DOES 'CAME' WORK? SUMMARY REPORT ON PHASE 2 OF THE COGNITIVE ACCELERATION IN MATHEMATICS EDUCATION, CAME, PROJECT

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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-pupil 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' attainments.

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' (Adey and Shayer, 1994) and as such is critical in terms of pupils reaching their potential. In CAME 1, 1993-95, we demonstrated the feasibility of the approach in Year 7 (Y7) and Y8, but not without considerable demands on teachers.

CAME 1 *Thinking Maths* (TM) lessons (30 over the two-year period) were carefully 'orchestrated' by the teacher: in managing small group work on well-defined challenges and in 'whole class' discussion. A key feature in the lessons is that the challenges are not 'closed', and in that sense they are similar to the 'investigations' which have become part of the National Curriculum, but with a focus on key mathematical strands (e.g., see Adhami et al, 1995, 1998). Further, the teacher's role becomes much more explicit in terms of mediating, as opposed to 'directing', the class activity. The focus is on pupils' thinking and the outcomes are not part of the normal expectations of pupils and teachers.

Aims and Objectives for CAME 2, 1995-97

The major aim of CAME 2 was to create an approach to both intervention and instruction in school mathematics in Y7 and Y8 such that (a) the cognitive development of pupils is enhanced through a context-delivered intervention, and (b) the proportion of pupils at level 6 and above in mathematics at the end of Key Stage 3 (Y9) is considerably increased. The main research aspect of the current phase, Le., by the end of Y8, was that of documenting the results of the intervention. This was done through two forms of data collection: detailed notes of observations of TM lessons (over 100 lessons were documented), and pupils' performance on two measures of achievement/development.

A related objective (ii) was to create a working relationship between researchers and whole school maths departments so that the ownership of the underlying intervention theory became that of the teachers. In such collaborative research much of the invention of specifics of classroom management and grounding the lesson content in mathematics was done by the teachers. The researchers responsibility was to assist in them in the appropriation of theory and to competently record the variety of detail.

A further objective (iii) was to address and solve the problems involved as teachers engaged in a long-term evolution of their teaching skills. Some of these problems were managerial: the researchers needed to ensure that each school addressed these in light of the long-term aim and objectives above. Others were conceptual: a form of professional development was offered throughout the work which respected the expertise of both partners to the enterprise.

The Programme

The project team undertook to work closely with four 'core' schools, designated C 1, C2, C3 and C4. When work commenced in September 1995 the decision had been made to include a further eight 'attached' schools, designated as Al through A8. The new schools were accepted on the condition that they administered the same pre- and post-tests as the core schools, and also sent representatives to the project's central Continuing Professional Development, CPO, programme. The reason for extending the school involvement was linked to objectives (ii) and (iii) above: we thought that bringing both groups of teachers, i.e., 'core' and 'attached', together in the central CPO sessions might assist the evolution of their teaching skills (by offering them the opportunity to form part of a wider collaborative community all working toward the same aim).

Research Methodology

The lesson observation notes provided confirmation on the implementation of the approach in the TM lessons in a variety of contexts (e.g., different ability groups and teaching styles). Thus the main focus in this paper is on the analysis of the quantitative data from the two assessments of cognitive development - one a general measure and the second specific to mathematics.

All core schools and six of the eight attached schools administered the *Thessaloniki Maths* test (TSLM) (Demetriou et al, 1991) as Pre-test in the Autumn term 1995, and as Post-test at the end of June 1997 (two attached schools have delayed in the administration of the Post-test for valid reasons). The TSLM test is in three sections: the four operations, the development of algebraic language and ratio and proportion. The test has been standardised (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.

In addition the science departments at schools C 1 and C2 also administered *Volume and Heaviness* PRT (Piagetian Reasoning Test (NFER, 1979» as Pre-test and *Pendulum* PRT as Posttest, so for these schools we have an estimate of the effect of the CAME intervention on pupils' general thinking ability.

All tests for the four core schools were marked by the researchers. The others were marked by the teachers in the school, and were subject to a 10% check on the marking consistency of the scripts for each class (only minor adjustments were required).

In addition there were end of Y8 Control Post-test data available from four schools (C 1, C4, A4, and A5) on the TSLM test collected in the first week of July 1996 on a year group who had not received the CAME intervention. The mode of data analysis was such that for each of the Control schools' 1995 Pre-test TSLM data, the CAME class means were ordered. Likewise with the 1996 Y8 Control classes. Then the top class of each data set was matched to the top class of the other, and then likewise down the list by class means [1]. This gives the data for a plot of expected Y8 against Y7 class means, so that the sampling unit for the control's regression is the same magnitude as that of the Y8 experimental classes. The effect size is then computed for each class as the residualised gain score -height of data-point above regression line for the control classes, divided by 1.05-(the root mean square standard deviation (SD) of the control's Y7 and Y8 SDs).

