Education Endowment Foundation

Thinking, Doing, Talking Science

Evaluation report and Executive summary

June 2015

Independent evaluators:

Pam Hanley, Robert Slavin, Louise Elliott (Institute for Effective Education)

Institute for Effective Education

The Education Endowment Foundation (EEF)

The Education Endowment Foundation (EEF) is an independent grant-making charity dedicated to breaking the link between family income and educational achievement, ensuring that children from all backgrounds can fulfil their potential and make the most of their talents.

The EEF aims to raise the attainment of children facing disadvantage by:

- Identifying promising educational innovations that address the needs of disadvantaged children in primary and secondary schools in England;
- Evaluating these innovations to extend and secure the evidence on what works and can be made to work at scale;
- Encouraging schools, government, charities, and others to apply evidence and adopt innovations found to be effective.

The EEF was established in 2011 by the Sutton Trust, as lead charity in partnership with Impetus Trust (now part of Impetus-The Private Equity Foundation) and received a founding £125m grant from the Department for Education.

Together, the EEF and Sutton Trust are the government-designated What Works Centre for improving education outcomes for school-aged children.

For more information about the EEF or this report please contact:

Robbie Coleman
Research and Communications Manager
Education Endowment Foundation
9th Floor, Millbank Tower
21-24 Millbank
SW1P 4QP

p: 020 7802 1679
e: robbie.coleman@eefoundation.org.uk
w: www.educationendowmentfoundation.org.uk

About the evaluator

The project was independently evaluated by a team from the Institute for Effective Education (IEE), University of York: Pam Hanley, Bob Slavin, Louise Elliott and Kate Thorley, with statistical input from Chris Whitaker of Whitaker Research Ltd.

The lead evaluator was Pam Hanley.

Contact details:

Pam Hanley
Institute for Effective Education
University of York
Heslington, UK
YO10 5DD

p: 01904 328165
e: pam.hanley@york.ac.uk

Contents

Executive summary

The project

Thinking, Doing, Talking Science (TDTS) is a programme that aims to make science lessons in primary schools more practical, creative and challenging. Teachers are trained in a repertoire of strategies that aim to encourage pupils to use higher order thinking skills. For example, pupils are posed 'Big Questions', such as 'How do you know that the earth is a sphere?' that are used to stimulate discussion about scientific topics and the principles of scientific enquiry.

Two teachers from each participating school received five days of professional development training delivered by a team from Science Oxford and Oxford Brookes University. The training did not aim to provide participating teachers with a set of 'off-the-shelf' lesson plans to be delivered in schools; rather, it sought to support teachers to be more creative and thoughtful in planning their science lessons. In addition, teachers had dedicated time to work with colleagues to plan and review lessons taught as part of the project. Teachers were also encouraged to link pupils' learning in science, with their learning in numeracy and literacy.

This project sought to assess the impact of the programme on the academic outcomes and attitudes towards science of Year 5 pupils. 655 pupils from 21 schools across England completed the project. Participating schools followed the programme for the entirety of the 2013/14 academic year. A further 20 schools formed a randomised comparison group and did not receive training in the approach until the following year.

Key conclusions
1. Thinking, Doing, Talking Science appeared to have a positive impact on the attainment of pupils in science. Overall, Year 5 pupils in schools using the approach made approximately three additional months' progress.
2. There are some indications that the approach had a particularly positive effect on pupils eligible for free school meals, but further research is needed to explore this.
3. The programme had a particularly positive effect on girls and on pupils with low prior attainment.
4. The approach had a positive impact on pupils' attitudes to science, science lessons, and practical work in particular.
5. National test data will be used to assess the English and mathematics outcomes of participating pupils and to measure the long-term impact of the approach. In addition, further research could be conducted to investigate whether this result can be replicated in a larger number of schools.

Security rating

Security rating awarded as part of the EEF peer review process

Findings from this evaluation have **moderate security**. The study was set up as a randomised controlled trial, which aimed to compare the progress of pupils who received the programme to similar pupils who did not. The trial was classified as an efficacy trial, meaning that it sought to test whether the intervention can work under ideal or developer-led conditions in ten or more schools.

There was very low drop-out from the project (only 1 school out of the initial 42 who signed up), and the participating pupils appeared to be very similar to those in the comparison group. It is unlikely that the observed result occurred due to chance.

In the absence of a nationally recognised science assessment, a test was developed using age-appropriate, curriculum-relevant questions that had previously been used in a similar study. The tests were administered by participating teachers, who did not have access to the test prior to the day that it was taken. The security rating is discussed further in Appendix 9 of the main report.

