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Paper 1

MAGIC BULLETS OR CHIMERAS? SEARCHING FOR FACTORS CHARACTERISING EFFECTIVE TEACHERS AND EFFECTIVE TEACHING IN NUMERACY

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Magic bullets or chimeras? Searching for factors characterising effective teachers and effective teaching in numeracy

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***Abstract**: The National Numeracy Strategy has incorporated a change in pedagogy favouring whole class teaching and an interactive teaching style, which it has been claimed are effective in improving results. This paper questions the evidence for this. It also reports the work over the last four years of the Leverhulme Numeracy Research Programme on the issue of whether a particular kind of teacher or way of teaching produces higher learning gains. We have tried, mostly unsuccessfully, to identify any of a large number of factors relating to teachers and pedagogy which might have consistent and significant effects on student gains. We are as a result driven back to such internationally recognised factors as opportunity to learn and study time. Perhaps the differences between good and poor practice are associated more closely with differences in affect rather than differences in attainment?*

Pedagogy and the National Numeracy Strategy

The National Numeracy Strategy is widely regarded as one of the most successful educational initiatives launched in the first term of the Labour Government. The Task Force was being set up as Labour came into office, and was implemented in English primary schools in the academic year 1999/2000. The key features are:

- *an emphasis on calculation, especially mental calculation,* including estimation and appropriate selection from a repertoire of different strategies as well as recall of number bonds, multiplication tables and, eventually, standard written algorithms;
- *a three-part template for daily mathematics lessons,* starting with 10-15 minutes of oral/mental arithmetic practice, then *direct interactive teaching* of whole classes and groups, and finally 10 minutes of plenary review;
- *detailed planning using a suggested week-by-week Framework of detailed objectives,* specified for each year group;
- *a systematic and standardised national training programme,* run by newly appointed local consultants using videos and transparencies to demonstrate 'best practice'.

Thus although the Strategy has multiple features, including a shift in curriculum emphasis and a more tightly prescribed curriculum and teaching schedule, a change in pedagogy is perceived to be one of the more radical changes recommended. This pedagogy is not entirely new; indeed the Press Release accompanying the launch of the National Numeracy Strategy quoted from a speech made by David Blunkett at the North of England Conference in January, 1999, which described the initiative as reflecting an earlier postwar 'golden age':

> Numeracy is a vital skill which every youngster must learn properly. Yet for perhaps thirty years we have not focused on what we know works. The new daily maths lesson will ensure that children know their tables, can do basic sums in their heads and are taught effectively in whole class settings.

In fact, as Robin Alexander (1999) points out in commenting on the policies of the Blair Government, the 'golden age' he had in mind might equally well have been Victorian; he notes:

> the continuing resonance in late 20th century English Primary education of the structures and assumptions of the 19th century elementary education system. (p151)

As we have demonstrated (Brown et al., 2000), the change in pedagogy incorporated in the Numeracy Strategy derives owes much to the views of Chris Woodhead, as expressed directly and indirectly through HMI reports and other publications since the early 1990s.

The Strategy claims that the methods recommended derive from firm research evidence:

> We have aimed throughout our work to look at the evidence to find solutions to any problems with mathematics achievement, and to make practical recommendations based on methods that have been shown to be effective in raising standards of primary mathematics. (DfEE, 1998b, p.7)

A comprehensive description of that evidence, and the case for greater pedagogical prescription, has recently been provided by the Chair of the Task Force, David Reynolds (Muijs & Reynolds, 2001). However, although one of us was a member of the Task Force, we have some doubts about the strength of the evidence, which are discussed in this paper.

In view of the almost universal judgement that the Numeracy Strategy has been highly successful, it is interesting to note the trend of the Key Stage 2 national test results in mathematics in relation to those for science.

Subject	**Maths**			**Science**		
Levels	**5**	**4**	**4 or higher**	**5**	**4**	**4 or higher**
1997	18	44	62	18	50	68
1998	17*	42*	59*	16	53	69
1999	24	45	69	27	51	78
2000	24.5^	47.5^	72	34	50	84

Table 1: National test results, percentage distribution of levels awarded in mathematics and science at Key Stage 2, 1997-2000 *(Source: QCA, 2001a)*

* mental arithmetic tests were introduced for the first time in 1998

^ the results were presumably reported to the nearest 0.5 in 2000 as otherwise the rounded percentages would have been 24 and 47, summing to 71.

Two points become apparent from this table:

- the rise in the science results is more dramatic than the rise in mathematics results;
- the mathematics results rise most steeply between 1998 and 1999, the year *before* the Numeracy Strategy was implemented.

Since there has not been any recommended or observed change in classroom pedagogy for science, it must be assumed that the science scores improved for one or more of three reasons: the tests became easier, and/or the curriculum became closer to the test content, and/or the teachers became more expert at test preparation. Whatever weighting of these is responsible, there is no reason not to assume that the same factors were responsible for the improved figures for mathematics, where the improvement was much less dramatic. Thus there is no reason to infer that a change in pedagogy alone has had any effect on results.

The ministerial line was that the reason the largest improvement came in the year prior to the implementation of the strategy was because 70 per cent of schools had already starting implementing it early. If this is true, then the need for the £55 million dedicated to the implementation of the Strategy in 1999/2002 must be questioned. In fact the evidence from our visits to schools suggests that they had by 1999 already greatly increased the emphasis on mental calculation as a result of the 1998 changes in the national tests agreed under the previous government. As reported in detail in a later section, there was also more whole class teaching, but this was part of a longer term trend and not merely something which happened suddenly in 1998.

Of course it might justifiably be claimed that the full cumulative effect of the Numeracy Strategy would not become evident for a few years after the implementation. Nevertheless two preliminary surveys (TES 24/8/01) suggest that the increase in the percentage of pupils with Level 4 at Key Stage 2 in 2001 has been at most 3 percentage points. There have certainly been reports that ministers have been very disappointed with much less dramatic improvements in mathematics results than they had been led to anticipate.

Nor do the Key Stage 1 results for mathematics show very different trends, although in this case there is a slightly more gratifying change between 1999 and 2000:

Level	**3**	**2A or higher**	**2B or higher**	**2 or higher**
1997	20	45	65	83
1998	19	37	61	84
1999	21	41	63	86
2000	25	50	73	90

Table 2: National test results, showing cumulative percentage distribution of levels awarded in mathematics at Key Stage 1, 1997-2000, where Level 2 was split into 3 levels 2A, 2B , and 2C. *(Source: QCA, 2001b)*

Again the results do not suggest that the improvements reflect changes in pedagogy rather than in curriculum or test preparation.

The research evidence for the pedagogy of the Numeracy Strategy

Large scale surveys tend to find that only small effects on primary numeracy attainment that are due to the practices of individual teachers and schools, typically less than 10% of the variance that remains among pupils even after the effects of the much more powerful pupil variables have been removed (Mortimore et al., 1988; Creemers, 1997; Burstein, 1992).

In earlier articles (Brown et al., 1998; Brown, 1999) we have questioned whether in fact the evidence available to the Numeracy Task Force did clearly demonstrate the superiority of the 'whole class interactive teaching', the recommended form of pedagogy. In order to discuss this more concisely, it is necessary to distinguish first between the two most salient aspects of the 'new' pedagogy:

a) 'a high proportion' of *whole class teaching*, as opposed to group or individual teaching, and

b) the *'interactive'* character of the teaching style.

Whole class teaching

We will consider first the evidence on *whole class teaching'* . This is also sometimes referred to in the Numeracy Strategy training materials as 'direct teaching', drawing on 'direct instruction', a term utilised in the United States in the 1980s, and which Muijs and Reynolds (2001) consider to mean 'whole class teaching...in which the teacher is actively engaged in bringing the content of the lesson to students' (p.3). In spite of the claims of the Task Force that 'there is support in the research' for 'an association between more successful teaching of numeracy and a higher proportion of whole class teaching' (DfEE, 1998, p.19), the evidence is not unambiguous. It depends mostly on large-scale correlational studies, which cannot easily establish causation, and can only report variables that are measurable (Muijs & Reynolds, 2001). Many medium and large-scale studies in primary mathematics show no significant effect e.g.

Aitken, Bennett & Hesketh, 1981 (a re-analysis, after criticism, of the original data from Bennett, 1976); Burstein, 1992. In reviewing generic Dutch studies, Creemers (1997) noted that the proportion of whole class teaching appeared to have a significant correlation with attainment in only 3 out of the 29 studies, although the correlation is positive in all 3 cases.

In some large scale statistical studies it is true that there has been a positive correlation between the proportion of whole-class teaching and mathematics attainment (Galton, Simon and Croll, 1980; Galton and Simon (Eds), 1980; Good, Grouws & Ebermeier, 1983; Brophy & Good, 1986). However, noting that in cases of individual teachers, poor results have also been associated with whole class styles, investigators have in each of these cases cited evidence for the 'quality' of teacher-pupil interaction being a much more important factor than class organisation (Good & Grouws, 1979; Good and Biddle, 1988; Galton, 1995). These authors suggest that a whole class format may allow high quality teaching to have a greater effect, but may equally increase the negative effect of lower quality teaching. (What is meant by 'quality' is discussed in the next section on 'interactive' teaching, together with the evidence for the effectiveness.)

Galton in fact repeated part of his ORACLE study twenty years later in 1996, and showed that although the proportion of teacher interactions which took place with the whole class had risen from 19% in 1976 to 35% in 1996, there was nevertheless a significant fall in test results in mathematics and reading (Galton et al. 1999).

The data from TIMSS (the Third International Mathematics and Science Study), a survey carried out by the IEA in 1994, suggest a smaller proportion of English teachers of Year 5 pupils (11%) used whole class teaching in most mathematics lessons than that of teachers in almost any other country (Mullis et al., 1997). This lack of whole class teaching was considered by some to be a major factor in explaining the below average English score. The Numeracy Task Force therefore asked the National Foundation for Educational Research to carry out a detailed multi-level analysis of the English TIMSS data. However the analysis of the factors contributing to high achievement in Year 5 in TIMSS in English primary schools found that whole class teaching in most lessons was associated with lower attainment, although the level fell just short of significance. In contrast, use of individualised working from worksheets in most lessons was significantly associated with higher attainment. However one should not take the results too seriously as these effects were not found in the Year 4 sample. There is also some problem with the self-reporting of data as part of a questionnaire; in particular the TIMSS question was not particularly helpful as it related to the frequency rather than the proportion of time on whole class teaching. (These results have conveniently never been published, but were provided for members of the Task Force.)

That different forms of class organisation may have different strengths was shown by Peterson (1979), in a review of mathematical learning studies. She found that with the more direct approaches of whole class teaching, students tended to perform slightly better on achievement tests than they did where the teaching was in collaborative groups (although the effect sizes were small). However the pupils taught together as a class performed worse on tests of more abstract thinking, including creativity and problem-solving. Other American authors have confirmed that using small group collaborative learning was related to increased mathematics achievement on tasks at a higher cognitive level (e.g. Peterson and Fennema, 1985; Slavin, 1989), although once again Good, Mulryan and McCaslin(1992) in reviewing this work feel that it is the level of thinking generated rather than the format which is important.

