



HAL
open science

The Effect of Increasing Conceptual Challenge in Primary Science Lessons on Pupils' Achievement and Engagement

Jenny Mant, Helen Wilson, David Coates

► **To cite this version:**

Jenny Mant, Helen Wilson, David Coates. The Effect of Increasing Conceptual Challenge in Primary Science Lessons on Pupils' Achievement and Engagement. *International Journal of Science Education*, 2008, 29 (14), pp.1707-1719. 10.1080/09500690701537973 . hal-00513356

HAL Id: hal-00513356

<https://hal.science/hal-00513356>

Submitted on 1 Sep 2010

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



The Effect of Increasing Conceptual Challenge in Primary Science Lessons on Pupils' Achievement and Engagement

Journal:	<i>International Journal of Science Education</i>
Manuscript ID:	TSED-2006-0303.R1
Manuscript Type:	Research Paper
Keywords:	science education, conceptual change, primary school, curriculum
Keywords (user):	conceptual challenge, motivation, achievement



1
2
3
4 **Acknowledgements**
5

6 The authors would like to thank all of the teachers and their pupils who participated in
7 the project and the AstraZeneca Science Teaching Trust who provided the funding.
8
9

10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For Peer Review Only

The Effect of Increasing Conceptual Challenge in Primary Science Lessons on Pupils' Achievement and Engagement

This paper reports research into the effect on 11-year-old pupils of introducing more cognitively challenging, practical, and interactive science lessons. Our hypothesis was that such lessons would increase the children's enthusiasm for science and their engagement with the scientific process, thereby improving educational performance.

Schools in England are under pressure to raise achievement, as measured by the results of national tests. This has an impact on teaching, where revision of subject knowledge often dominates and can be particularly detrimental to more able pupils.

The research was a controlled trial which took place in 32 English primary schools as part of a project 'Conceptual Challenge in Primary Science'. Teachers from 16 intervention schools participated in continuing professional development (CPD) and developed science lessons that had more practical work, more discussion, more thinking and less (but more focused) writing. The proportion of pupils achieving the highest level (level 5) in the national science tests at age 11 was compared in the matched-school pairs before and after the intervention. Focus group interviews were also held with a group of pupils in each intervention school. There was a 10% (95% Confidence Interval 2-17%) increase in the proportion of children achieving the top score in the intervention schools. The pupils and teachers reported greater engagement and motivation. These findings suggest that moving from rote revision to cognitively challenging, interactive science could help improve science education. They merit replication in other international settings to test their generalisability.

Introduction

The research reported in this paper explored the effect of introducing science lessons characterized by more cognitive challenge, practical activity and discussion, rather than rote revision, on achievement and attitudes to science for 10-11 year old children.

Since the introduction of the National Curriculum (DfEE/QCA, 1999) in England in 1988, science has been one of the three core subjects taught in English primary schools. The National Curriculum determines the content of what will be taught at each Key Stage (age phase of schooling) and pupils take national tests (called Standard Assessment Tests or SATs) at the end of each Key Stage (ages 7, 11 and 14 years). School league tables of the national tests results are published each year and hence there is great pressure to raise the pupils' achievements in these tests.

However, since 2003, with the introduction of the Primary Strategy by the Department for Education and Skills (DfES, 2003), schools have been encouraged to become more creative and flexible. The above situation, with an emphasis on achievement in externally imposed tests on the one hand and a new drive for creativity on the other can be said to have led to a certain tension in the English education system. Teachers are being encouraged to be creative and to take risks in their teaching and yet schools are judged by prescribed outcome measures: national test results.

The research reported in this paper, was part of a project 'Conceptual Challenge in Primary Science', which arose in the context of, and partly in response to, the issues discussed above: schools being judged on outcomes, measured by national test scores, and at the same time being strongly encouraged to take a more

1
2
3 creative and imaginative approach to teaching and learning. The project was funded by the AstraZeneca
4
5 Science Teaching Trust (AZSTT). One of its aims was to test the hypothesis that the implementation of
6
7 cognitively challenging, practical, and interactive lessons in Year 6 (11 year olds) science, rather than a
8
9 content driven approach, would result in: 1) higher achievement in national tests; 2) increased children's
10
11 enthusiasm for science and their engagement with the scientific process.
12
13