Results

- On average, participating pupils achieved higher scores on a combined measure of science knowledge and understanding, compared to pupils in the comparison group. The effect was equivalent to roughly three additional months' progress.
- There appeared to be greater effects for girls (+4 months on average) than for boys (+2 months). In addition, it is not possible to rule out chance as an explanation of the positive effect for boys.
- There appeared to be a slightly greater positive effect for pupils with low prior attainment (+4 months) compared to those with high prior attainment (+3 months). However, all pupils benefitted relative to similar children in comparison schools.
- Pupils eligible for free school meals made five additional months' progress on average, compared to similar pupils in comparison schools. However, due to the low numbers of pupils eligible for free school meals participating in the trial, this finding has lower security.
- Pupils in classes following the approach reported having more positive attitudes towards science on the vast majority of measures, and were more likely to believe that it was important to learn science.
- In line with the TDTS model, pupils in classes following the approach reported having more discussions and doing less writing in lessons, compared to those in comparison classes.
- Participating teachers reported using practical work, discussions and time for thinking much more often than teachers in comparison schools. There was little evidence that participating teachers were more confident than teachers in comparison classes.
- All participating teachers felt that they had changed the way they taught science, and were more positive about their pupils' science ability and engagement than teachers in comparison schools. All teachers were positive about their experience of the training sessions and resources.

Cost

The cost of the approach as delivered in the trial is estimated at £26 per pupil. This estimate is based on two classes of 25 pupils and a group of 21 schools receiving training together. Schools were charged £1,000 each to take part, which included five full INSET days, an in-school 'launch day' to begin the project, resources and materials. The estimate also includes the cost of three pilot days, which were used to refine the approach prior to the start of the intervention but were not passed onto schools (estimated at £6,720 in total).

Group	Effect size	Estimated months' progress	Security rating	Cost
All pupils	+0.22	+3 months		**£**
Girls	+0.32	+4 months	-	**£**
Boys	+0.12	+2 months	-	**£**
FSM pupils	+0.38	+5 months	-	**£**

Introduction

Intervention

Thinking, Doing, Talking Science (TDTS) comprises a series of professional development sessions, support, and resources for primary school teachers. It aims to improve pupils' thinking skills and science attainment by making science lessons more conceptually challenging, more practical, and more interactive. Rather than teaching science simply as a body of facts to be learned, the approach emphasises the principles of scientific inquiry: how to ask good questions and design simple experiments to find out the answers. The aim is not to provide a set of 'off-the-shelf' lesson plans to be delivered in schools; rather it is to make teachers more creative and thoughtful in planning their science lessons and to equip them with a repertoire of strategies and ideas that they can use and adapt to suit their context.

The project included a pilot stage in the previous academic year, during which Year 5 teachers in the intervention schools received three days of professional development. This helped refine the training sessions and introduced the approach to the school (though importantly, not to the study cohort of pupils). In the main study, two teachers from each school participated in five days of professional development (both were Year 5 teachers or, in one-form entry schools, Year 5 and another member of staff such as the science subject leader). Due to staff changes, in many cases these were not the same teachers that had taken part in the pilot. In the professional development sessions, the teachers were shown how to plan and deliver their own conceptually challenging lessons, tailored to the needs and abilities of their pupils. They also spent two days in-school planning and sharing knowledge to ensure the strategies were embedded.

Background evidence

The evidence that this approach can work comes from a quasi-experiment in primary schools in rural Oxfordshire (Mant, Wilson and Coates, 2007). In that study, 16 treatment schools were matched with 16 control schools based on size, results in previous science SATS, and proportion of children with special educational needs. With intensive training, the treatment schools used the 'conceptually challenging' approach for one year. Researchers then compared the improvement in Key Stage 2 science results across the two groups. They found that the proportion of pupils achieving level 5 in science increased by 10 percentage points more in treatment schools than in control schools.

The approach is an attempt to remedy a major problem with primary level science teaching highlighted by the Parliamentary Office for Science and Technology (2003): primary school teachers tend to concentrate too much on factual content and not enough on core scientific ideas. The EEF decided the project was suitable for an efficacy trial, using random assignment to get a better estimate of the impact and to test whether the approach works in disadvantaged schools. It was the first science project funded by the EEF.

Evaluation objectives

The evaluation was designed to establish whether TDTS had any impact on:

- pupils' science attainment;
- pupils' attitudes towards science; and
- pupils' performance in English and Maths at KS2.

Project team

The TDTS programme was developed and delivered by Bridget Holligan from Science Oxford and Helen Wilson from the School of Education, Oxford Brookes University.

Ethical review

The evaluation team obtained ethical approval from the Department of Education, University of York Ethical Review Panel on 27 July 2012. Headteachers signed an agreement outlining the main commitments of the three parties in the study: the school, the project developers and the evaluators. The evaluation team provided information and opt-out consent forms for parents/guardians.