In a more recent study in English primary schools, 'Effective teachers of numeracy', carried out at King's College for the Teacher Training Agency, again the beliefs and specific didactic practices of the teachers were closely related to mean gains whereas the amount of whole class teaching seemed to have little effect (Askew et al., 1997). In particular the teacher with the highest gains only taught in a group setting, and one teacher in an inner city school with very high gains only taught individually.

Thus many studies show no particular relation between whole class teaching and attainment. In those major primary studies that do show such an effect for mathematics, the authors without exception have claimed that the effect is more likely to have been due to other confounding variables, in particular the quality of teaching.

'Interactive' teaching

This takes us on to the evidence relating to *'interactive' teaching*, although there is some problem here deciding on the meaning of the term. Muijs & Reynolds (2001) reserve 'interactive teaching' for teaching which includes a high frequency of questions, but go on to suggest that the questioning must also be 'effective', which means including:

> the right mix of higher and lower-level questions, the best way to react to right and wrong answers and the use of prompting (p.17).

Many teachers however have reasonably taken characterisations such as:

> teachers provide clear instruction, use effective questioning techniques and make good use of pupils' responses (DfEE, 1998b, p14),

together with video extracts which reflect the emphasis on 'pacy' lessons, to mean simply that the whole class dialogue should be of the type which incorporates repeated 'question-answer', or more specifically IRF (item-response-feedback), sequences, sometimes degenerating into 'cued elicitation' or 'funnelling' (Bauersfeld, 1988; Voigt, 1985, 1994; Edwards & Mercer, 1987; Yang & Cobb, 1995). In this form of dialogue pupils are trying less to think mathematically than to iteratively guess what response their teacher requires. However at other points in the training, the importance of pupils being asked to describe and explain their strategies, and for teachers to use these as a focus for discussion, is also emphasised, as is the role of class questioning in providing information for formative assessment:

> Good direct teaching with the whole class is characterised by genuine communication about mathematics. Teachers give pupils the opportunity not only to show what they know, but to explain the reasons behind it , and suggest creative ways of tackling new problems. This gives teachers important feedback about where pupils may be uncertain and where they are not making connections between old and new knowledge. (DfEE 1998a, p.19)

Both international and English observational studies seem to show some agreement on some of the aspects of teacher quality which correlate with attainment. These include the use of higher order questions, statements and tasks which require thought rather than just practice; emphasis on establishing, through dialogue, meanings and connections between different mathematical ideas and contexts; collaborative problem-solving in class and small group settings; more autonomy for students to develop and discuss their own methods and ideas (Creemers, 1997; Galton, 1989; Bell, 1993; Cobb & Bauersfeld, 1995; Yackel & Cobb. 1996; Wood, 1996; Stigler and Hiebert 1997; Boaler, 1997; Askew et al., 1997). Many of these characteristics are technically espoused by the Numeracy Strategy although in practice other aspects of it militate against them. For example the requirement to cover large numbers of objectives in the rather short times allocated on the recommended teaching schedule may lead to a fast pace, in both dialogue and curriculum terms. This means that pressurised teachers may not always have the time or motivation to engage with pupils' ideas or states of learning or to allow them space for collaborative work or autonomous thought. (Some evidence about styles of interaction currently used by teachers is described later.)

In the TTA 'Effective teachers of numeracy' study (Askew et al., 1997), we found that low numeracy gains were obtained by *transmission* approaches, where teachers asked low-level factual questions more to move the lesson on in the desired direction rather to expose children's ideas. Such teachers demonstrated specific procedures that children were expected to follow, often preceded by practical and/or diagrammatic justifications. On the other hand teachers using *connectionist* approaches all had classes who obtained high gains. Connectionist approaches were characterised by teachers who attempted to connect both with the children's ideas and between different mathematical ideas and representations. This meant giving children time to develop, explain and negotiate their ideas.

These approaches have also been incorporated in the primary phases of the Reform movement launched by the Standards documents of the National Council of Teachers of Mathematics in the United States (NCTM, 1989, 2000). Emerging evidence suggests that where such approaches have been adopted they are raising achievement (U.S.Dept. Ed., 1999), in spite of a ‘Math Wars’ backlash from the academic and religious right. However, ironically, Stigler & Hiebert (1997) in the TIMSS video study noted that the methods recommended in the NCTM Standards, which were rarely recorded by them in the US schools, were very close to those observed in Japanese schools.

Hence while the research supporting the whole class teaching format required by the Numeracy Strategy is equivocal, there is more evidence for the effectiveness of many of the elements included in the definition of ‘interactive’ teaching. Nevertheless, as will be seen later, in many classrooms many of these elements are either not understood, or not perceived to be an important part of the Strategy, or for other reasons, such as competing and more salient messages, not implemented.

The Leverhulme Numeracy Research Programme

The Leverhulme Numeracy Research Programme (LNRP), based at King’s between 1997 and 2002, is a 5-year longitudinal study of the teaching and learning of numeracy *investigating factors leading to low attainment in primary numeracy in English schools, and testing out ways of raising attainment*.The study combines large-scale monitoring in a Core Project and in-depth case study investigations of different aspects of numeracy teaching and learning in five Focus Projects.

In the Core project two cohorts of children, one starting in Reception and one in Year 4, are being tracked through five years of schooling. The Core sample is drawn from 10 schools in each of 4 varied LEAs (now in the final year reduced to 36 schools), with schools selected according to size, religious affiliation, and mathematics attainment (both absolute and value-added). Each cohort contains about 1600 pupils in about 75 classes. Pupils are tested on our own overlapping sequence of numeracy tests, developed and trialled over a 15-year period, in October and June of each year.

All schools are visited once a year, with a single observation in each class and interviews with teachers, heads and co-ordinators. All teachers complete a questionnaire, adapted with permission from that used in the TIMSS study (Beaton et al., 1997; Mullis et al., 1997) about their beliefs, practice, experience and qualifications. Out of on average about 75 classes in each cohort each year the response rates for teachers’ questionnaires has been over 85%, and almost all the missing questionnaires were for classes where the class teacher had changed during the year.

In one of the Focus Projects, detailed case studies are being carried out of a subsample (six children from each cohort in each of five varied schools). This includes a week of classroom observation towards the start and end of each year, and individual interviews with children.

The mean gain between the numeracy attainment at the start and end of each year (early October and early June) are calculated for each class each year. In some years the results have had to be adjusted slightly (Tukey, 1997) to ensure that the average gains are constant across the attainment range, but generally the test design has ensured this. These class mean gains have then been matched against other data which is being collected to assess the contribution of various factors to effectiveness.

Determining what characterises effective pedagogy in the Leverhulme Numeracy Research Programme

Using the teacher questionnaire data, we examined the correlations between the Year 4 and Year 5 mean gains for each class against a range of variables In Years 4 and 5, with respect to biographical data (e.g. level of mathematical qualifications, years of experience, appointment to co-ordinator post) and to pedagogical factors including frequency of access to and use of calculators and frequency and type of homework set, no variables have been statistically significant across both years, and only a handful have reached significance in either year. Unlike the Effective Teachers of Numeracy study, we have not even so far found any connection with attendance at long term training courses in mathematics. The lack of association with biographical data, including mathematical qualifications, is supported by many other studies e.g. (Begle, 1979; Askew, 1997; Hay McBer, 2000).

That no pedagogical factors covered in the questionnaire have had an effect size of more than 0.25 in both years is perhaps even more surprising. Again there is considerable support for this in other studies (e.g. Begle, 1979; Mullis et al., 1997; Farrow et al., 1999; Ruthven, 1997). To quote from the most recent large-scale international study of mathematical attainment, TIMSS:

> "We have been poring over the data ...and there is just no simple answer." ...Beaton and his colleagues concluded that, while each (variable) probably has an effect, none by itself made a major difference. (Beatty (Ed.), 1997, p.8)

Whole class teaching

One of the variables which featured in the teacher questionnaire in years 4 and 5 was the frequency of whole class teaching. Using the same question as that in the 1994 TIMSS survey, so that a comparison would be possible, teachers were asked whether they taught the whole class together during most mathematics lessons. Unfortunately this was not the ideal question as it did not take into consideration the length of the period of whole class teaching. It also depended on self-reported data. We therefore matched the data from the questionnaire in the Autumn Term of each year with that in observation and interview data in the following Spring Term, and retained in the analysis only those 52 teachers on which we had consistent data which suggested that they taught the whole class together on a daily basis for at least 25 per cent of the lesson time.

The first interesting result was the change over time in the frequency of whole class teaching in most lessons, as shown in Table 3.

Study	Data source	Date	Year group	Percentage
TIMSS (national sample*)	Questionnaire only	1994	Year 5	11%
Leverhulme (65 teachers)	Questionnaire only	Autumn, 1997	Year 4	52%
Leverhulme (52 teachers)	Qu'aire, interview & observation	Spring, 1988	Year 4	60%
Leverhulme (66 teachers)	Questionnaire only	Autumn, 1998	Year 5	80%

Table 3: Percentage of teachers who teach the whole class directly most days for mathematics *(Source: Mullis et al., 1997, and Leverhulme data)*

** It is not easy to work out how many teachers were involved for Year 5 but the sample size was 128 schools so it seems likely to be at least 150.*

By 1999/2000, the year when the National Numeracy Strategy was introduced and Cohort 2 were in Year 6, the percentage was up to 100%. Thus there has been a major change in the pedagogy used in primary mathematics, which has increased significantly the use teachers make of whole class teaching. However it is clear that this had already started to take place before the Labour Government took office in Summer 1997.

The direction of these changes is consistent with those reported for observational studies in primary classrooms across all subjects. Pollard et al. (2000, p.56) give average figures of 18%, 26% and 34% of teacher-interactions which take place in whole class contexts for studies taking place in the 1970s, 1980s and 1990s respectively. As already noted, Galton's comparison in the same schools between 1976 and 1996 showed the proportion of teacher interactions taking place in a whole class setting rose 19% to 35% (Galton et al., 1999) .

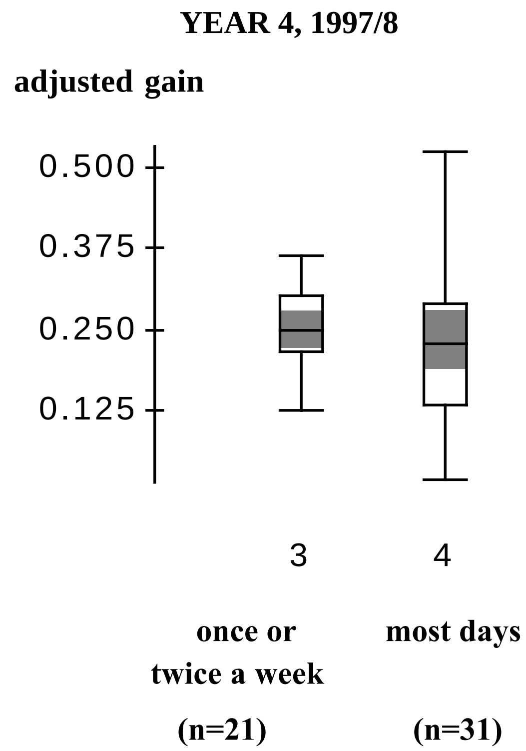
Even where teachers said they were not teaching the whole class together for mathematics most days, no teachers in our sample of 52 were using individualised work patterns with children working through books on their own at their own pace, which had been a more common pattern in the 1970s and 1980s (Galton, Simon and Croll, 1980; Galton and Simon (Eds), 1980). By the Spring Term 1998 all those teachers who were not teaching the whole class together most days said they did so at least once a week, most commonly at the start and finish of the mathematics topic which was being followed by all children, although often with work set at different levels of difficulty.

