Education project (CASE) to monitor the results of schools which had received Professional Development (pD)training from King's College beginning in 1995. All schools had previously administered *Volume and Heaviness* PRT [Piagetian Reasoning Test (NFER 1979)] to their Year 7 entry, and the 1998 Year 9 classes had received neither the CASE nor the CAME intervention. *Volume and Heaviness* was the test whose data were used to standardise the TSLM test to the CSMS norms, so both tests should be equivalent for the purpose of estimating the mean and range of school Year 7 intakes in relation to National variation.

Results

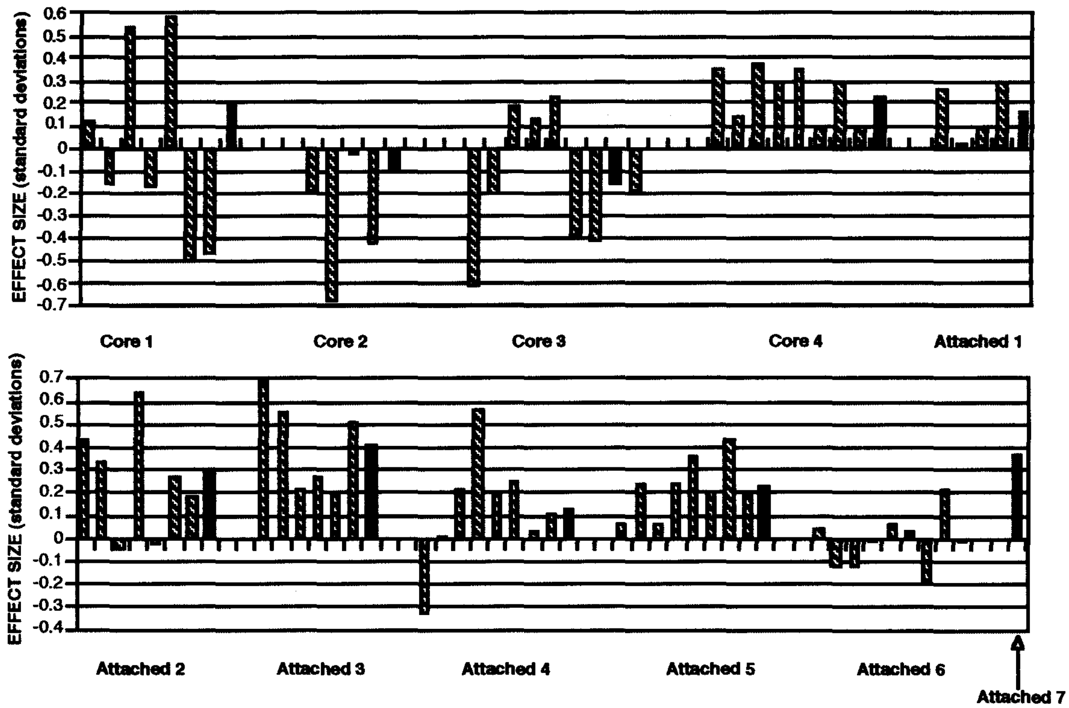
In Figure 1 the mean Key Stage 3 level for the subject is plotted against the mean CSMS percentile of the Year 7 school intake.

Figure 1: CAME schools Key Stage 3 Value-added data



There were one or two odd results for English-and indeed much greater variation in the control schools data-but it can be seen that the average effect for the CAME schools is positive iIi relation to control schools for mathematics, and even greater for science and English.

FIGURE 2: Key Stage 3 Mathematics 1998: Effect-sizes shown for classes within CAME II schools



In Figure 2 the maths results are shown for each class, expressed as effectsizes. These were computed by dividing the residual above the regression line for each control class by the standard deviation of the National KS3 results published by the DtEE (1.3 NC levels), The mean effect for the school is shown in black.

It can be seen that three schools-Core 2 and Core 3, and Attached 6-were showing no long-term effect (for each class an effect-size of 0.3 standard deviations are required for statistical significance). Within each school there is considerable variation from class to class, as might be expected in a first-time use of new professional skills by all the teachers in the department (in Attached 7 only one teacher was involved).

The relation between the effect-sizes in Maths, Science and English are compared in Table 1 for Core 4 and Attached 3 schools. The effect-sizes shown in bold are statistically significant at p< .05 or less.