14
15
16
17 This hypothesis is supported by the work of several authors, including Montgomery (2001) and Black
18
19 and Wiliam (1998) and resonates with the opening words of Excellence and Enjoyment a strategy for
20
21 primary schools (DfES, 2003): 'Children learn better when they are excited and engaged...when there is
22
23 joy in what they are doing, they learn to love learning'.
24
25

26
27 It is also supported by the school inspectorate OfSTED (2004) in their annual report into primary
28
29 science, particularly with regard to the use of scientific enquiry, and discussion of scientific ideas:
30
31 'Teaching remains most effective where pupils are actively involved in thinking through and carrying
32
33 out scientific enquiry'. (p.2)
34
35
36
37

38 39 **Educational Context**

40 41 42 *Decline in enthusiasm for science*

43
44 Several authors internationally have noted a decline in enthusiasm for science. In the UK Pell and Jarvis
45
46 (2001) noted that this decline in enthusiasm for science appears to begin towards the end of the years in
47
48 primary school. Their findings reinforced the previous findings of the Primary Assessment, Curriculum and
49
50 Experience Project (PACE) (Pollard & Triggs, 2000). PACE was a longitudinal study in the UK and
51
52 considered a cohort of children as they moved from Year 1 to Year 6 from 1990 to 1996. In a comparative
53
54 league table of the pupils' favoured curriculum activities, from Year 1 to Year 3, science featured, albeit in a
55
56
57
58
59
60

1
2
3 fairly lowly position. However, science did not feature at all in the same league table when the children were
4
5 in Years 4 to 6. Worse still, science did feature amongst the top five of least liked subjects in Years 5 and 6.
6
7 Interestingly, the children's comments in the PACE study in Key Stage 2 indicated that what made them
8
9 dislike science was the weight of information presented to them which they had to learn. (Pollard & Triggs,
10
11 2000, pp 86, 87, 95). Analysis of the data from the Planet Science (2003) student review of the science
12
13 curriculum in the UK suggested that a strong negative or positive primary science experience carries through
14
15 for the next six or seven years. (p.18).
16
17
18
19

20
21
22 In the United States the study by Piburn and Baker (1993) gave evidence of a decline in positive attitudes
23
24 toward science as pupils progress through school. More recently, Sjøberg and Schreiner, (2006) noted that:
25
26

27 The falling recruitment to most science and technology educations is seen as a large problem in most
28
29 European countries. The same tendencies are noted in the United States and in most other countries
30
31 within the Organisation for Economic Co-operation and Development. (p.2)
32
33
34
35
36

37 *Content driven teaching*

38
39 There is a wealth of evidence that the primary science curriculum in the UK, particularly in the latter years, is
40
41 perceived by many as being content laden and assessment driven. Harrison (2001) pointed out that an
42
43 increasing number of teachers are teaching their Year 6 pupils to the science test and that they are teaching
44
45 tips, tricks and techniques to achieve higher percentages. Black and Wiliam (1998) discussed the influence of
46
47 external tests and noted that 'Such tests can dominate teachers' work and, insofar as they encourage drilling to
48
49 produce right answers to short out-of-context questions, this dominance can draw teachers away from the
50
51 paths to effective formative work'. (p.17)
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Murphy and Beggs (2003) noted that science is frequently being taught as a 'body of knowledge' in the final two years of primary school (p.109). The perception that science is a body of knowledge that has to be delivered in order for pupils to reach the required standards has inevitably had a major impact on teaching styles. This was summarized by the Parliamentary Office for Science and Technology (2003) which noted that:

Many teachers feel under pressure to focus on the factual content specified in the national curriculum as preparation for SATs. This can leave little time to build on children's interests; engage pupils in discussion on scientific ideas and issues; and teach scientific enquiry. (p.2)

Lack of discussion

Galton, Hargreaves, Comber and Wall (1999) cited, in their study of practice in the primary classroom in England, a figure of 50% for whole class teaching in science, which is considerably higher than that for English or mathematics. The teachers interviewed justified this emphasis on whole class activity by arguing that it was the only means of covering sufficient content to ensure that pupils performed satisfactorily in the national tests. Galton and MacBeath (2002) in their study for the National Union of Teachers (NUT) on the impact of changes on primary teachers' working lives pointed out that there is 'more whole class teaching, more pressure to move on, less time for discussion left less time to explore, to make meaning, to use illustration and anecdote to develop understanding'. (pp.51-52) Osborn, McNess and Broadfoot (2000) were similarly concerned about this trend towards whole-class teacher instruction in primary schools and suggested that an outcome of the current assessment system has been a reduction in interactive pedagogy. They went on to suggest that 'the quantity of pupils' learning experiences, rather than the quality has become the prime focus'. (p.231)