We examined the distribution of the mean class gains over the year for those who taught the whole class for substantial periods in most mathematics lessons and those who taught the whole class together only once or twice a week (See Figure 1). There was very little difference between the mean gains ($p > 0.4$ and $p > 0.8$ for Years 4 and 5 respectively). The teachers with a lower frequency of whole class teaching had slightly higher gains in Year 4 and slightly lower gains in Year 5. This research did therefore not support the belief that there was any benefit from a higher proportion of whole class teaching. However by 1997/8, two years before the Numeracy Strategy, there were no teachers who only taught the whole class very infrequently, so it was not possible to estimate the effectiveness of such methods.

This evidence therefore suggests two reasons why there was no real justification for the Strategy to prescribe an increased proportion of whole class teaching:

• there is no clear benefit

• if government policy was against extreme forms of individualisation for whatever reason, there were by 1998 no longer a significant number of classrooms where this existed.


YEAR 4, 1997/8
adjusted gain
0.500
0.375
0.250
0.125
3
4
once or twice a week
most days
(n=21)
(n=31)

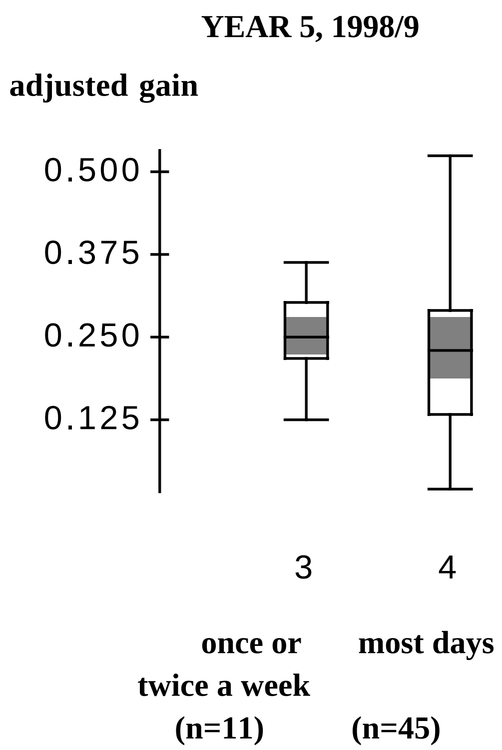

YEAR 5, 1998/9
adjusted gain
0.500
0.375
0.250
0.125
3
4
once or twice a week
most days
(n=11)
(n=45)

Figure 1: Boxplots showing mean class gains in Year 4 and Year 5 by teachers who taught the whole class every day and those who taught the whole class once or twice a week *(Source: Leverhulme data*) (Note: 3 and 4 denote groups; there were no teachers in these years in groups 1 and 2 which denoted those who taught the whole class for mathematics less frequently than once a week)

In both Year 4 and Year 5 the standard deviations of the group who do more whole class teaching are greater, as can be seen from the boxplots in Figure 1. In Year 4 this difference almost reaches significance at p=0.05, although the difference is much smaller in Year 5. This seems to give some qualified support to the suggestion in the research reviewed earlier that, by increasing the proportion of whole class teaching, effective teachers can improve the gains made by their classes, but less effective teachers may reduce them.

These results on whole class teaching therefore generally support the research findings quoted in the second section above, which can be summarised by a quotation from an American research review:

> At various times educators in this century have advocated as answers large-group instruction, small-group teaching and individualised teaching!...However it seems clear that simple characteristics of instruction have never predicted instructional effectiveness...The issue is not individualised instruction or small-group instruction, but rather the quality of thought and effort that can occur within these structures...(Good & Biddle, 1988 p.116)

Interactive teaching

Since neither the proportion of whole class teaching as assessed by questionnaire, observation and interview, nor other teacher or pedagogical variables elicited from the questionnaire yielded significant statistical associations with class mean gain, we then focused as Good and Biddle suggest on assessing the quality of the classroom teaching as assessed by classroom observation.

We have thus been seeking a descriptive framework based on lesson observations which may help us explore qualitative differences in lessons and their impact on pupils' learning. Rather than starting from any theoretical or professional basis for defining the characterisation of ‘quality’, we began by using an empirically based method. Using the Year 4 data we had obtained in the first year of the research programme, five members of the research team examined in detail the records of lessons taught by those teachers who had mean class gains which fell into the lowest 15 and highest 15 places out of 74 classes, looking among our sets of evaluative notes on each lesson for commonalities within and differences between these groups. Having pooled and discussed our findings, we listed 18 characteristics which we felt differentiated most reliably between the most and least effective teachers as measured by the class mean gains.

These were that the most effective teachers

- challenge pupils to think mathematically
- expose and relate to children’s existing knowledge
- develop significant mathematics e.g. strategies, generalisations
- develop connections between mathematical ideas, & between mathematics and the real world
- stimulate pupils’ interest, curiosity, excitement and sustain engagement
- don’t set artificial ceilings
- permit access to mathematics & task for all pupils
- have integrity of mathematics and context
- have consistency between task and objectives
- use symbols, diagrams and apparatus not for window dressing or as objects in themselves but to communicate, represent, and/or provide good models for thinking
- involve range of modes of expression
- encourage development of more sophisticated strategies
- focus on mathematics rather than work, or getting answers
- allow sharing of methods and value contributions of children
- show teacher working with children (use of ‘we’)

- recognise multiple meanings
- focus on reasoning not answers (not ‘cued elicitation’)
- accept and work with children’s errors.

Of course this list is not completely grounded in the data, but quite likely reflects our own philosophical positions too. Nevertheless we felt satisfied that the list did differentiate adequately between the group of teachers with the highest gains and those with the lowest; we recognised however that there were some exceptions in both groups.

Having tried to classify and organise these characteristics we found that the structure we were arriving at was closely related to Saxe's (1991) four-parameter model for examining emergent goals, we therefore adapted Saxe’s structure with some modifications to fit our observations. Our four main parameters are

- *Task*
- *Talk*
- *Tools*
- *Relationships & norms.*

These parameters were used to create some initial framing questions, which are presented below. (This is in fact a slightly amended set with small changes made after a year of use).

Tasks

• Mathematical challenge: To what extent does the lesson content/tasks mathematically challenge all pupils appropriately?

• Integrity & significance: Are the tasks of the lesson developed in ways that draw out mathematical/didactical integrity and significance?

• Engage interest: Do the lesson’s tasks engage pupils’ interest in the mathematical content?

Talk

• Teacher talk: To what extent does the teachers’ talk focus on mathematical meanings and understandings as co-constructed and not simply transmitted?

• Teacher-pupil talk: To what extent do teachers and pupils engage in discussion about the mathematics?

• Pupil talk: To what extent does the lesson encourage pupils to talk mathematically and display reasoning and understanding?

• Management of talk: To what extent is the lesson managed by the teacher to encourage engagement of all pupils in talk about mathematics?

Tools

* Range of Modes: Do the learning tools cover a range of modes of expression, e.g. oral, visual, kinaesthetic?

* Types of models: Are the models of mathematics didactically "good"?

Relationships & norms

• Community of learners : To what extent do teacher and pupils participate as a community of learners?

• Empathy: To what extent does the teacher display empathy with the pupils’ responses to the lesson, both affective and cognitive

Each question was developed into a four point scale (0-3) for evaluation of lesson observations, deriving the descriptions based on the Year 4 lesson observations and the associated gain ranks. This produced a lesson evaluation instrument (reproduced in full in the Appendix).

Having developed the instrument from ranking the classes on the basis of mean class gains for Year 4 (Cohort 2) we decided to test if we could use our framework to predict the ranking of the mean class gains for Year 5; matching the results with the outcomes would then provide a much more rigorous test of validity of the instrument. We therefore used the instrument to evaluate the lessons observed in the following year (1998/9), for both Cohort 2 (now in Year 5) and Cohort 1 (now in Year 1). Values of 0-3 were given for each question according to the evaluation instrument. Initially some lessons were scored by two of the four researchers involved in observing lessons: the researcher who originally observed the lesson and one other. Discussions about reconciling scores took place in the team of four, enabling us to clarify our interpretations of the scales and improve the degree of consistency. Once we were confident that our interpretations were consistent we scored our own observations. We later examined the means and standard deviations of the four assessors and checked that they were reasonably similar.

Finally we totalled the scores for each lesson and plotted them against the class mean scores after they had been analysed the following Autumn.

Figure 2 shows the results of our scoring of the Year 5 lessons and Figure 3 the scoring of the Year 1 results. Both clearly demonstrate that the scores were not good predictors of mean class gains, with Sprerman’s rank correlations of only 0.11 and 0.08 respectively.

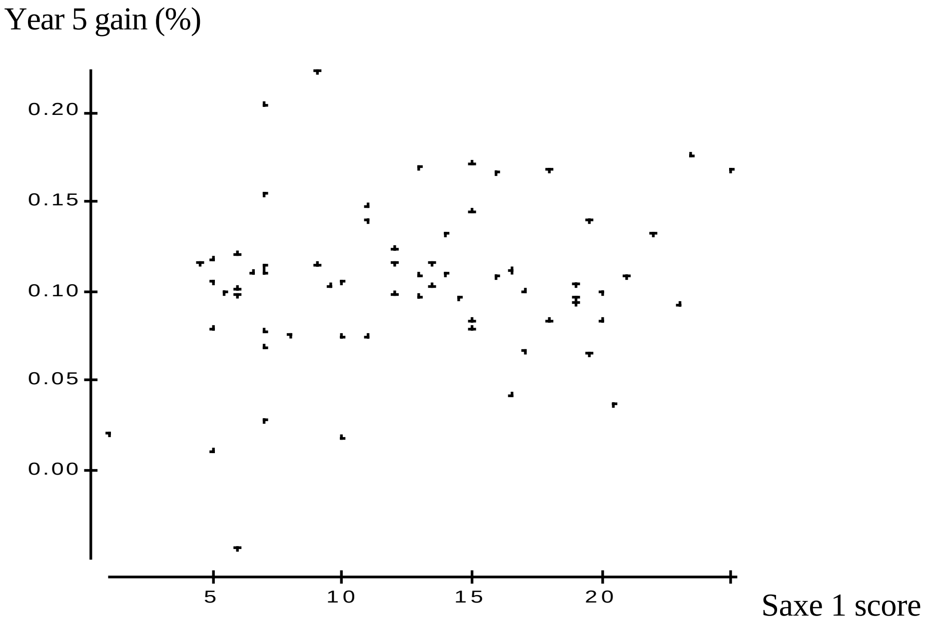


Figure 2 Year 5 class mean gain vs. Saxe 1 lesson evaluation score (r = 0.11)