Data was managed in accordance with the Data Protection Act (1998). The trial database is securely held and maintained on the University of York's research data protection server, with non-identifiable data. Confidentiality is maintained and no one outside the trial team has access to the database. Data was checked for missing elements and/or double entries. All outputs were anonymised so that no schools or students could be identified in any report or dissemination of results.

Trial registration

This trial was registered at http://www.isrctn.com/ISRCTN54969918

Methodology

Trial Design

A two-armed clustered randomised-controlled trial was carried out. Forty-two primary schools were recruited to the project in Autumn 2012. The evaluators matched schools into pairs based on pre-test results, pupils eligible for free school meals, pupils with English as an additional language, and the size of the school. One of each pair was randomly allocated to receive TDTS and the other to the delayed treatment control.

School-level randomisation was chosen in preference to within-school randomisation (e.g. within-year randomisation in two-form entry schools) because teacher collaboration is inherent to the intervention. Therefore, there would have been a high risk of teachers in the comparison groups learning about the intervention approaches, for example through staffroom conversation or witnessing classroom practice. A wait-list control group was used to prevent teachers becoming demoralised post-allocation and to keep them engaged in the trial.

Between January and June 2013, Year 5 teachers in the intervention schools were introduced to the TDTS programme to implement it with their current pupils (who were not part of the main study). From September 2013 to July 2014, TDTS was delivered to the same 21 intervention schools. The 21 control schools were offered the intervention from September 2014 to July 2015.

Both groups were pre- and post-tested (in December 2012/January 2013 and June/July 2014 respectively). The self-completion tests were administered by the teachers, with the pre-test being completed before randomisation (when the pupils were still in Year 4). The post-test marking was blinded, meaning that the assessors were unaware of which treatment group the pupils were in. The analyses used an intent-to-treat-design, meaning that every effort was made to retain schools that dropped out for any reason in the main analyses.

Eligibility

All primary schools in Oxfordshire were eligible for recruitment to this trial provided they were large enough to release a pair of teachers for the training and had not taken part in the previous related study (Mant *et al.,* 2007). They were approached by the developers and invited to a recruitment conference where they learnt about TDTS and where the concept and practicalities of participating in an RCT were explained to them. At least one of the teachers agreeing to participate had to be teaching science to Year 5 and the cohort of pupils in Year 5 during the 2013-2014 school year was involved in the evaluation.

Schools committed themselves to meet the requirements of the programme and evaluation when they signed up to the trial, and opt-out consent for pupils to take part in pre- and post-testing was sought from parents/guardians via the schools.

Intervention

TDTS is a primary school CPD programme designed to help teachers plan challenging science lessons that will enhance children's engagement and cognitive skills. After three preliminary sessions to refine the content of the training days in the 2012-2013 academic year, the main intervention consisted of a series of five full-day sessions over the 2013-2014 academic year. The main five sessions took place at Oxford Brookes University premises in September and November 2013, and January, March and June 2014. Details of the content of these sessions can be found in Appendix 2. The training days were designed to enable the teachers to develop:

- their questioning skills, to extend pupils' thinking about scientific ideas;
- dedicated discussion slots in science lessons;

- their understanding of appropriate and challenging science practical work, including investigations and problem solving; and
- pupils' focused and creative recording in science.

The CPD was spread over the academic year to allow teachers to try out and evaluate the suggested strategies with their pupils between sessions. It was delivered by Bridget Holligan from Science Oxford and Helen Wilson from Oxford Brookes University. Over half (22 out of 38) of the teachers who attended the main phase of training sessions reasonably regularly also attended the three preliminary sessions.

Prior to the main intervention, a launch day was delivered in each intervention school to demonstrate approaches to science teaching and to enthuse the school more generally about the project. The launch day was delivered to children who were not going to be involved in the study (meaning that they would not be in Year 5 in 2013-2014). In three schools, the launch days were delayed until September/October 2013. The event involved pupils (not in the evaluation cohort) participating in a hands-on investigation, for example trying to identify the best ketchup for a café to use.

The key features of the CPD were focused on three main elements: thinking, talking and doing science. This included the use of a dedicated discussion slot, the 'Bright Ideas Time', which utilised specific prompts to stimulate pupil talk, in particular:

- The Odd One Out
- The PMI
- The Big Question

In the first of these, the pupils are shown three different objects and asked to say which the odd one out is and why. This gives them the opportunity to draw upon their scientific understanding and vocabulary to justify their answer. There is no one 'right' answer.