Results

The overall effect size for each of the 12 (actually 10) schools is given in Table 1 and, for illustrative purposes (due to space limitations), the mean scores for individual classes in the four schools which also provided the control sample are given i~ Table 2.

Table 1: School Pre- and Post-test Effects for the TSLM test

School C = Core; A = Attached		No. of classes	Effect-size (standard dev's)	Statistical significance
C1	Cambridge	7	0.40	p< 0.001
C2	Cambridge	4	0.17	?
C3	London	8	0.13	?
C4	London	8	0.43	p<0.001
A1	London	4	0.48	p< 0.001
A2	Newcastle	7	0.55	p<0.001
A3	Peterborough	6	0.28**	t=2.39, p<0.01
A4	Brightlingsea	8	0.01	n.s.
A5	London	8	0.37	p<0.001
A6	Manchester	8	0.19*	t= 2.19, p<0.025
A7/A8	Birmingham/Rochdale	-	post-test 1998	-

[1] Note that this method of data-analysis rests on the assumption that on average the Y7 intakes for successive years in the same school will have the same mean and range. Although this is not 100% true, with four schools variation would be expected to cancel out, so that the expected systematic error is minimal, at the expense of some random 'noise' being added to the data.

Table 2 Pre- and Post-test class and school means for schools C1, C4, A4 ar

School	Class	Tchr	Pre-	Post-	Control Y8	Effect size
Core 1		SM1	5.62	6.40		**0.31**
		SM2	5.86	6.88		**0.56**
		CS	6.76	7.81		**0.66**
		KW2	6.00	6.40		-0.02
		KW1	6.52	7.78		**0.84**
		LS2	4.94	5.15		-0.28
		LS1	4.47	5.78		**0.73**
		ALL	6.08	7.00	*6.69*	**0.40**
Core 4	8.1		5.24	6.59		**0.71**
	8.2		5.09	6.11		**0.43**
	8.3		4.90	6.03		**0.50**
	8.4		5.44	6.37		**0.37**
	8.5		5.59	6.84		**0.65**
	8.6		5.85	6.40		0.10
	8.7		5.80	6.72		**0.38**
	8.8		5.82	6.64		**0.31**
	ALL		5.45	6.47	*6.07*	**0.43**
Attchd 4	8S		6.10	6.16		-0.33
	8T		5.94	6.01		-0.33
	8U		5.89	6.32		0
	8V		5.45	6.29		**0.36**
	8W		5.39	5.93		0.07
	8X		5.52	6.45		**0.45**
	8Y		5.54	6.00		0
	8E		5.67	6.01		-0.10
	ALL		5.69	6.15	*5.84*	0.01
Attchd 5	W1		5.33	6.29		**0.46**
	W2		5.37	6.27		**0.41**
	G1		5.47	6.26		**0.31**
	G2		5.31	6.28		**0.47**
	M1		5.02	6.22		**0.67**
	M2		5.16	5.75		0.10
	T1		4.99	5.88		**0.36**
	T2		5.77	6.42		0.20
	ALL		5.30	6.17	*5.97*	**0.37**

In Figure 1 the effect-size for each class is shown along with the mean for the whole school (the column to the far right for each school). Any effect-size value over 0.3 is higWy significant statistically, and in addition any value ~.5 is usually regarded as being 'substantial' and ~0.8 as 'large'-that is, in terms of the *size* of the effect (in relation to the pupils' subsequent achievement). It can be seen that not only are there wide differences between schools, but also within schools there is wide variation between the effects shown by different classes.

Table 3 gives effect-sizes for the gains on the Piagetian tests for individual classes as well as the overall effect in schools Cl and C2 (two of the classes which had large effects on the TSLM test in Cl are missing, as they were low-level sets who were not given the Piagetian post-test). It can be seen that the results for C2 were uniformly good. C2 was one of the core schools where many *Thinking Maths* lessons were observed and recorded - providing further evidence that all the pupils were benefiting. Here the TSLM test items on the Algebra and Ratio and Proportion sections were probably above the pupils' 'ceiling' in all of the sets but one, so that there was less opportunity for the effects of the intervention to be shown on the TSLM test (Figure 1).