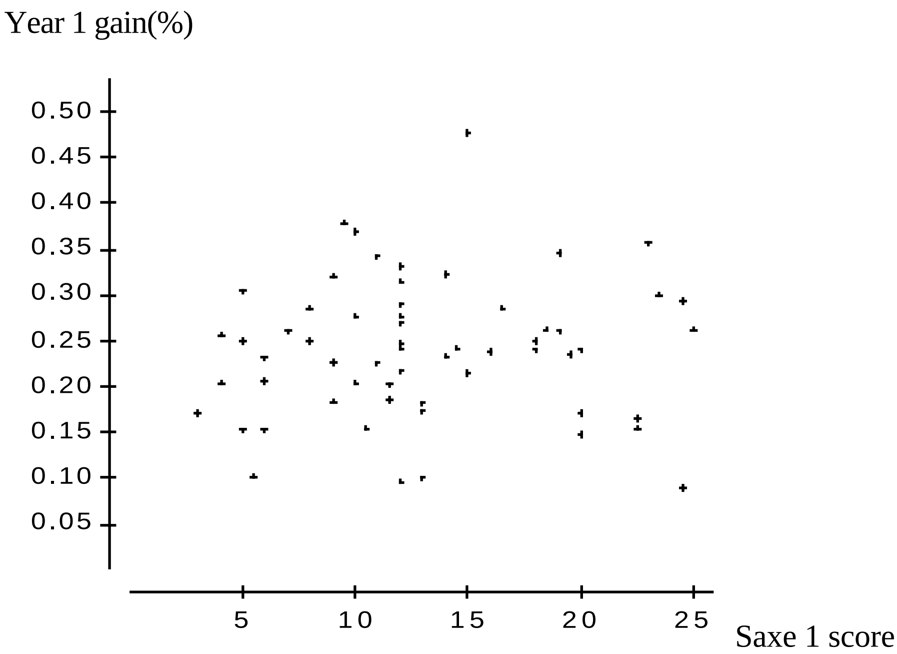


Figure 3 Year 1 class mean gain vs. Saxe 1 lesson evaluation score (r = 0.08)

After this failure to be able to predict the results for Years 5 and 1 we discussed the possible problems and tried again the following year (1999/2000) with a slightly amended instrument to predict the results for Years 6 and 2. The results were however only marginally more successful, with Spearman's rank correlations between the lesson evalution scores and the class mean gains of 0.39 and 0.18.

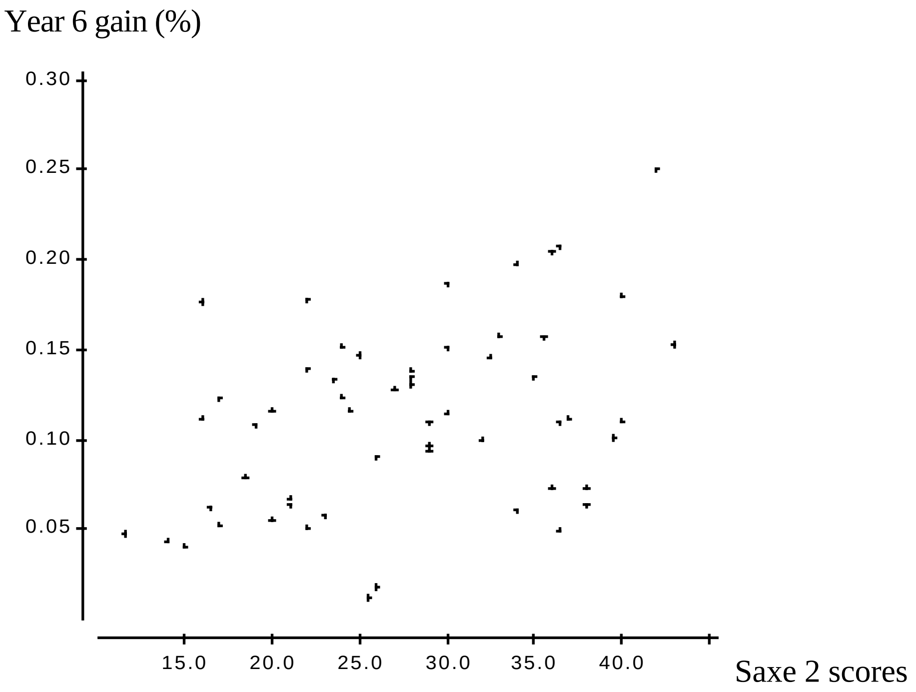


Figure 4 Year 6 class mean gain vs. Saxe 2 lesson evaluation score (r = 0.39)

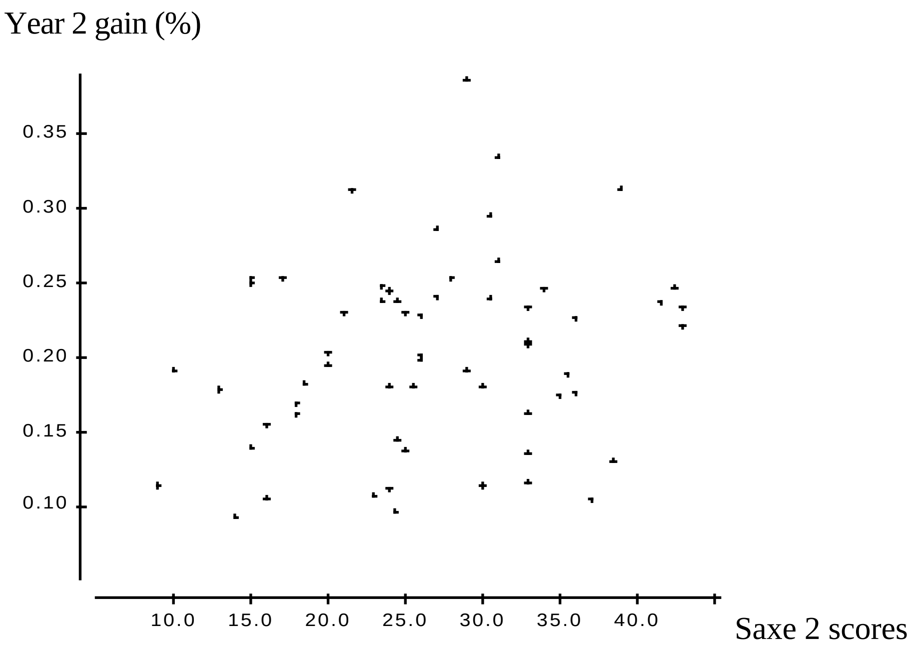
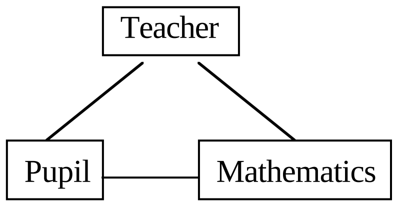


Figure 5 Year 2 class mean gain vs. Saxe 2 lesson evaluation score (r = 0.18)

It is not clear why there is a stronger correlation in the case of the Year 6 figures than for others; perhaps because with the considerable practice for the national Key Stage 2 tests which we observed there is greater similarity of the curriculum between different classes which makes any pedagogical factors more salient. However after several attempts we were still at best only able to account for about 15% of the variance.

During that same year (1999/2000) we tried yet one more time. We had been aware that the instrument based on the Saxe categories, in both its first (Saxe1) and second (Saxe 2) versions, was complex and we felt in completing it that there was considerable redundancy. We therefore returned to our work on the TTA Effective Teachers of Numeracy project (Askew et al., 1997) in which we termed the most effective teachers connectionist and decided to focus on the connections that were being made in the classroom. We selected the triad:



We then focused for each lesson on the strength of the connections between:

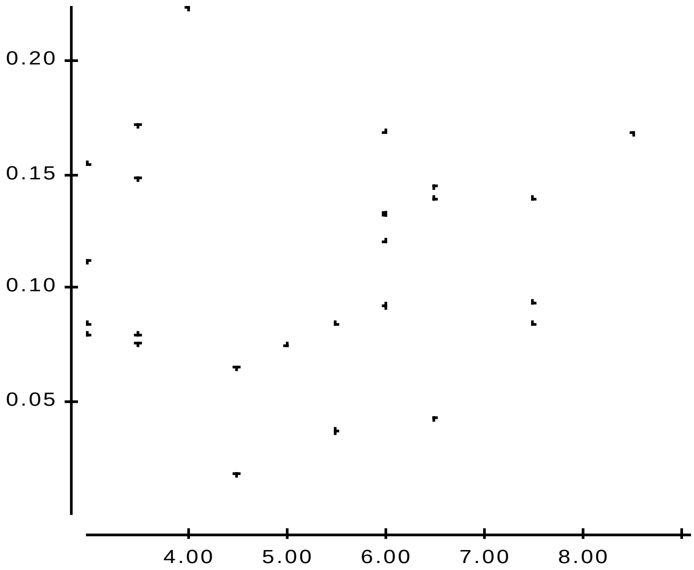
• the teacher and the pupil, in the context of the mathematics

• the teacher and the mathematics, in the context of the pupils

• the pupils and the mathematics, in the context of the classroom.

Using the definitions of connectionist teachers in Askew et al (1997) , we rated each leg of the triad on a 1-3 scale. However this time we just rated those lessons with classes with the 15 highest and 15 lowest mean class gains, covering just less than half of the teachers. We plotted the separate scores, since we noted some lessons which were much higher or lower on one relation than on the other two, and the total scores for all three legs of the triad. The results for the total are in Figure 6 and for the separate legs in Figure 7.

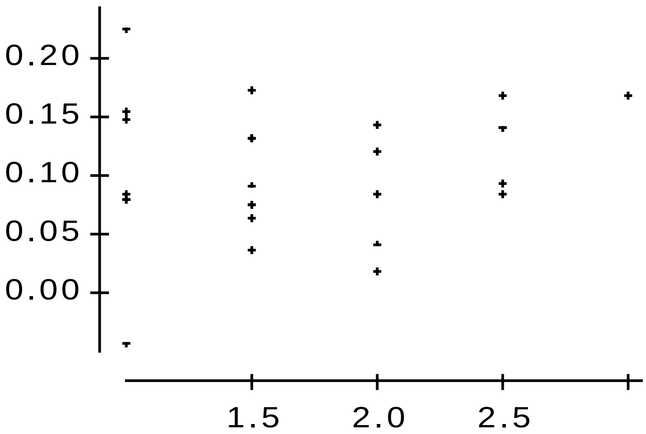
Year 5 gain (%)



Total triad score

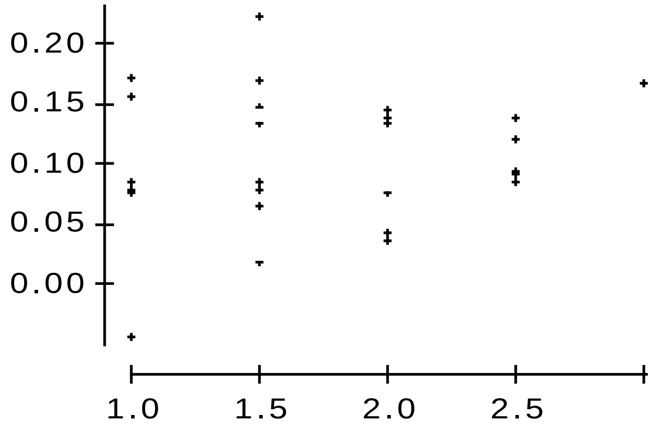
Figure 6 : Year 5 class mean gain vs. total triad score (r = 0.14)

Year 5 gain (%)



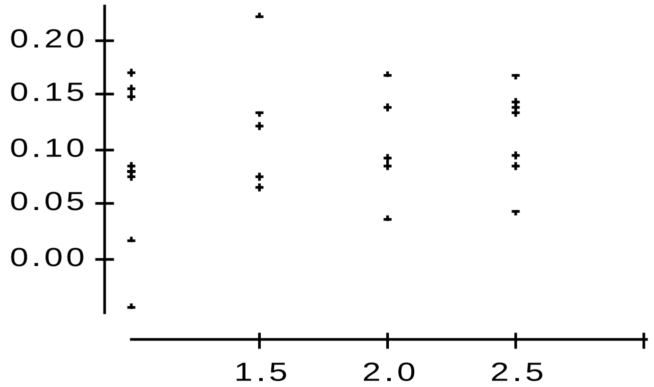
Teacher-Maths relation (r = 0.16)

Year 5 gain (%)



Pupil-Maths relation (r = 0.12)

Year 5 gain (%)



Teacher-Pupil relation (r = 0.18)

Figure 7 : Year 5 class mean gain vs.triad scores

It is clear that although we find this triad model the most appropriate one now for describing qualitatively the relationships in a lesson, and are using it in the qualitative analysis, it has no more predictive power than the other evaluative models.