The 'PMI thinking tool' (De Bono, 1995) presents a scenario and asks pupils to identify and discuss a positive (P), a minus (M) and interesting features (I). So, for example, if the scenario was 'all door handles are made of chocolate', the pupils would need to use their understanding of the properties of materials to give pros and cons, and then move on to creative, imaginative ideas that arise from the scenario.

The 'Big Question' poses a question linked to an area of science that will extend the children's thinking. For example, 'How do you know the Earth is a sphere?'

Each training day was themed around a particular area of the science curriculum, such as evolution, forces, or electricity. Teachers were given specific examples of each of these prompts in the different areas of the science curriculum and were encouraged to always include at least one in their science lessons.

Another strategy was the use of 'Practical Prompts for Thinking'—short teacher demonstrations that are designed to intrigue pupils and act as discussion starters.

There was also an emphasis on pupils undertaking a variety of different types of practical science, including problem solving and fair testing. The pupils focused their recording on the learning objectives, thus trimming the time spent writing and releasing time for thinking, talking and doing. The aim was to make it sharp and focused so that it would be useful as an assessment tool for teachers.

The control schools continued with business-as-usual teaching. They were all offered the training on completion of the evaluation, starting in September 2014, with launch days as for the intervention schools.

Outcomes

The primary outcome was knowledge, thinking and reasoning in science. Since KS2 science SATs were discontinued in 2008, there has been no widely-recognised standardised science assessment for English primary pupils of any age group. The evaluators developed tests that spanned science curriculum content appropriate for the year group tested. These tests were compiled from standardised assessment questions[1] and had actually been originally devised for a previous, unrelated RCT[2]. Each test was carefully compiled to represent questions from a range of topics (broadly biology, chemistry and physics) and a balance of different types of assessment question (process/inquiry-based; shorter concept-based; and more open-ended conceptually-based). Copies of the tests can be found in Appendices 5 and 6.

The secondary outcome reported here was pupils' attitudes towards science, measured by a questionnaire adapted from Kind, Jones and Barmby (2007). The survey instrument can be found in Appendix 7. An additional secondary outcome will be attainment in English and Maths. This will be measured by obtaining the study pupils' KS2 results in autumn 2015. (An analysis of those figures will be published as a later addendum to this report).

The tests and attitude surveys were posted to schools and completed under exam conditions, supervised by teaching staff in school. The pre-testing took place before randomisation, but the staff were aware of allocation during post-testing. Data marking and entry was carried out by IEE staff who were unaware of which treatment group the pupils were in.

Sample size

The statistical power of the planned analyses was estimated using Optimal Design software. Based on extensive experience with similar analyses, assumptions were made as follows:

Pupils per school per year group: 45

Proportion of variance in the outcome explained by covariates (R-squared): +0.49

Intra-class correlation: 0.10

Criterion for statistical significance (α): $p<.05$

MDES: 0.25

Power: 0.80

Based on these assumptions, a sample size of 40 schools would be needed (20 per treatment group) to detect an effect size of 0.25. The recruitment target was 46 schools to allow for some dropout. The total number of schools that signed up to the study was slightly lower than this, at 42. The power calculations at different stages of the project (as planned in the protocol; at randomisation; and at analysis) are shown below.

[1] We are grateful to Terry Russell and Linda McGuigan (Centre for Research in Primary Science and Technology, University of Liverpool)for permission to take these questions from Science Assessment Series 1/2

[2] Wellcome Trust, publication pending

Stage	N [schools/pupils] (n=intervention; n=control)	Correlation between pre-test (+other covariates) & post-test	ICC	Power	Alpha	Minimum detectable effect size (MDES)
Protocol	40 (20;20) 45 pupils per school	0.6	0.15	80%	0.05	0.25
Randomisatio n	42(21;21) 45 pupils per school	0.6	0.15	80%	0.05	0.25
Analysis (i.e. available pre- and post-test)	41 (21;20) 23 pupils per school	0.51	0.12	80%	0.05	0.28

Randomisation

The schools were allocated to matched pairs based on the following criteria: pre-test score; students eligible for free school meals (FSM); school size, and students with English as an additional language (EAL). A random number generator was used in Excel to randomise one of each pair to the control and one to the intervention. The randomisation was carried out by the IEE's Data Manager.