Lack of practical science

The National Curriculum (DfEE/QCA, 1999) places a clear emphasis on practical scientific enquiry, which is part of one of the four programmes of study within the science section. However in their scoping study of primary science in the UK, Murphy and Beggs (2005) highlighted as one of their key findings that the carrying out of science investigation in the classroom was constrained and that this was partially due to concentration on national tests and lack of time. They went on to note that teachers agreed that pupils greatly enjoy practical work in science but that allowing them to carry out their own investigations was not always considered possible because of the perceived pressures on time. (p.7) The reduction in practical work was also highlighted in the Qualification and Curriculum Authority (QCA, 2005) annual report on the science curriculum and assessment which found that almost half of the primary teachers interviewed said that, because of the negative impact of class size, science experiments undertaken by pupils were limited.

Adverse consequences for the more able.

A key effect of 'teaching for the test' has been to constrain the extent to which the teaching approaches within the core curriculum areas are sufficiently challenging and stimulating (Galton, Hargreaves & Pell, 2003). This revision and lack of cognitive challenge in the daily curriculum can be an arid process, which results in boredom and disaffection (Montgomery, 2001). Rimm and Lovance (1992) pointed out that there is a further problem with lack of challenge: 'If we don't provide a challenging environment, we are, in a *de facto* way, teaching our children to underachieve.' (p. 10)

It can be argued that this type of revision and subsequent lack of challenge can hinder in particular the more able pupils. In the USA Rogers (1999), in her synthesis of research findings regarding provision for the gifted

1
2
3 and talented, showed that gifted students are significantly more likely to forget or mislearn science content
4
5 when they must drill and review it more than two or three times. They become bored and 'switch off'.
6
7
8
9

10 In the literature of different countries, the meaning of the terms 'able', 'gifted' and 'talented' can vary and, as
11
12 Winstanley (2004) pointed out, the myriad of definitions is alarming. Gagné, (2004) discussed the variety of
13
14 meanings and highlighted the distinction between aptitude (potential) and achievement by using the term
15
16 gifted to describe innate ability and talent as the expression of that potential in terms of exceptional
17
18 performances in any field or fields. Porter (2005) pointed out that another way of seeing giftedness has been
19
20 as a general or pervasive trait, whereas talent is ability within a specific field. (p.4)
21
22
23
24
25
26

27 In England generally, however, the gifted and talented are defined quite differently, and giftedness refers to
28
29 academic abilities, whereas talent refers to 'non-academic' abilities, such as in art and design, music or
30
31 physical education (QCA, 2001). Others, such as Freeman (1998), in her study of international research, use
32
33 the terms 'very able' or 'high ability' to avoid what Freeman called 'the troublesome word, "gifted", with its
34
35 implications of gifts bestowed intact from on high.'
36
37
38
39
40

41 The term 'able pupils' has been employed throughout this paper. Porter (2005) defined these pupils as 'those
42
43 who have the capacity to learn at a pace and level of complexity that is significantly in advance of their age
44
45 peers' (p.33). Coates and Wilson (2003) pointed out that ability in science may not be accompanied by an all-
46
47 round ability in other subjects.
48
49
50

51
52
53 Both Renzulli (1998) and Hewston *et al.* (2005) have shown that teaching strategies that cater for, and
54
55 challenge, the able can be employed for all children within the normal classroom. Moreover, they
56
57
58
59
60

1
2
3 demonstrated that this is often advantageous and can raise the performance of all students. Freeman (1998)
4
5 discussed how pupils with ability can be identified through providing challenge for all within a normal
6
7
8 classroom.
9

10 11 12 **Method**

13 14 15 *Study design*

16
17 The study compared the effect of a continuing professional development (CPD) initiative in classes of 10-11
18
19 year old children in 16 matched pairs of primary schools – 32 schools in all. The intervention was provided to
20
21 one in each pair of schools but the main outcome measure (the percentage of children achieving the highest
22
23 scores (level 5) in the national science test) was measured in both schools in two consecutive years, the year
24
25 before the project and the year of the project. In the 16 intervention schools only, group interviews with
26
27 participating children were carried out by the science coordinator at the end of the project year.
28
29
30
31
32
33
34
35