We have considered what can be the causes of our difficulty in describing reliably the characteristics of effective teaching. The problem could be that our instruments for assessment of pupils and/or of lessons are not sufficiently reliable. This is quite possible, but if this is the case we are suspicious of those who would claim to be able to do better. We have been working to refine our tests over a period of about 10 years and our evaluation instruments over about 5 years. We do not believe that either Ofsted ratings for lesson evaluation or national test results for pupil assessment are any more reliable than our instruments. We are also aware that most of these ratings are on the basis of one lesson; yet for some 40 teachers we have 10 lessons each and we feel that most of these would be very similar in their ratings.

We are therefore left with the perhaps rather happy conclusion that the behaviour of effective teachers and less effective teachers are not easily characterised; much depends on the particular way that teachers and classes as people relate together. There are signs that certain types of behaviour may often lead to higher gains, but there are always exceptions in both directions. Indeed we have several teachers who appear twice or more in our sample and there is sometimes a considerable difference in their effectiveness as measured by the gain scores with different classes.

Conclusion

By examining the literature and the data from the Leverhulme Numeracy Research Programme we have found that:

• the evidence for the effectiveness of whole class teaching is much less strong than is claimed

• although there is some evidence that certain behaviours are effective in teaching mathematics their effect seems to be small and variable.

The results therefore throw doubt on the claims that teacher effectiveness can reliably be assessed by classroom observation, either by Ofsted inspectors or by headteachers or assessors in deciding on threshold promotions. Indeed the Hay McBer study (Hay McBer, 2000) on which the latter is based is likely to be flawed on account of:

- the quality of the assessment data;
- the fact that 21% of the cases (35% in the ‘outstanding’ group) were judged to be awkward and were simply omitted from the analysis (para 3.1.6, 3.2.5, 3.3.8);
- the use of Ofsted-type observation data (para 3.3.5);
- low sample sizes e.g. only 28 teachers in the outstanding group across *all phases and subjects (para 3.3.8).*

The results also throw some doubt on the premises of the Numeracy Strategy that there will be a significant rise in standards as a result of changing the pedagogy; it seems most likely from the evidence so far that if there is such a rise, which must still be in doubt, the curriculum taught is a much more salient factor, as has been shown in a number of international studies, for example:

> All we can safely say (we hope) is that students do experience different types of instructional arrangements cross-nationally and that the influence of these arrangements generically appears to be weak relative to such matters as prior learning and the contents of learning opportunities during the course of study. (Burstein, 1992, p.278)

What we are considering now as a result of the Leverhulme Programme is that maybe teacher characteristics described by our Saxe models and the triad models are more closely related to affect than attainment gain. But that is another project!

References

Aitken, M., Bennett, N. and Hesketh, J. (1981) Teaching Styles and Pupil Progress: a re-analysis. *British Journal of Educational Psychology, 51*, 170-186.

Alexander, R. (1999) Culture in Pedagagy, Pedagogy across cultures, in: R. Alexander, P. Broadfoot & D.Phillips (Eds) *Learning from Comparing: new directions in comparative educational research . Vol I, Contexts, Classrooms and Outcomes,* pp. 149-180 (Wallingford, Symposium Books).

Askew, M., Brown, M., Rhodes, V., Wiliam, D. and Johnson, D. (1997) *Effective Teachers of Numeracy.* London: King's College London.

Beaton, A E, Mullis, I V S, Martin, M O, Gonzalez, E J, Kelly, D L and Smith, T A (1996) *Mathematics Achievement in the Middle School Years: IEA's Third Mathematics and Science Study*. Chestnut Hill, Massachusetts: Boston College.

Beatty, A. (Ed.) (1997) *Learning from TIMSS - Results of the Third International Mathematics and Science Study: Summary of a Symposium.* Washington,DC: National Academy Press.

Begle, E.G. (1979) *Critical Variables in Mathematics Education*. Washington, DC: Mathematical Association of America.

Bennett, N. (1976) *Teaching Styles and Pupil Progress*. London: Open Books.

Brophy, J. E. & Good, T. L. (1986) Teacher behavior and student achievement. In M. Wittrock (Ed.) *Handbook of Research on Teaching* (p.328-375). New York: Macmillan.

Brown, M., Askew, M., Baker, D., Denvir, H. & Millett, A. (1998) Is the national numeracy strategy research-based*? British Journal of Educational Studies, 46*, 4, 362-385.

Brown, M. (1999) Is whole class teaching the answer? *Mathematics Teaching, 169,* 5-7.

Brown, M., Millett, A., Bibby, T. & Johnson, D.C. (2000) Turning our attention from the what to the how: the National Numeracy Strategy. *British Educational Research Journal, 26,* 4, 457-471.

Burstein, L (1992) *The IEA Study of Mathematics III: student growth and classroom processes.* Oxford: Pergamon Press.

Creemers, B. (1997) *Effective schools and effective teachers: an international perspective.* Warwick: Centre for Research in Elementary and Primary Education

Department for Education and Employment (DfEE) (1998b) *The Implementation of the National Numeracy Strategy: The final report of the Numeracy Task Force.* London: DfEE.

Farrow, S., Tymms, P. & Henderson, B. (1999) Homework and attainment in primary schools. *British Educational Research Journal,* 25 (3), 323-341.

Galton, M., Simon, B. and Croll, P. (1980) *Inside the Primary Classroom*. London: Routledge.

Galton, M., and Simon, B. (Eds) (1980) *Progress and Performance in the Primary Classroom*. London: Routledge.

Galton, M. (1995) *Crisis in the Primary School.* London: Routledge.

Galton, M., Hargreaves, L., Comber, C., & Wall, D. , with Pell, A. (1999) *Inside the Primary Classroom : 20 Years On.* London: Routledge.

Good, T. & Grouws, D. (1979) The Missouri Mathematics Effectiveness Project: An experimental study in fourth-grade classrooms. *Journal of Educational Psychology,* 71, 355-362.

Good, T.L., Grouws, D.A., & Ebmeier, H. (1983) *Active Mathematics Teaching.* New York: Longman.

Good, T.L. & Biddle, B.J. (1988) Research and the improvement of mathematics instruction: the need for observational resources. In D.A. Grouws & T.J. Cooney (Eds.), *Perspectives on Research on Effective Mathematics Teaching*,(p.114-142). Reston, Va.: NCTM/Lawrence Erlbaum.

Good, T.L., Mulryan, C., and McCaslin, M. (1992) Grouping for instruction in mathematics: a call for programmatic research on small-group processes. In D. A. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning*. New York: Macmillan.

Hay McBer (2000*) Research into Teacher Effectiveness. Phase 2 report : A model of teacher effectiveness.* London Hay McBer for the DfEE.

Mortimore, P., Sammons, P., Stoll, L., Lewis, D. and Ecob, R. (1988) *School Matters: The Junior Years.* Wells: Open Books.

Mullis, I. V. S, Martin, M. O., Beaton, A. E., Gonzalez, E. J., Kelly, D. L. & Smith, T. A. (1997) *Mathematics Achievement in the Primary School Years: IEA's Third Mathematics and Science Study*. Chestnut Hill, Massachusetts: Boston College.

Muijs, D & Reynolds, D. (2001) *Effective Teaching: Evidence and Practice.* London: Paul Chapman Publishing.

National Council of Teachers of Mathematics (NCTM) (1989) *Curriculum and Evaluation Standards for School Mathematics*. Reston, VA: NCTM.

National Council of Teachers of Mathematics (NCTM) (2000) *Principles and Standards for School Mathematics*. Reston, VA: NCTM.

Peterson, P. L. (1979) Direct instruction reconsidered. In P. L. Peterson & H. J. Walberg (Eds.*) Research on Teaching: Concepts, findings and implications* (pp 57-69). Berkeley, CA: McCutchan Publishing Corporation.

Peterson, P. & Fennema, E (1985) Effective teaching, student engagement in classroom activities, and sex-related differences in learning mathematics*. American Educational Research Journal, 22*(3), 309-335.

Pollard, A. & Triggs, P., with Broadfoot, P., McNess, E. & Osborn, M. (2000) What Pupils Say: Changing Policy and Practice in Primary Education. London: Continuum.

Qualifications and Curriculum Council (QCA) (2001a*) Standards at Key Stage 2: English, Mathematics and Science.* London: QCA

Qualifications and Curriculum Council (QCA) (2001b) *Standards at Key Stage 1: English and Mathematics.* London: QCA

Ruthven, K. (1997) *The Use of Calculators at Key Stages 1-3 (Discussion Paper no. 9).* London: School Curriculum and Assessment Authority.

Saxe, G. B. (1991) *Culture and Cognitive Development: Studies in mathematical understanding.* Hillsdale, N.J.: Lawrence Erlbaum Associates, Inc.

Slavin, R. (1989) Co-operative learning and student achievement. In R. Slavin (Ed.), *School and Classroom Organisation*. Hillsdale, NJ: Lawrence Erlbaum.

Stigler, J. W. & Hiebert, J. (1997) Understanding and improving classroom mathematics instruction. *Phi Delta Kappan,* September 1997, 14-21.

Tukey, J.W. (1977). *Exploratory Data Analysis.* Reading, MA: Addison-Wesley.

United States Department of Education, Mathematics and Science Expert Panel (1999) *Exemplary Promising Mathematics Programs*. Washington: US Department of Education.