Analysis

The impact evaluation of the pupil tests used hierarchical linear modelling (HLM), a multilevel analysis in which pupils are nested within schools. Because randomisation was carried out using matched pairs, the pairings were accounted for by including them as an extra level in the analysis. This results in a 3 level model, with Pupil nested within School nested within Pair. The HLM analysis used degrees of freedom associated with the number of schools, not the number of students. Pupils in schools randomly assigned to TDTS were compared to those in the randomly assigned control group, controlling for the pre-test scores. After the main analyses across all pupils, subgroup analyses were carried out for boys and girls; for high and low achievers based on the pre-test scores (using greater or equal to the median and below the median). Although we conducted an analysis for FSM-eligible pupils (defined as ever eligible for FSM), it should be noted that there were four schools with no pupils eligible for free school meals, and nine further schools with fewer than five FSM pupils. There were a number of reasons for this low number of FSM pupils. Firstly, there was a focus on poorly-performing schools and not just those with high rates of FSM at recruitment. Secondly, more of the schools recruited through the developers' existing contacts had low rates of FSM. Thirdly, reflecting the rural nature of parts of the county, some schools were very small and did not have many Year 5 pupils in total. Since there was such a high level of attendance at the training sessions, which acted as a proxy for implementation fidelity, it was not appropriate to perform the intended analysis by fidelity.

The effect size was calculated using Hedges' g. Since this was a cluster randomised trial, there are options for the calculation of the effect size (Hedges 2007). We chose to calculate the effect size as the adjusted difference in the means between the arms (accounting for pairing) divided by the unadjusted total standard deviation in the outcome at endline. The pupil attitude ratings were analysed using descriptive statistics (paired comparison of school-level means for each statement).

Despite requests from the evaluation team, it proved impossible to persuade one control school to complete the post-tests. However, there was no important difference to the estimated values when including or excluding the intervention school with the missing paired control school. Therefore it was included in the analysis, to use all the available data.

Process evaluation methodology

A process evaluation was conducted to explore intervention and control teachers' approaches to science teaching and intervention teachers' feedback about TDTS. This was achieved through a short self-completion survey dispatched at the same time as the pupil post-tests and attitude surveys. In the intervention schools, staff who had attended the TDTS CPD sessions were asked to complete these, and in the control schools copies were addressed to Year 5 teachers. Attendance records from the training sessions in the evaluation year were also studied. There were no school visits in this study.

The teacher survey was conducted with teachers in both treatment and control schools. It was a postal survey and recipients were assured that data would remain anonymous. Teachers were asked to indicate only the name of their school, although they could have returned it completely anonymously had they wished. Questions covered teaching approaches used, confidence in different aspects of science teaching and reflection on their pupils' engagement with and progress in science across the year. These questions were identical for intervention and control teachers so that comparisons could be made. Intervention teachers were then asked additionally about TDTS: the training, the perceived effect on their classroom practice and their pupils; and which of the strategies they found most and least useful. A copy of the questionnaire can be found in Appendix 6.

Impact evaluation

Timeline

The main intervention period was the 2013-2014 academic year, when the study pupils were in Year 5, and taught science by participating teachers. Pre-tests were administered when the study cohort was in Year 4. The wait list control schools received the intervention from September 2014, with specific instruction not to use TDTS with the study cohort (now in Year 6). In May 2015, participating pupils completed their Key Stage 2 SATs tests. These will subsequently be analysed through the National Pupil Database.

Date	Activity
October–December 2012	Recruitment of schools. Parental opt-out consent sought
December 2012–mid January 2013	Pre-tests
23 January 2013	Randomisation
February 2013–July 2013	Intervention (pilot stage)
September 2013–July 2014	Intervention (main stage)
June–July 2014	Post-tests
June–July 2014	Pupil attitude questionnaires
June–July 2014	Teacher surveys
September 2014–July 2015	Waitlist control schools receive TDTS (not study pupil cohort)
May 2015	Pupils sit KS2 SATs

Participants

Recruitment was managed by the development/delivery team. There were 235 primary schools in Oxfordshire at the start of the project, and it was estimated that about 100 would be ‘ineligible’ either because they were very small and would probably find it difficult to participate in the study as envisaged, or because they had been part of the previous, related research with Oxford Brookes University.

The developers contacted 88 schools to ask if they would participate in the project. Of those, 24 said ‘no’; 22 failed to reply to repeated attempts at contact (combinations of phone, e-mail and fax); and 42 agreed to take part. Although the aim was to recruit 46 schools to allow for attrition, the high retention rate meant that there were more than the required 40 schools remaining at post-test. The developers struggled with the funding model (see Costs section). Asking for money from the schools to participate in the trial acted as a barrier to recruitment because it made it much harder to explain the project benefits and funding procedures to the headteachers. Some schools were also not in a position to produce the necessary funds and other arrangements had to be made so that they were not deprived of the opportunity to take part.

The first 30–40 schools contacted were selected on the basis of appearing to be a good match to EEF ‘target schools’, meaning that they had a high number of FSM students and below average performance data. The second 40–50 were schools known to Oxford Brookes University through existing partnerships. Recruitment took place between October and December 2012.