36 *Continuing Professional Development (CPD) Intervention*

37
38 The intervention involved training two key teachers within each of the 16 intervention schools - the science
39
40 coordinator and a class teacher for the 10-11 year age group (Year 6 in the UK education system). The
41
42 teachers attended eight days and four twilight sessions of CPD in the university spaced at regular intervals
43
44 throughout the school year. In addition the project provided funds for time for the two teachers in each school
45
46 to work together to develop their teaching.
47
48

49
50 The CPD sessions explored with the participating teachers strategies for cognitively challenging, practical
51
52 science lessons with plenty of space for thinking and discussion. Well-established strategies for challenge for
53
54 the gifted and talented, particularly the encouragement of higher order thinking (Coates & Wilson, 2003,) were included. However, the project promoted the use of such strategies with the whole class on an inclusive
55
56
57
58
59
60

1
2
3 basis. A particular feature of the CPD was the development of 'Bright Ideas Time' discussion slots. These
4
5 short focused discussions utilized a 'discussion prompt' to stimulate discussion and encourage the children to
6
7 share their ideas. The 'discussion prompts' included 'odd one out', 'Big Questions' and a de Bono thinking
8
9 tool called 'PMI' (De Bono, 1986). In these a scenario is set and children identify and discuss P – positive, M
10
11 – minus and I – interesting features. Further details of 'Bright Ideas Time' prompts and the other strategies
12
13 endorsed in the CPD can be found in Wilson & Mant (2006).
14
15
16
17
18
19

20 The participating teachers practised and discussed the teaching strategies introduced during each CPD session.
21
22 They then implemented them in their classes with all their pupils, followed by evaluation, further discussion
23
24 and refinement in later CPD sessions. .
25
26

27 In summary, the CPD promoted science lessons with the following characteristics:

- 28 1) Increased time spent in discussion of scientific ideas;
 - 29 2) An increased emphasis on the encouragement of higher order thinking;
 - 30 3) More practical work and investigations;
 - 31 4) More focused and purposeful recording by pupils, less writing
- 32
33
34
35
36
37
38
39
40
41

42 *Intervention schools*

43
44 The Local Government Education Authority science team for the county of Oxfordshire was asked to
45
46 recommend schools for the project which would be interested in developing their science teaching and able to
47
48 give the necessary commitment. The schools were all approached individually and visited by one of the
49
50 researchers so that the head teacher and teachers were fully aware of the expected level of commitment. All
51
52 the recommended schools were situated in small towns or rural (village) locations. The numbers on the school
53
54 role ranged from 137 to 505. The percentage of pupils from households needing financial support was lower,
55
56
57
58
59
60

1
2
3 but the range of percentages of pupils registered with Special Educational Needs (SEN) similar, to the
4 national average. Only one school had a significant number of children from ethnic minorities or with
5 English as an additional language.
6
7
8
9

10 11 12 13 *Control schools*

14
15 The control schools did not receive the intervention. They were selected to match the intervention schools
16 according to three characteristics applied sequentially: 1) percentage of pupils in the relevant 10-11 year (Year
17 6) age group achieving the top (level 5) grade in the national science assessment test; 2) the number of
18 children in the year group (four strata: less than 25 pupils, 25 – 35 pupils, 36 – 60 pupils and more than 60
19 pupils); 3) the percentage of pupils with special educational needs (SEN). Data not in the public domain were
20 supplied by the Local Education Authority. If no control school could be identified using this sequence the
21 first criterion was relaxed, initially to $\pm 1\%$ and if necessary to $\pm 3\%$ and the sequence repeated. The final
22 result of this matching sequence was that each control school had the same percentage of pupils achieving
23 level 5 $\pm 3\%$ (12 out of 16 control schools either equal to or $\pm 1\%$), were in the same size group, and had the
24 same percentage of pupils with SEN $\pm 5\%$ as the participating school with which it was matched.
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42

43 *Main outcome measure*

44
45 The main outcome measure was the proportion of children in the 10-11 year group in each school achieving a
46 top (level 5) score in the end of year national science assessment test. These tests are taken by all children in
47 England and are marked according to criteria defined in the National Curriculum (DfEE/QCA, 1999). These
48 data were collected for both intervention and control schools for the year before as well as the year of the
49 intervention.
50
51
52
53
54
55
56
57
58
59
60

Statistical analysis

The change in the percentage of children in each intervention school achieving level 5 in the year of the project and in the previous year was compared with its matched control school. The distribution of these between-pair differences was described in terms of the median, mean and standard deviation. The 95% confidence interval for the mean difference was calculated based on the standard error of a proportion. To test the null hypothesis (i.e. that the changes in the percentage of pupils achieving level 5 for the project and the matched schools are the same) the observed mean difference between pairs was compared with the hypothetical value of zero using a Student t-test.