Appendix : Instrument for evaluating mathematics lessons

TASKS

Mathematical challenge			
All/nearly all pupils are appropriately challenged mathematically, e.g. • most of pupils, most of the time appear to be doing mathematics which challenges them to think mathematically • pupils have some control over level of difficulty	About half the pupils are appropriately challenged all of lesson/all pupils appropriately challenged for a part of the lesson, e.g. • good differentiation in main part of lesson, plenary/intro. not adequately differentiated	Some pupils are doing appropriately challenging work for some of the time.	No/very few Pupil are doing work which is appropriately challenging
Integrity & significance			
Lesson tasks have high mathematical integrity and significance, e.g. • pupils are encouraged to develop significant connections either within maths or to the application of ideas. • pupils are encouraged to generalise on the basis of the outcomes of tasks	Lesson tasks have some math'l integrity and significance, e.g. • pupils can describe different ways of checking their answers; where they might use this mathematics.	While lesson is mathematically sound, it is not enacted in such a way as to draw on integrity or significance, e.g. • opportunities for pupils to make appropriate connections between different aspects of mathematics or to appropriate applications are not drawn upon • pupils are not encouraged to generalise from the tasks.	Pupils carry out tasks as routines and appear to have no meanings or connections beyond this.
Engage interest			
All/nearly all the pupils are engaged in doing mathematics for nearly all of the lesson	Around half of the pupils are engaged/ most pupils are engaged for around half of the time	A few pupils are engaged/most pupils are engaged for a little of the time in doing mathematics	Virtually no pupils are engaged in doing mathematics

TALK

Teacher talk			
Teacher talk demonstrates high level of attention to developing shared mathematical meanings, e.g. • awareness of distinction between objects or symbols and mental objects. • draws on different models to provide further explanations	Teacher talk demonstrates some attention to developing shared mathematical meanings, e.g. • teacher provides elaborated explanations	Teacher talk demonstrates belief in meaning residing in texts rather than being brought to them by the subject, e.g. • teacher gives reasons and/or meanings but assumes that a single way of explaining will convey meaning	Teacher talk demonstrates belief in mathematical meaning simply needing to be transmitted, e.g. • instructs pupils in procedures. • no reasons given that might help develop relational understanding.
Teacher-pupil talk			
Teacher-pupil talk displays high level of features of discussion, e.g. • provides mathematical feedback on pupils explanations. • pupils take initiative to feedback to teacher, seek clarification and ask questions	Teacher-pupil talk displays some features of discussion, e.g. • teacher feedback to pupils on reasons and explanations is praised irrespective of mathematical content. • pupils only communicate their understandings to teacher when asked	Teacher-pupil talk is directed by teacher and does not feature any elements of discussion, e.g. • feedback provided to pupils by teacher limited to whether or not answers are correct • pupils expected to feedback correct answers to teacher.	No teacher-pupil talk beyond closed questions and answers
Pupil talk			
Many pupils are frequently encouraged to provide extended accounts of reasons / understandings.	Some pupils are afforded the opportunity to provide extended accounts of reasons and understandings	Opportunities to encourage pupils to display reasoning are not used, e.g. • questions do require pupils to figure out answers but little opportunity for extended explanations.	Pupils do not express their reasons or understandings

Management of talk			
Lesson is skillfully managed to encourage maximum participation of all pupils, e.g. • pupils are encouraged to engage with each others' explanations, questioning and seeking clarification • teacher checks that pupils are attending to each others explanations	Lesson is managed to encourage participation of pupils who are selected to talk, but not the engagement of the others.	Opportunities to engage pupils in talk are not used, e.g. • pupils explain reasons and understandings but mainly to the teacher. • pupils do not engage with each others' explanations	Talk is not managed at all effectively

TOOLS

Range of Modes			
The tools provided for the lesson enable most pupils to engage with those most suited to their learning styles, e.g. • range of modes to suit range of learning styles/preferences • pupils encouraged to select and work with tools of their choice.	The tools provided for the lesson enable some pupils to engage with those most suited to their learning styles, e.g. • some range of modes but not all • teacher determines which tools to use.	The tools provided for the lesson only enable pupils to engage infrequently with those most suited to their learning styles, e.g. • some range of modes but not necessarily within one lesson.	No attention to learning styles, e.g. • modes limited to one only (e.g. 'chalk and talk' or only unifix cubes)
Types of models			
Models used are appropriate and effective for tasks, e.g. • models are useful in going from "model of" to "model for".	Range of models used but teacher does not draw pupils attention to the limitations of any particular models.	Models provided may lead to unitary view of concepts, e.g. • fractions always as bits of pizza, subtraction as 'take-away'	Models only provide window dressing.

RELATIONSHIPS AND NORMS

Community of learners			
Teacher explicitly works on developing classroom as a community of learners, e.g. • norms are explicitly communicated to pupils. • teacher provides explicit feedback to pupils on expected norms.	Teacher appears to have expectations of norms that might lead to a community of learners but does not explicitly share these with pupils.	Classroom norms separate teacher and pupil - roles are not seen as mutually dependent, e.g. • I teach - you learn • you discover - I facilitate	Classroom norms based on mathematics as jobs to be done rather than ideas to learn about
Empathy			
Teacher displays high level of empathy with all pupils and encourages them to feel good about themselves as learners of mathematics even if this involves struggle.	Teacher displays some empathy with some pupils.	Teacher displays awareness of pupils affective and cognitive responses but does not work with these.	Teacher displays little/no empathy with pupils.

Magic bullets or chimeras? Searching for factors characterising effective teachers and effective teaching in numeracy

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Esther Ranson and Dylan Wiliam

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National test results, percentage distribution of levels awarded in mathematics and science at Key Stage 2, 1997-2000

(Source: QCA, 2001a)

	Maths			Science		
Level	**5**	**4**	**>=4**	**5**	**4**	**>=4**
1997	18	44	62	18	50	68
1998	17*	42*	59*	16	53	69
1999	24	45	69	27	51	78
2000	24.5	47.5	72	34	50	84

* mental arithmetic tests were introduced for the first time in 1998

- *’whole class teaching* ...(direct instruction)...in which the teacher is actively engaged in bringing the content of the lesson to students’ (p.3)

- ‘*interactive teaching* ...effective questioning techniques... (including) the right mix of higher and lower-level questions, the best way to react to right and wrong answers and the use of prompting’ (p.17).

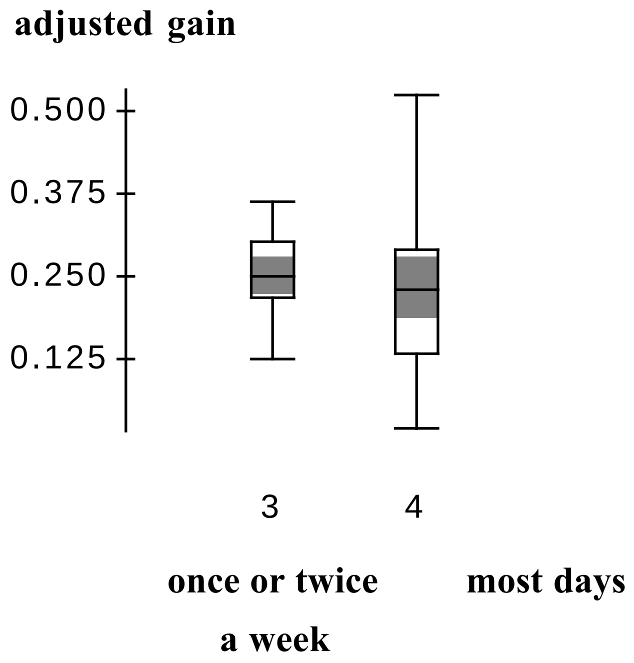
Muijs & Reynolds (2001)

Percentage of teachers who teach the whole class directly most days for mathematics

(Source: Mullis et al., 1997, and Leverhulme data)

Study	Data source	Date	Year group	Percent
TIMSS (national sample)	Qu’naire only	1994	Year 5	11%
Lev’h’me (n=65)	Qu’naire only	Autumn, 1997	Year 4	52%
Lev’h’me (n=52)	Qu’aire, interview & obs’v’n	Spring, 1988	Year 4	60%
Lev’h’me (n=66)	Qu’naire only	Autumn, 1998	Year 5	80%

Frequency of whole class teaching
Year 4, 1997/8



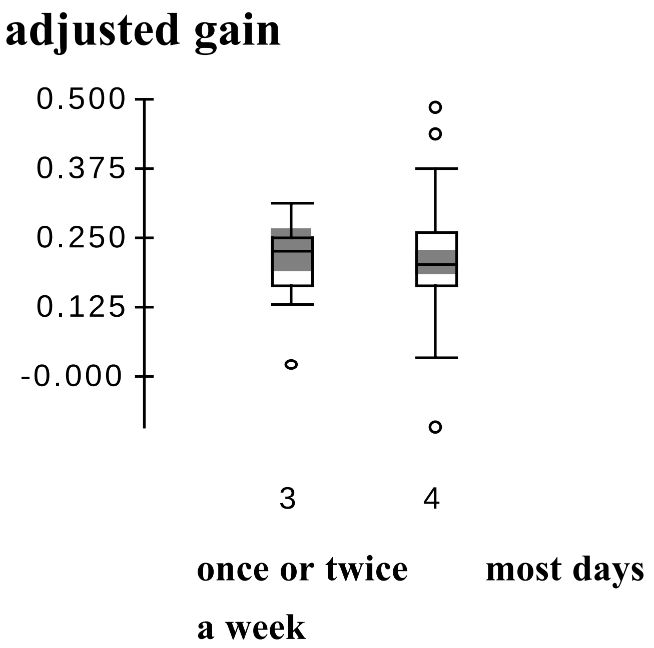
Summary of **TeachTG**
For categories in **Q1a**
No Selector
65 total cases of which 13 are missing

Group	Count	Mean	StdDev	PopStdv
3	21	0.254440	0.065460	0.063882
4	31	0.231059	0.122287	0.120299

Analysis of Variance For **TeachTG**
No Selector
65 total cases of which 13 are missing

Source	**df**	**Sums of Squares**	**Mean Square**	**F-ratio**	**Prob**
Const	1	3.00773	3.00773	281.45	≤ 0.0001
Q1a	1	0.006844	0.006844	0.64044	0.4273
Error	50	0.534324	0.010686		
Total	51	0.541168			