The evaluation team sent opt-out consent letters to all 42 schools in the trial for dispatch to parents/guardians of pupils in the trial. Parents were given a form to return to the school if they did not want their children to participate in the pre- and post-tests. No forms were returned to the evaluation team.

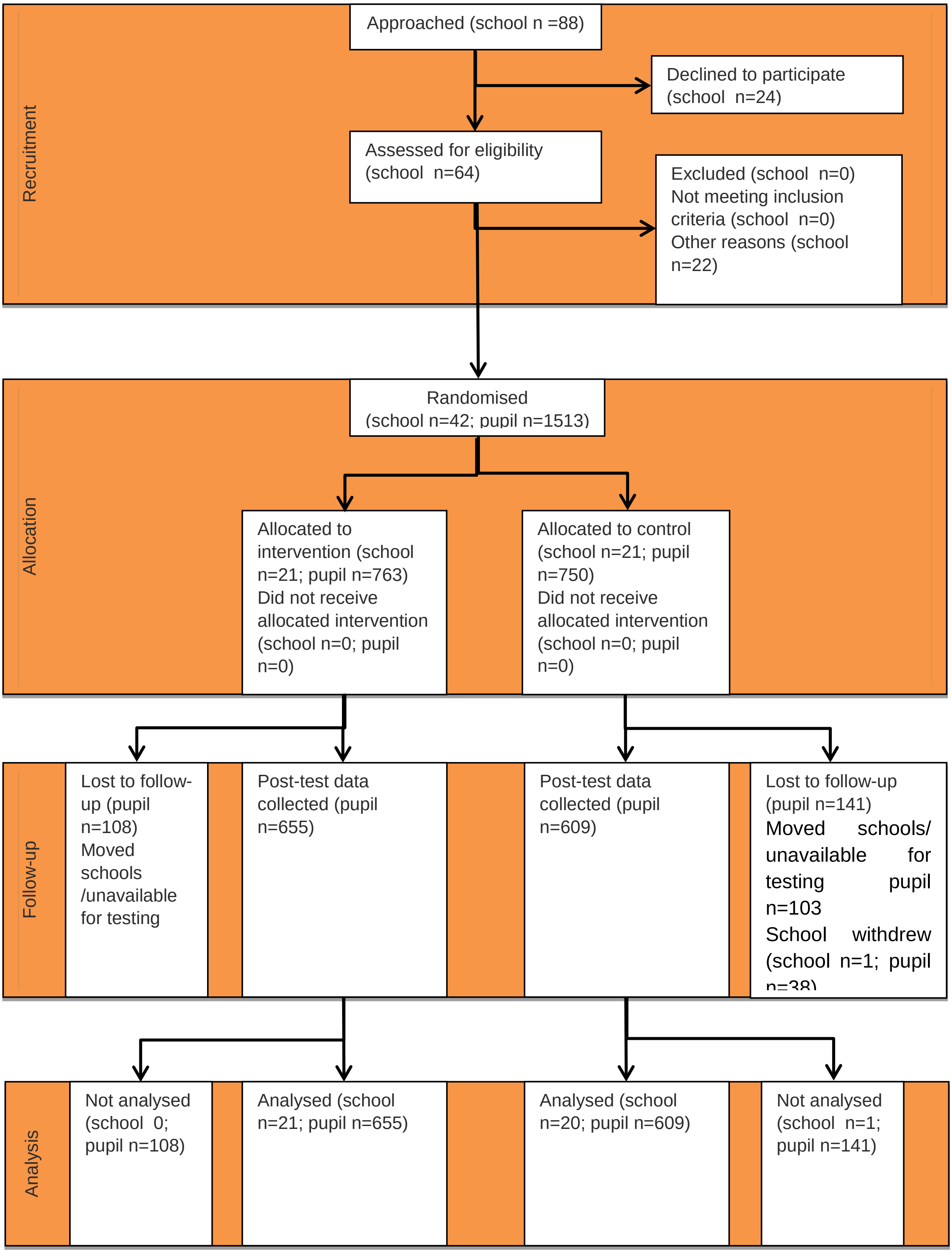
The pupils completed the pre-test when they were in Year 4 and the post-test at the end of Year 5 (18 months later). Post-tests were dispatched along with a list of pupils that had completed the pre-tests, to ensure that only the correct pupils were asked to complete the test. One control school (38 pupils) withdrew because, despite contact from the evaluators and the developers, the new head teacher could not find time for the pupils to complete the post-test. A further 211 pupils (108 intervention and 103 control) had left the schools or were absent at the time of the post-test. This was an attrition rate of 2% of schools and 16% of pupils (see Figure 1).