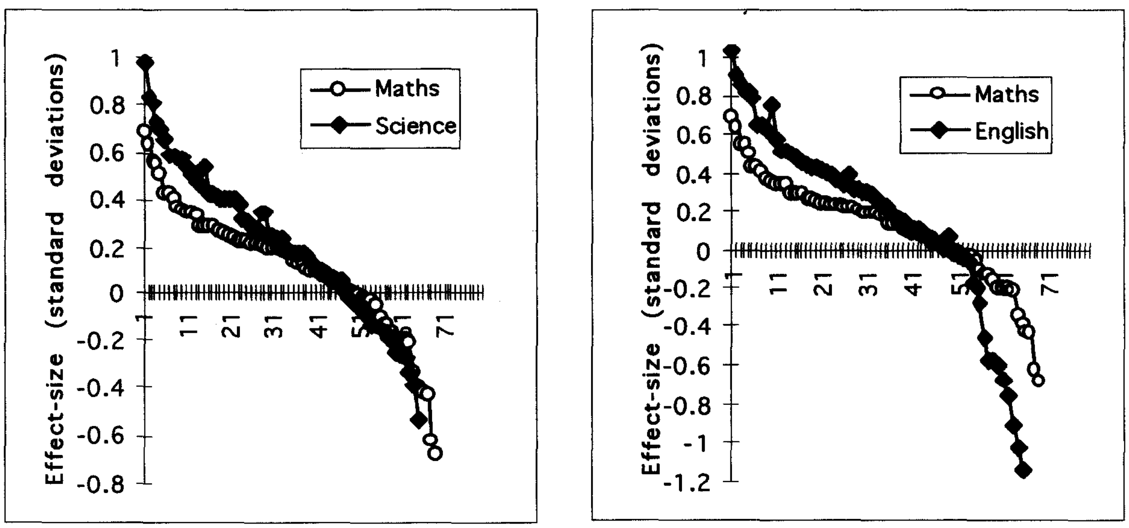
Table 1: Effect-sizes for each class in KS3 Maths, Science and English

School	Core 4								Attached 3					
Class	1	2	3	4	5	6	7	8	1	2	3	4	5	6
Maths	**0.35**	0.14	**0.37**	**0.29**	**0.35**	0.09	**0.29**	0.09	**0.69**	**0.55**	0.21	0.27	0.2	**0.51**
Science	**0.54**	**0.70**	**0.98**	**0.42**	**0.47**	0.11	**0.41**	-0.14	**0.41**	**0.66**	**0.43**	**0.31**	**0.81**	**0.58**
English	**0.91**	**0.83**	**0.87**	**0.43**	**0.83**	0.18	**0.52**	0.24	**0.58**	**0.44**	**0.32**	**0.31**	**0.66**	0.07

It can be seen that , for each class, the effects are substantially correlated across the three subjects. The comparative magnitude of the effects are shown in Figure 3. Here the effect-sizes in mathematics, science and English from the 69 classes reported have each been ordered separately by magnitude, and then plotted as a time senes.

For science, it can been seen that there is no difference in relative magnitude of effect-sizes in maths and science once the effect-size for mathematics drops below 0.3 standard deviations. But as soon as the maths effects become statistically significant, then the set of science effects are systematically higher. The same applies to the comparison with English, except that-probably for reasons of English as second language etc.-the negative effects for English become substantially lower than those for maths.

Figure 3: Effect-sizes in Science and English compared with those for Maths



Discussion

The professional teaching skills promoted by CAME are an instance of what has been called a *context-delivered* intervention (Adey and Shayer, 1994, chapter 3). The overall intention is that of raising the thinking level of the pupils-that is, increasing both their capacity to process more complex information, and also their belief in their possession of that capacity. By placing this aim within a major school subject both pupil and teacher are provided a context enabling them to be metacognitive about their own learning processes. The preceding data-analysis was directed toward testing the way in which that aim may have been achieved.

From Figure 1 it can be seen that the effect of the CAME intervention on Key Stage 3 maths achievement was generally positive, and from Figure 3 it can be seen that the effect-sizes for each class indicate that large effects of between 0.5 and 0.7 standard deviations are possible. But over half the classes had effects which were either negative or below the level of statistical significance. We know that in some cases the low results were due to the class-teacher using half or less than half of the Thinking Maths lessons over the two-year period. But it does not help interpretation that the second largest effect-size in the Core I school (0.53 SD) and the one at -0. 18 SD were classes taken by the same teacher (the two large negative effect-sizes were from two small remedial classes). Interaction of teacher with class must be an important factor. But what is the cause of the enhanced mathematical achievement?-Is it due to the teaching of mathematical process skills?

The hypothesis of teaching maths process skills would explain the gains in maths achievement, and would also predict some, if lower, gains in science as well, since there is much mathematical modelling involved in the learning of science. But it would not predict any gains in English if the effect were simply transfer of training. The alternative hypothesis is that the context-delivered intervention has affected the learning ability of the pupils in general. This is supported by Figure 1 and the detail of Table 1. But the hypothesis ofmaths process skills appears contradicted by Figure 3: where the effects on mathematics were large enough to be statistically significant, the effects both on English and Science were even higher. It is not argued that the process skills of the pupils in mathematics were *not* affected-clearly they must have been improved- but the improvement was indirect, and due to the greater involvement of the pupils in awareness of their own thinking and learning. Hence the effects on the other two major subjects-an effect which has also been reported from the use of the sister project's methods in schools-CASE-see Shayer (1999). It would be misleading if this paradoxical conclusion were interpreted as indicating that CAME does not directly contribute to the art of maths teaching. Our subsequent experience of PD with teachers in schools adopting CAME is that they frequently report that they understand the learning problems of their pupils better, and this is even more marked in our current Leverhulme supported research with Primary school teachers with pupils in Year 5 and 6.

[1] The Concepts in Secondary Mathematics and Science programme (CSMS) was funded at Chelsea College from 1974 to 1979 by the Social Science Research Council, and produced surveys of some 14,000 children aged 10 through 16 on Piagetian tests and also 10 strands of mathematical concepts

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