Frequency of whole class teaching
Year 5 1998/9



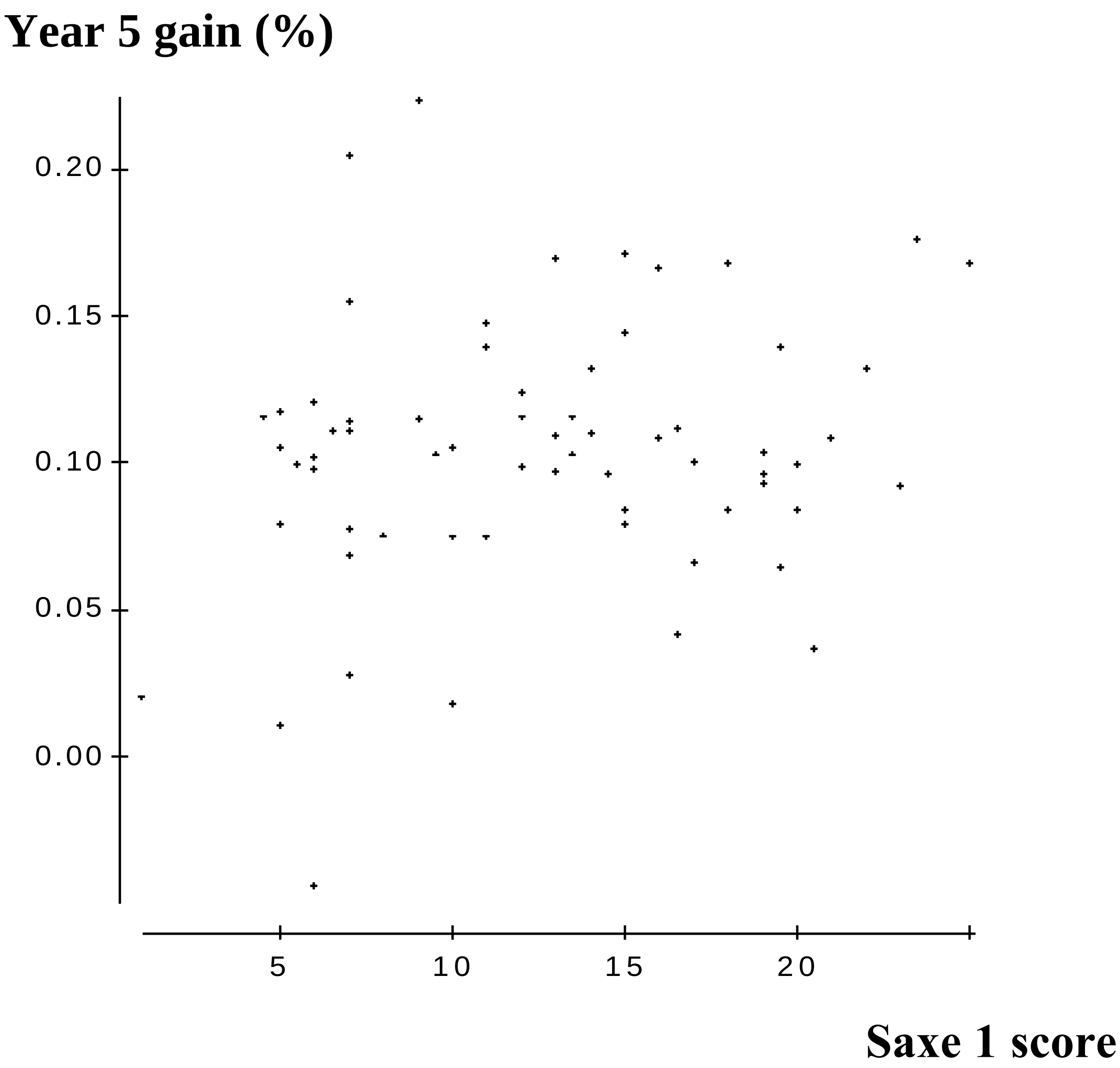
Summary of **Teach TG**
For categories in **Q1a**
No Selector
127 total cases of which 71 are missing

Group	Count	Mean	StdDev
2	0	•	•
3	11	0.207796	0.079007
4	45	0.216300	0.106148
5	0	•	•

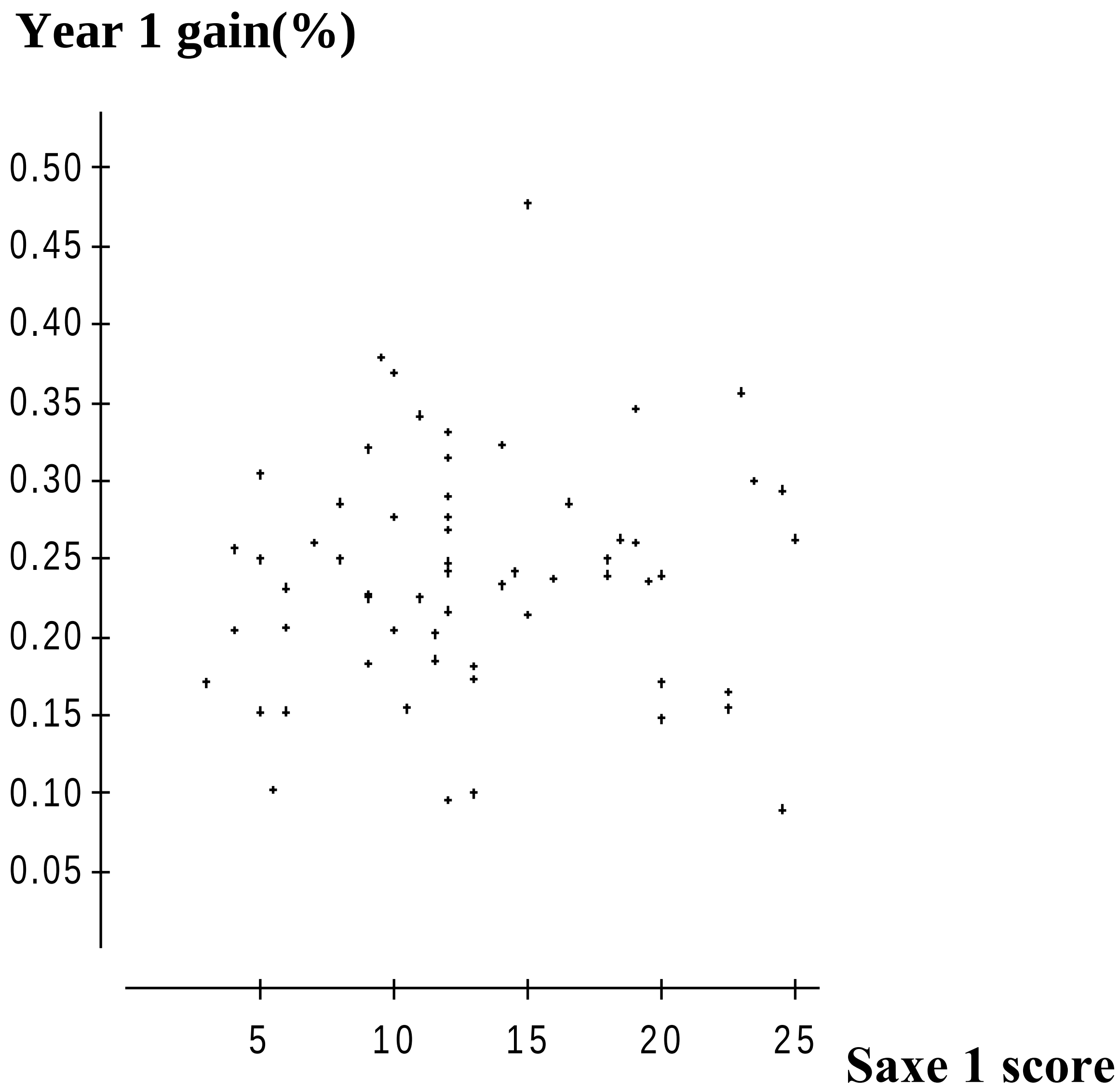
Analysis of Variance For **Teach TG**
No Selector
127 total cases of which 71 are missing

Source	df	Sums of Squares	Mean Square	F-ratio	Prob
Const	1	2.57969	2.57969	249.56	≤ 0.0001
Q1a	1	0.000639	0.000639	0.06185	0.8045
Error	54	0.558190	0.010337		
Total	55	0.558829			

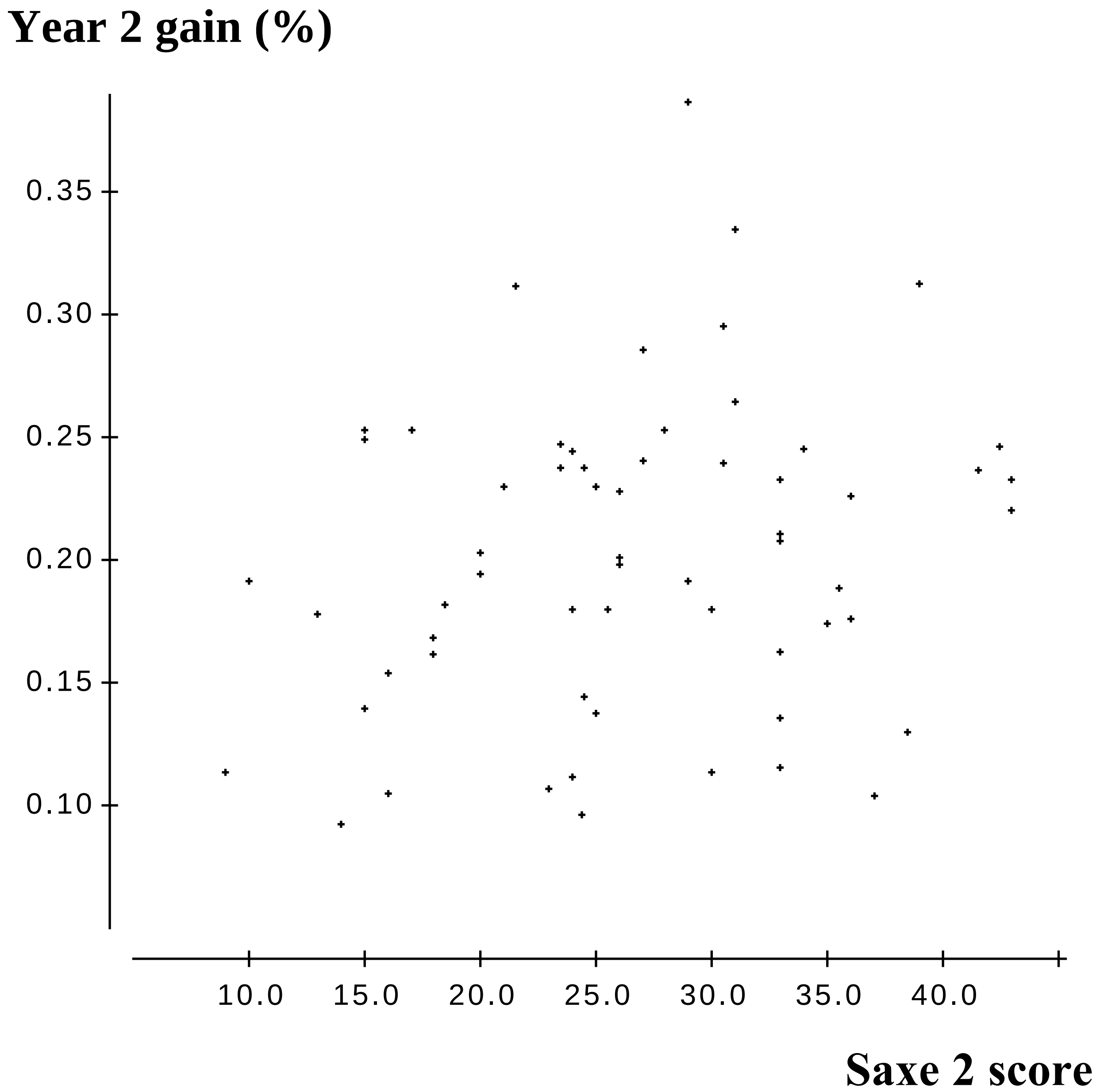
YEAR 5 GAINS vs SAXE 1 SCORE (r = 0.11)