Randomisation was carried out by the IEE’s Data Manager using a random number generator. Schools were allocated to matched pairs based on pre-test score; pupils eligible for free school meals (FSM); school size; and pupils with English as an Additional Language (EAL). One of each pair was randomised to the control and one to the intervention using a random number generator. Table 1 shows that the schools were well matched in terms of size, type and level of FSM and EAL, at randomisation and in the final analysis. The proportion of pupils with FSM (15–16%) was slightly lower than the national average of 19%, as was the proportion with EAL (16% compared with 18% nationally, DfE, 2013). The group of intervention schools was more likely to be based in an urban or rural environment, and the control schools in the town and fringe. Although it was not controlled for in the analysis, it should be noted that almost half the intervention schools were rated as requiring improvement or inadequate in the Ofsted inspection prior to recruitment, compared with none of the control group.

Table 1: School characteristics

	As randomised (N=42)			As analysed (N=41)		
	Intervention	**Control**	**Difference**	**Intervention**	**Control**	**Difference**
Number of schools	21	21		21	20	
Number on roll (average)	297	283	14	297	280	17
School Type						
LEA Maintained	81%	81%	0%	81%	80%	1%
Academies	19%	19%	0%	19%	20%	-1%
School Setting						
Urban	81%	71%	10%	81%	70%	11%
Town and Fringe	0%	19%	-19%	0%	20%	-20%
Village	19%	10%	9%	19%	10%	9%
Mixed school	100%	100%	0%	100%	100%	0%
Eligible FSM	16.0%	15.0%	1.0%	16.0%	15.5%	0.5%
EAL	16.3%	16.1%	0.2%	16.3%	16.5%	-0.2%
Ofsted Rating						
Outstanding	0	3		0	3	
Good	11	18		11	17	
Requires improvement	7	0		7	0	
Inadequate	3	0		3	0	

Figure 1: Sample allocation and attrition



Pupil characteristics

Table 2 summarises the pupil characteristics of the sample, comparing the pre- and post-test profiles. At pre-test, the average score for pupils subsequently allocated to the intervention and control groups was almost identical. The control group had a higher proportion of boys than girls, whereas the intervention group was fairly evenly split. At 23% (intervention) and 22% (control), the proportion of pupils ever eligible for FSM was similar in the two groups. “Ever eligible” is those who have ever claimed FSM and is therefore higher than the figure shown in Table 1, which shows those currently eligible and claiming. The profile for pupils completing post-tests was very similar to the pre-test, indicating that attrition had acted at a similar rate across these demographics.

Table 2: Pupil characteristics

	All pupils in 42 reporting schools (as randomised)			All pupils with post-test scores (as analysed)		
	Intervention	**Control**	**Difference**	**Intervention**	**Control**	**Difference**
Pre-test score	24.04	24.03	0.01	24.17	24.26	-0.09
Gender						
Male	48.1%	49.9%	-1.8%	50.1%	53.9%	-3.8%
Female	47.1%	41.5%	5.6%	49.6%	45.3%	4.3%
Unknown	4.8%	8.7%	-	0.3%	0.8%	-
FSM (Ever FSM)						
No	71.8%	69.9%	1.9%	77.3%	76.5%	0.8%
Yes	23.3%	21.5%	1.7%	22.4%	22.7%	-0.3%
Unknown	4.8%	8.7%	-	0.3%	0.8%	-
Number of pupils (all)	763	750	-	655	609	-

Outcomes and analysis

For analysis there were 1264 completed post-tests, representing 84% of the original children.

The outcome variable was tested to establish if there was any difference between intervention and control in a three step modelling process:

Statistical analysis showed that both ‘pair’ and ‘school’ were, as expected, necessary components of the multilevel model. As the schools were chosen to be representative of all schools available to the study, both ‘pair’ and ‘schools’ were included in the model as random factors.

Next the effect of the baseline score for each child was added to the model. This controlled the outcome scores for the pre-test, showing how important the pre-test was in predicting outcome scores, given the school the child is in. Pre- and post-test marks were strongly correlated: $r = .71$, $p < .001$.

We then checked whether the effect of the pre-test score on the post-test score was the same for all schools, or varied between schools. Including this effect in the model did not improve the fit. So the effect of the pre-test score did not vary between the schools.

We fitted and tested the final multilevel model, which accounted for schools and pairs as random factors, and adjusted for baseline pre-test marks. This model tests the effect of the Intervention against the Control after the pre-test measure had been accounted for and taking into account the multilevel structure of the data. We assessed the diagnostics for this model and found them to be adequate, therefore we are confident that this model is robust.