Supporting qualitative outcomes

At the end of the year, focus group interviews were conducted with children in the 16 intervention schools to ascertain their views on their science lessons during the year. Lewis (1992, p.413) suggested that group interviews are a viable and useful technique with primary-aged children. She highlighted the possibility of obtaining greater depth and breadth in responses than occur in individual interviews. She also observed that children may be less intimidated by talking in a group than when talking individually and hence the dialogue is likely to be more natural and less stilted.

These interviews were conducted by the school science coordinator, rather than their own class teacher. Training in conducting focus group interviews was given to the teachers as part of the CPD sessions. The chosen participants were four or five children identified by their class teacher as high achievers in science, based on the teacher's knowledge of the children and their test scores. The interviews were audio taped and later transcribed. The interviews were semi structured and focused on the following questions:

1) What have you enjoyed / liked about science this year? Why?;

1
2
3 2) What have you not enjoyed / liked about science this year? Why?;

4
5
6 3) Have you noticed any changes in science this year? If so, what?
7
8
9

10 Each focus question was posed to the group as a whole and followed up with further questions, as appropriate,
11 in order to clarify the responses. It was not possible to ascribe oral contributions to particular individuals from
12 the tapes and the groups of pupils tended to be collaborative in their responses, hence each interview was
13 analysed as one unit. The interview transcripts were scrutinized by two researchers and the emergent themes
14 identified. Particular attention was given to themes which illuminated the children's perspective on their
15 attitudes to the science lessons.
16
17
18
19
20
21
22
23
24
25
26
27

28 Results

29 *Overall effect on test scores*

30
31
32 Table 1 shows the overall effect of the project on the proportion of pupils achieving the top (level 5) test
33 score. In the year before the project, the mean proportion of children achieving level 5 was very similar in the
34 intervention schools (39.6%) and the control schools (39.4%). In the project year, the mean proportion of
35 children achieving level 5 increased by 11.8% in the intervention schools and 2.0% in the controls schools. In
36 only 3 of the 16 intervention schools did the proportion of children achieving level 5 fall in the project year.
37
38 The median change in score was +16.5% in intervention schools and +2% in the control schools.
39
40
41
42
43
44
45
46

47 [Insert table 1 about here]

48 *Comparison of matched pairs*

49
50
51 In the analysis of the matched pairs of schools, the intervention school did better than the control school in 12
52 out of 16 pairs. The median difference between the matched pairs was +10.5%. The mean difference between
53
54
55
56
57
58
59
60

1
2
3 the matched pairs was 9.7% (95% confidence interval 2.4 to 17.0%). It is statistically unlikely that a mean
4
5 difference between pairs of this magnitude would occur by chance (Student's $t = 2.69$, $p < 0.02$).
6
7
8
9

10 11 *Children's perceptions of the lessons*

12
13 All the groups of children interviewed were unanimously positive about their science lessons during the year
14
15 of the project and talked enthusiastically about the changes they had perceived in the lessons. The main
16
17 themes emerging from the interviews identified four characteristics of the lessons to which the children
18
19 attributed their increased enthusiasm and engagement: 1) more experiments and investigations; 2) new
20
21 discussion activities; 3) more thinking for themselves; 4) less time spent writing,. The number of interviews in
22
23 which the children expressed a comment relating to each theme, are shown in Table 2.
24
25
26

27
28 [Insert table 2 about here]
29
30

31 *Children's perceptions of the impact of the lessons on their learning*

32
33 The children articulated how they perceived these lesson characteristics had increased their engagement in
34
35 learning. This is illustrated with a selection of recorded quotations.
36

37
38 Firstly, they demonstrated a strong awareness of how they were learning. They acknowledged that this was
39
40 facilitated by the encouragement to think and the challenges provided by the teachers:
41

42
43 *'Yeah, it's actually more challenging. I like things to be more challenging. And when it's just easy*
44
45 *and everything's done for you and you're just to write down the results, I find it boring. I like a bit*
46
47 *more challenge'.*
48