Figure 1: CLASS GAINS ABOVE EXPECTED GAIN OVER TWO YEARS

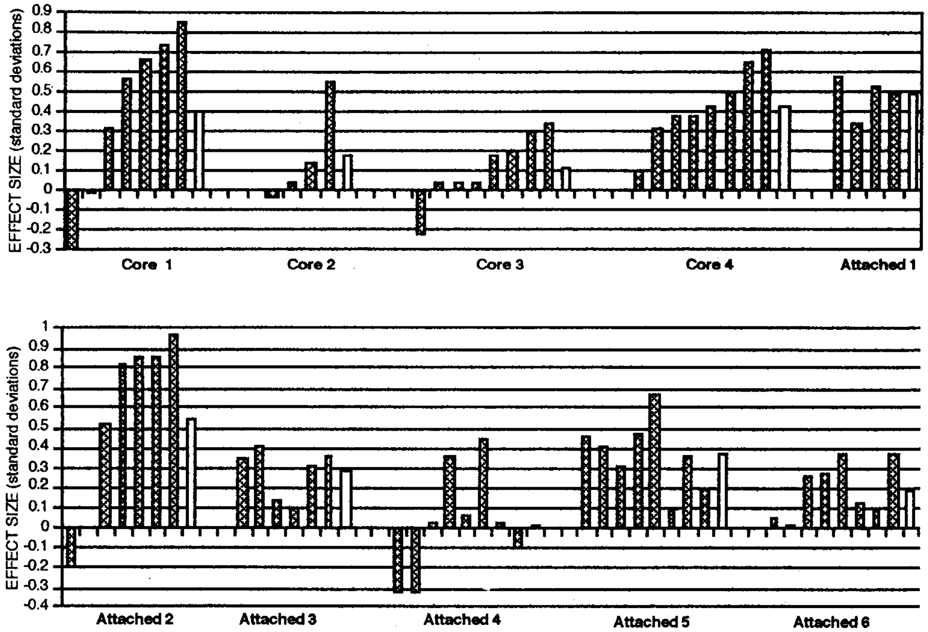

Table 3 Effect size (sd's) Pre- Post-test gains over expected on Piagetian tests

School	**Core 1**						**Core 2**				
Class	CS	KW1	KW2	SM1	SM2	**ALL**	TD1	TD2	AW1	AW2	**ALL**
Effect size	**0.56**	0.24	-0.08	**0.37**	**0.97**	**0.41**	**0.60**	**0.58**	**0.53**	**0.64**	**0.59**

Note: Significant effects are shown in bold

Discussion

When the two groups of schools shown in Table 1 are compared there is little to choose in their overall mean effects. Although the teachers in the core schools did get feedback from the researchers in the form of detailed lesson notes and researcher participation in department meetings (when scheduled to focus on CAME lessons), these were the only opportunities for providing support over and above that provided centrally, so it does appear that the central professional development seminars were an important feature in supporting all schools. The school showing the largest effects, A2 (see Figure 1), had been using other intervention methods since about 1991. During the CAME project the science teachers also used the CASE (Cognitive Acceleration through Science Education) materials *(Thinking Science)* and the two bottom classes also received the Feuerstein Instrumental Enrichment programme from other teachers during the two-year period of the CAME project. Thus the effects shown on the TSLM test cannot be attributed solely to the effects of CAME for this school.

For an overall evaluation of the potential of the *Thinking Maths* approach we think that Figure 2 best shows the story. Although the overall median effect-size is 0.34 SO, it can be seen that the distribution is tri-modal. The mode at the top is due (with one exception) entirely to Attached school 2

(A2). The second modal distribution, with a median about 0.5 SD, can be interpreted as representing the CAME approach in the hands of teachers who developed the new teaching skills required. The third distribution, with a median around zero, has not yet been analysed in detail, however on the basis of an initial consideration of lesson delivery, it would appear that in some cases this could be due to the fact that some teachers did not utilise the approach on any regular basis over the two-year period (for a variety of reasons, including difficulties in class management). This has been documented and in the case of, for example, Attached school 4 (A4), the uneven results are represented in the quite extreme variation in pupils' performance (see Table 2).

Figure 2 Stem and leaf distribution - Effects of the CAME Project

Stem														
1														
0.9	***0.96***													
0.8	***0.82***	***0.84***	***0.85***	***0.86***										
0.7	***0.71***	***0.73***												
0.6	***0.65***	***0.66***	***0.67***											
0.5	***0.50***	***0.52***	***0.52***	***0.55***	***0.56***	***0.57***								
0.4	***0.41***	***0.41***	***0.43***	***0.44***	***0.45***	***0.46***	***0.47***	***0.49***						
0.3	***0.31***	***0.31***	***0.31***	***0.31***	***0.32***	***0.34***	***0.35***	***0.36***	***0.36***	***0.36***	***0.37***	***0.37***	***0.37***	***0.38***
0.2	0.20	0.21	0.26	0.27	0.27									
0.1	0.10	0.10	0.10	0.13	0.13	0.14								
0	0.00	0.00	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.07				
-0.1	-0.04	-0.02	-0.01											
-0.2	-0.17	-0.10												
-0.3	-0.28													
-0.4	-0.33	-0.33	-0.30											

Notes: Sampling unit is one class (68 in all). Effect-sizes are in SD units of the TSLM test above or below the expected change over two years. Effect sizes given in bold-italics are statistically significant at p<0.0l.

The full story is yet to come. In July 1998 we will be collecting the results of National tests for Key Stage 3 (end of Y9). These will provide a more complete picture as to the potentiallong(er) term effects of the intervention on pupils' achievements - *pupils realising their potential.*

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