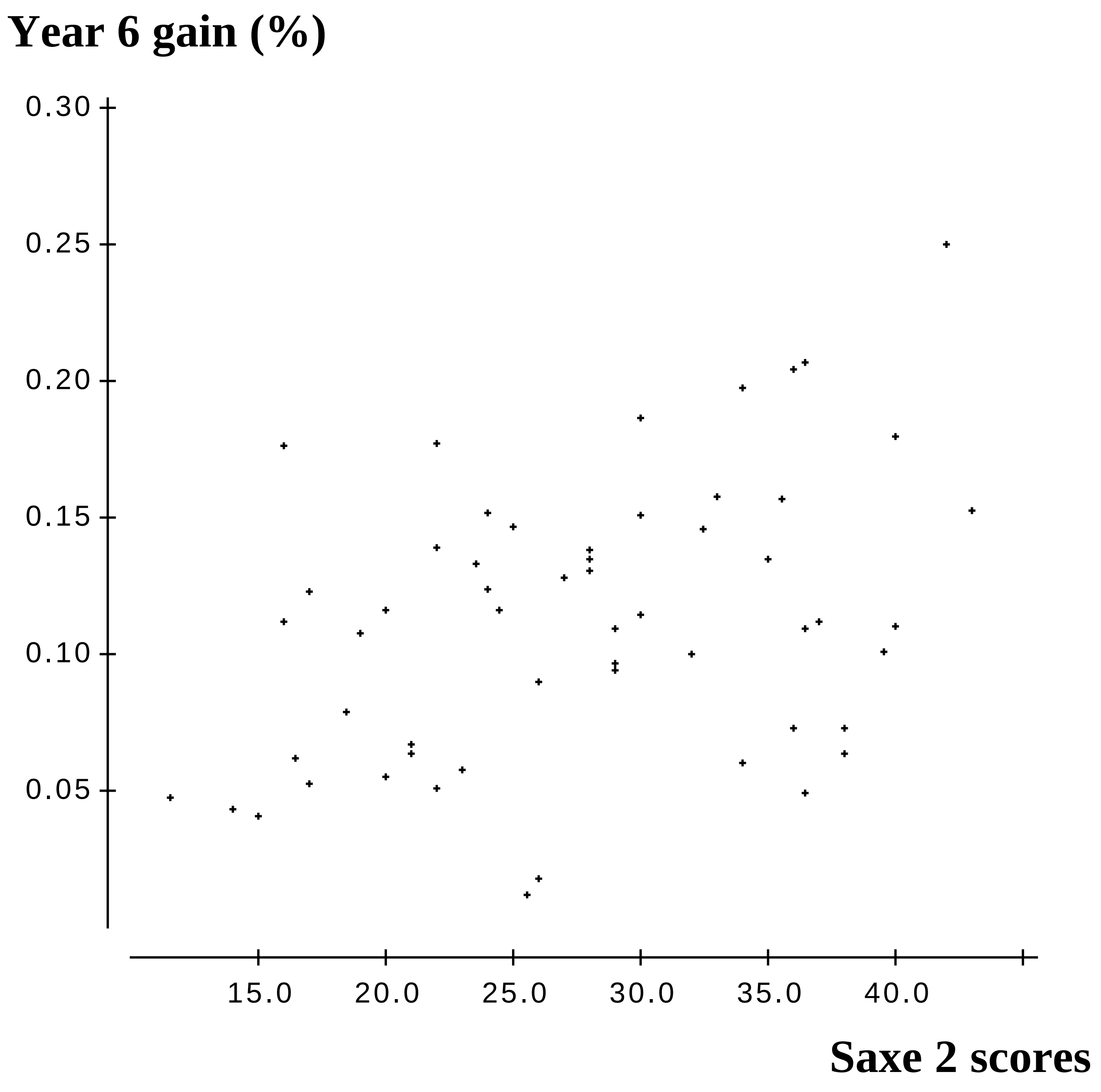
YEAR 1 GAINS vs SAXE 1 SCORE (r = 0.08)



YEAR 2 GAINS vs SAXE 2 SCORE (r = 0.18)

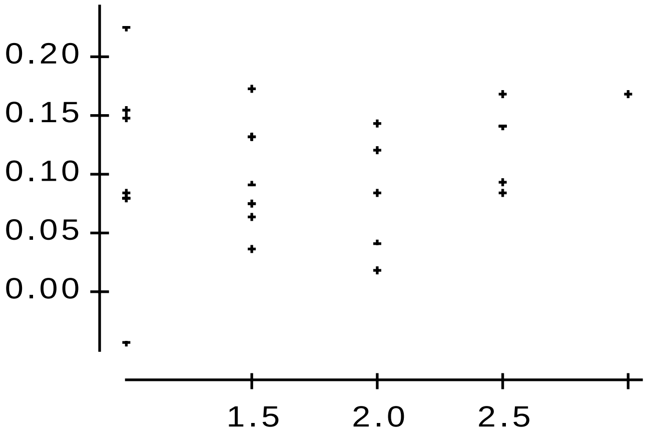


YEAR 6 GAINS vs SAXE 2 SCORE (r = 0.39)



YEAR 5 GAIN vs TRIAD RELATIONSHIPS

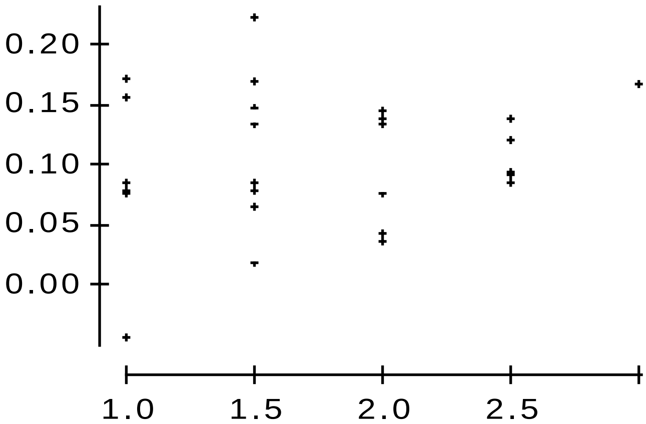
Year 5 gain (%)



Teacher-Maths relation

(r = 0.16)

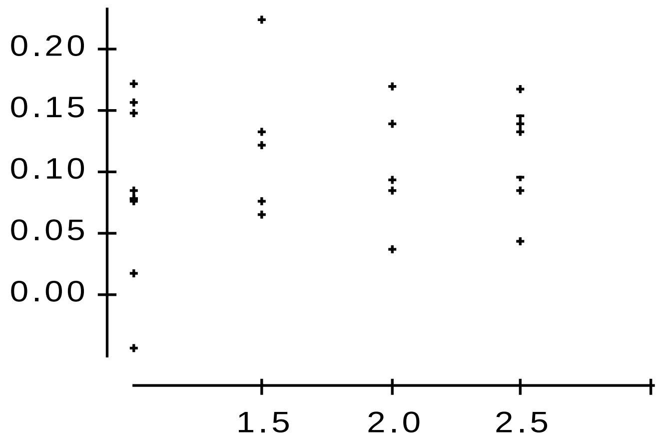
Year 5 gain (%)



Pupil-Maths relation

(r = 0.12)

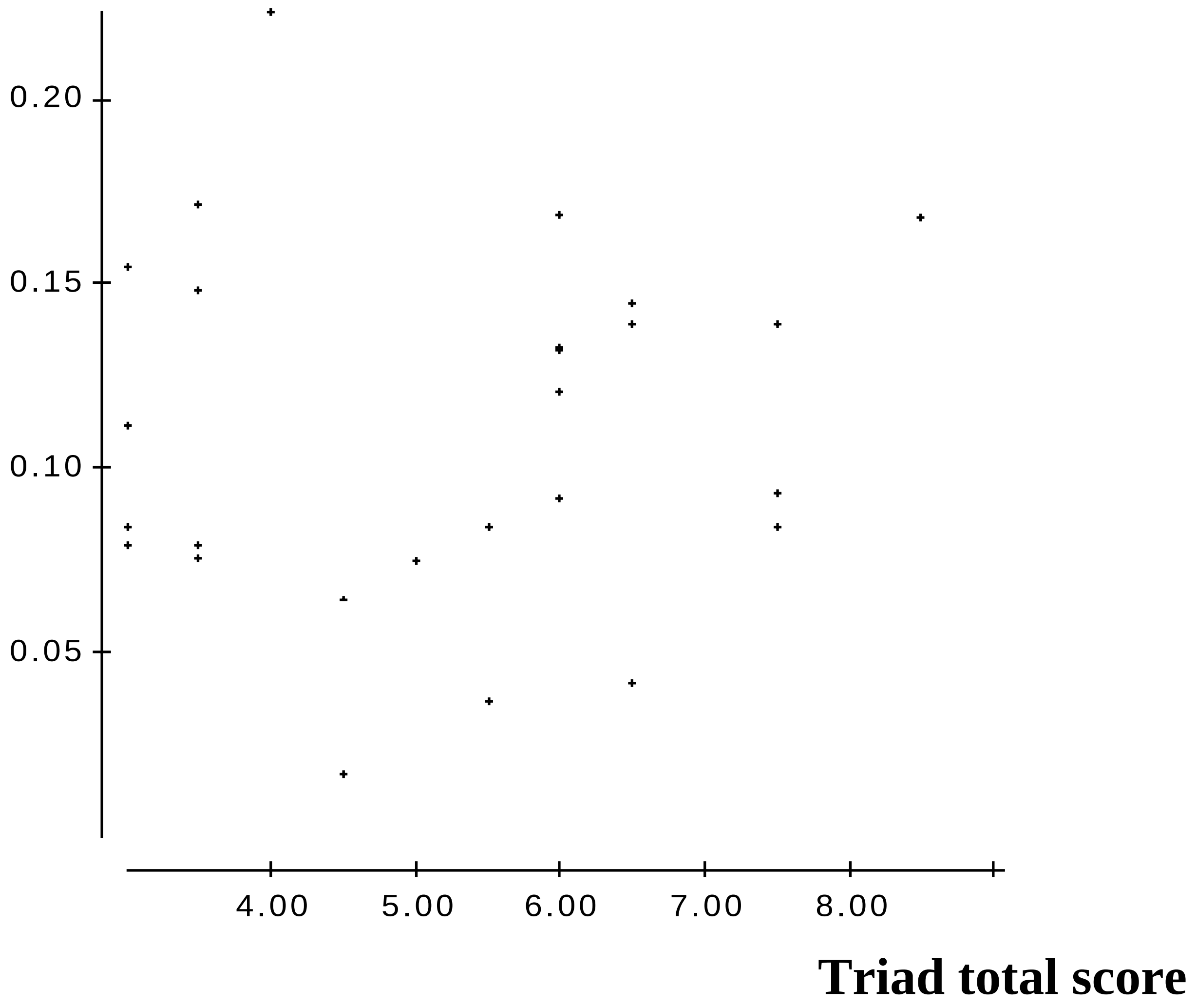
Year 5 gain (%)



Teacher-Pupil relation
(r = 0.18)

YEAR 5 GAIN vs TRIAD TOTAL (r = 0.14)

Year 5 gain(%)


0.20
0.15
0.10
0.05
4.00
5.00
6.00
7.00
8.00
Triad total score