49
50 Secondly, they had a clear sense of 'doing' helping 'learning'. The reasons they gave included awareness of
51
52 practical involvement resulting in deeper and more lasting learning:
53

54
55 *'I enjoyed active ... things. Because if you just get told everything that happens, it's very easy to*
56
57 *forget. whereas if you're actually finding out what happens by yourself, it will stick in the brain more'.*
58
59
60

1
2
3 Thirdly, they explicitly stated that they liked discussing their ideas with each other, particularly working in
4
5 small groups, and were able to reflect on how their own ideas had developed as they talked to each other:
6
7

8 *'I also liked doing the think pair share. Miss C put some stuff on the board and we talked with our*
9
10 *partner, and then we shared our thoughts with the rest of the class. (Why did you like that?) Because*
11
12 *we got to think about different people's different ideas'.*
13
14

15 Lastly, they appreciated that the teachers were encouraging them to think more for themselves, and in
16
17 particular to use their own ideas in investigations, hence increasing their autonomy.
18
19

20 *'I think I have had more chances to say what I am thinking and to say my own things. It has made me*
21
22 *think for myself instead of always relying on you (the teacher) for the answer'. 'I think we have done*
23
24 *more thinking this year. Before, we did it, but now we are asking questions first and then trying things*
25
26 *out'.*
27
28
29
30
31
32
33

34 **Conclusions**

35
36 The research hypothesis was that more cognitively challenging, practical, and interactive lessons in science
37
38 for pupils age 10-11 would result in better achievement in national science tests and an increase in both the
39
40 children's enthusiasm for science and their engagement with the scientific process. The data presented from
41
42 the science national test results and the pupils' interviews support this hypothesis.
43
44
45
46
47

48 The quantitative data provide good evidence that the training intervention impacted significantly on the
49
50 quality of teaching and consequent performance of the children taught. The differences between the
51
52 intervention and control schools is educationally important - an estimated increase in the proportion of
53
54 children achieving the top grade (level 5) in science in the end-of year national tests of between 2 and 17%,
55
56
57
58
59
60

1
2
3 with a best estimate of 10%. The matching of schools appears to have been satisfactory. The national testing
4 is independent of the investigators. The effect of the inevitable year-to-year variation in the performance of
5
6 different cohorts of children was minimised in the study design but must to some extent explain the observed
7
8 year-to-year variability in test results. The fact that the intervention showed an effect despite such variability
9
10 increases the robustness of the result.
11
12

13
14
15
16
17 The pupil interviews provide further qualitative supporting evidence of engagement in science. There was also
18
19 evidence of increased attainment in terms of the children's perceptions of their own learning. All of the
20
21 groups of pupils interviewed, including those from the schools where the percentage of pupils achieving level
22
23 5 had decreased, commented on their increased learning and attributed this to the teaching strategies
24
25 introduced by the teachers.
26
27
28
29
30

31
32 One of the key features of the changed lessons was more practical work. This is supported by Successive
33
34 OfSTED reports that have linked the highest standards of achievement to good use of scientific enquiry
35
36 (OfSTED, 2004, p.9). Another key feature was the use of strategies to increase discussion of scientific ideas
37
38 and encourage pupils to think for themselves. It can be argued that the increase in scientific enquiry, where
39
40 the pupils planned and carried out their own investigational work, and the accompanying climate of
41
42 discussion and questioning resulted in increased scope for thinking and reasoning. Both the teachers and
43
44 pupils reported a reduction in the amount of time spent writing in science lessons. The teachers focused on the
45
46 purpose of recording by the pupils, so that although less was demanded it was of a higher quality. The
47
48 reduction in writing released time for practical work and discussion and contributed to the positive attitudes of
49
50 the pupils.
51
52
53
54
55
56
57
58
59
60

1
2
3 A key question is the generalisability of our findings. The participating schools were not urban and a similar
4 project in an inner city setting would test further the applicability of the teaching strategies. Questions also
5 arise as to whether the teachers demonstrated increased enthusiasm for science because of the ongoing
6 involvement in the CPD and that this was in turn a significant contributing factor to the increased enthusiasm
7 and achievement of their pupils. The science national test results from the participating schools will need
8 monitoring over the coming years to discover whether or not this improvement is sustained without the
9 impetus of the CPD. This will produce data that will give information about the extent to which the project
10 teaching strategies have become embedded in ongoing practice. However, despite these necessary
11 reservations, the findings from this project have relevance to more than just English primary schools in rural
12 and semi-urban areas. There is international concern about the decline in pupil attitudes to science. The
13 findings on the type of science lessons which stimulate pupils and lead to increased scientific understanding
14 have implications for all pupils everywhere.

15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34 In summary, the authors suggest all pupils need teaching from the earliest age that will inspire curiosity and
35 scientific understanding. The evidence from this research points the way from a less content driven approach
36 to one that encourages thinking through discussion and practical investigations and, at the same time, raises
37 standards.

38 39 40 41 42 43 44 45 46 **References**

47 De Bono, E. (1986) *Six thinking hats*. Harmondsworth: Viking

48 Black, P. & Wiliam, D. (1998) *Inside the black box*. London: King's College

49
50
51
52
53 Coates, D. & Wilson, H. (2003) *Challenges in primary science: Meeting the needs of able young scientists at*
54
55 *Key Stage 2*. London: NACE/Fulton

- 1
2
3 Department for Education and Employment & Qualifications and Curriculum Authority (DfEE/QCA) (1999)
4
5 *The national curriculum for England: Science*. London: HMSO
6
7
8 Department for Education and Skills (2003) *Excellence and Enjoyment: a strategy for primary schools*.
9
10 London: Department for Education and Skills. Retrieved 17 May, 2006 from
11
12 <http://www.dfes.gov.uk/primarydocument/>
13
14
15 Freeman, J. (1998) *Educating the very able: Current international research*. London: HMSO
16
17 Gagné, F. (2004) Transforming gifts into talents: the DMGT as a developmental theory. *High Ability*
18
19 *Studies* 15 (2) 119 - 147
20
21
22 Galton, M., Hargreaves, L., Comber, C. & Wall, D. (1999) *Inside the Primary Classroom: 20 years on*.
23
24 London: Routledge
25
26
27 Galton, M. & MacBeath, J. with Page, C. & Steward, S. (2002) *A life in teaching? The impact of change on*
28
29 *primary teachers' working lives*. Retrieved May 15, 2006, from
30
31 <http://www.educ.cam.ac.uk/download/NUTreport.pdf>
32
33
34 Galton, M., Hargreaves, L. & Pell, T. (2003) Progress in the middle years of schooling: Continuities and
35
36 discontinuities at transfer *Education 3 – 13*, 31 (2), 9 -18.
37
38
39 Harrison, S. (2001) SATs and the QCA Standards Report *Primary Science Review* 68, 28 - 29
40
41
42 Hewston, R., Campbell, R. J., Eyre, E., Muijs, D., Neelands, J., & Robinson, W. (2005) *A baseline review of the*
43
44 *literature on effective pedagogies for gifted and talented students*. The National Academy of Gifted and Talented
45
46 Youth. Retrieved May 3, 2006, from http://www.nagty.ac.uk/research_centre/publications/index.aspx
47
48
49 Lewis, A. (1992) Group Child Interviews as a Research Tool *British Educational Research Journal*, 18 (4),
50
51 413 - 421
52
53
54 Montgomery, D. (2001) *Able Underachievers*. London: Whurr
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160

- 1
2
3 Murphy, C. & Beggs, J. (2005) *Primary science in the UK: a scoping study. Final report to the Wellcome*
4
5 *Trust*. Belfast: St. Mary's University College & Queen's University Retrieved June 6, 2006 from
6
7 <http://www.wellcome.ac.uk/assets/wtx026636.pdf>
8
9
10 OFSTED (2004) *Ofsted Subject Reports 2002/3: Science in primary schools*. London: OfSTED
11
12 Osborn, M., McNess, E., Broadfoot, P., with Pollard, A. & Triggs, P. (2000) *What teachers do: Changing*
13
14 *policy and practice in primary education*. London and New York: Continuum
15
16
17 Parliamentary Office for Science and Technology (2003) Number 202, *Primary science*. London:
18
19 Parliamentary Office for Science and Technology. Retrieved June 19, 2006 from
20
21 <http://www.parliament.uk/post/pn202.pdf>
22
23
24 Pell, T. & Jarvis, T. (2001) Developing attitude to science scales for use with children from five to eleven
25
26 years. *International Journal of Science Education*, 23 (8), 847 – 862
27
28
29 Piburn, M. & Baker, D. (1993) If I were the teacher ... qualitative study of attitude towards
30
31 science. *Science Education*, 77, 393-406.
32
33
34 Planet Science, Institute of Education and Science Museum (2003). *Student review of the science curriculum:*
35
36 *Major findings*, London: Planet Science. Retrieved 18 June, 2006 from [http://www.planet-](http://www.planet-science.com/sciteach/review/Findings.pdf)
37
38 [science.com/sciteach/review/Findings.pdf](http://www.planet-science.com/sciteach/review/Findings.pdf)
39
40
41 Pollard, A. & Triggs, P. with Broadfoot, P., Mcness, E. & Osborn, M. (2000) *What pupils say: Changing*
42
43 *policy and practice in primary education*. New York: Continuum
44
45
46 Porter, L. (2005) *Gifted Young Children*. Buckingham: Open University Press
47
48
49 QCA (2001) *Guidance on Teaching Gifted and Talented Pupils*. Retrieved 30 November 2006 from
50
51 <http://www.nc.uk.net/gt/general/index.htm>
52
53
54
55
56
57
58
59
60

- 1
2
3 QCA (2005) Science. *2004/5 annual report on curriculum and assessment* December 2005 Retrieved 21 June,
4
5 2006 from
6
7
8 http://www.qca.org.uk/downloads/science_2004_5_annual_report_on_curriculum_and_assessment.pdf
9
10 Renzulli, J. (1998) *A rising tide lifts all ships: Developing the gifts and talents of all students*. Retrieved 18
11
12 June, 2006 from <http://www.gifted.uconn.edu/sem/semart03.html>
13
14
15 Rimm, S. & Lovance, K (1992) The use of subject and grade skipping for the prevention and reversal of
16
17 underachievement. *Gifted Child Quarterly* 36 (2), 100
18
19 Rogers, K. (2001) Best practice research summary Retrieved 15 June, 2006 from
20
21 http://www.isd194.k12.mn.us/g_BPPrac.htm
22
23 Sjøberg, S. & Schreiner, C. (2006). *How do learners in different cultures relate to science and technology? Results and*
24
25 *perspectives from the project ROSE (the Relevance of Science Education)*. APFSLT: Asia-Pacific Forum on
26
27 Science Learning and Teaching, 7(1), Foreword
28
29 Wilson, H. & Mant, J. (2006) *Creativity and excitement in science: Lessons from the AstraZeneca Science Teaching*
30
31 *Trust project*. Oxford: Oxford Brookes University
32
33 Winstanley, C. (2004) *Too Clever by Half*. London: Trentham Books Limited
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Table 1. Changes in the proportion of pupils achieving the top grade (level 5) in the national science test in the intervention and matched control schools.

<i>Matched school pair</i>	Intervention Schools			Matched Control Schools			Differences between intervention and control schools (C_I - C_{MC})
	% pupils level 5 in previous year	% pupils level 5 in intervention year	% change (C _I)	% pupils level 5 in previous year	% pupils level 5 in intervention year	% change (C _{MC})	
<i>1</i>	22	53	31	22	51	29	2
<i>2</i>	24	31	7	23	41	18	-11
<i>3</i>	31	48	17	30	32	2	15
<i>4</i>	68	71	3	71	55	-16	19
<i>5</i>	27	20	-7	25	25	0	-7
<i>6</i>	38	57	19	38	53	15	4
<i>7</i>	41	60	19	42	50	8	11
<i>8</i>	64	86	22	63	50	-13	35
<i>9</i>	40	56	16	40	36	-4	20
<i>10</i>	38	59	21	38	30	-8	29
<i>11</i>	34	59	25	36	33	-3	28
<i>12</i>	19	41	22	19	29	10	12
<i>13</i>	41	53	12	39	41	2	10
<i>14</i>	63	44	-19	63	36	-27	8
<i>15</i>	47	36	-11	46	49	3	-14
<i>16</i>	37	49	12	36	54	18	-6
Mean	39.6	51.4	11.8	39.4	41.6	2.1	9.7*

* 95% Confidence Interval 2 to 18%; $p < 0.02$ (Student's $t = 2.69$, 15 d.f.).

Table 2 Changes in lessons identified by pupils during focus group interviews

Change identified	Number of interviews with responses in this category (n = 16)
Lessons were better	16
More experiments and investigations	16
New discussion activities	13
More thinking for themselves	12
Less writing	11