The post-test marks for the Intervention, after taking account of the pre-test mark and the variability among the schools, were 1.5 units higher than the control [95% CI (0.74, 2.25)]. This result is unlikely to happen by chance [$F(1, 36.50) = 6.61$, $p = .014$].

The analyses performed for the full data were repeated for the subgroups gender and achievement level (defined as less than the median at pre-test and greater than or equal to the median at pre-test for the P1 marks).

The effect size was calculated according to Hedges (2007). The 95% confidence interval (CI) was calculated as the estimate +/- 1.96 SE (standard error). Table 3 summarises the primary outcomes. For all pupils combined, there was a moderate effect size of +0.22 which equates to around 3 months' progress (Table 4). This was lower than the minimum detectable effect size (MDES) calculated in the power analysis (see Sample size section on p.11), suggesting that the original estimates in the calculation were too conservative.

Moderate effect sizes were shown for those with lower and higher prior science attainment, with slightly more impact evident for those with lower attainment. There was also a moderate effect size for girls (+0.32).There was a lower effect size for boys (+0.12), and it is not possible to rule out chance as an explanation for the effect observed. . The difference between the effect on the girls and boys was sufficiently large to provide evidence that TDTS was more effective for girls than boys (p=.023). The effect size for FSM pupils was +0.38. However, it must be noted that the FSM pupils were unevenly distributed amongst the schools, although the numbers in the intervention and control groups were similar (138 control and 147 intervention). Four schools had no FSM participants and almost two-thirds of the 285 FSM pupils across the sample were accounted for by 11 schools.

There were some changes to the analysis outlined in the original protocol, which stated that as well as the main analyses including all pupils, subgroup analyses would be carried out for boys and girls, and for high, average and low achievers (based on the pre-test). The analysis by achievement was divided into two rather than three categories (at or above the median versus below the median) to give more robust sample sizes.

Analysis by implementation fidelity was not conducted because the proxy measure (attendance at training sessions) was high for the large majority of the sample. An additional analysis, of those ever eligible for FSM (to reflect the EEF's priority focus on this demographic) could not be included because of low sample sizes. Ten intervention schools and 10 control schools had fewer than five FSM participants. The total number of FSM pupils in the analysis was 285, with eleven schools accounting for almost two-thirds of them.

Table 3: Primary outcomes

	Raw Means						Effect size	
	Intervention group			Control group				
Outcome	n (missing)	Mean (95%CI)	SD	n (missing)	Mean (95%CI)	SD	n in model (Int, Con)	Effect size (95%CI)
All pupils	763 (108)	22.25 (21.72, 22.77)	6.71	750 (141)	21.05 (20.49, 21.62)	6.92	1264 (655, 609)	0.22 (0.11, 0.33)
Boys	367 (39)	21.77 (21.00, 22.53)	6.90	374 (46)	21.25 (20.48, 22.02)	6.94	656 (328, 328)	0.12 (-0.03, 0.27)
Girls	359 (34)	22.75 (22.03, 23.47)	6.48	311 (35)	20.84 (20.01, 21.67)	6.90	601 (325, 276)	0.32 (0.16, 0.48)
FSM pupils	178 (31)	19.52 (18.48, 20.56)	6.38	161 (23)	17.62 (16.60, 18.65)	6.11	285 (147, 138)	0.38 (0.15, 0.62)
Lower than median at pre-test	353 (55)	18.10 (17.41, 18.79)	5.96	349 (75)	16.47 (15.84, 17.10)	5.21	572 (298, 274)	0.30 (0.13, 0.46)
Above or equal to median at pre-test	410 (53)	25.71 (25.16, 26.26)	5.17	401 (66)	24.80 (24.17, 25.44)	5.8	692 (357, 335)	0.22 (0.07, 0.37)

Pupil attitudes to science

The attitude survey was completed by Year 5 pupils around the same time as the science test, and findings for the control and intervention groups were compared. The survey took the form of a series of statements for which pupils were asked to indicate their level of agreement on a five-point scale from ‘agree a lot’ to ‘disagree a lot’. Pupil-level results can be found in Appendix 1. Because these do not account for clustering within schools or the effect of pairing, Tables 4–6 (below), only provide the most “favourable” response (usually agree a lot, but disagree a lot where the items were reversed, as indicated) for intervention and control pupils separately. This is to give an indication of the strength of agreement or disagreement for each statement. The commentary focuses on the school level analysis which, although more limited, is more reliable because it allows for pairing and clustering. This was conducted by taking 19 pairs of schools as matched at randomisation (excluding the pair with the school that withdrew and one school that did not return the attitude survey). For each statement, mean scores were calculated for each school. The means were then compared within each pair. The tables report how many cases in which the intervention score was higher, lower or the same as its matched control.

The first group of attitude statements relate to school science lessons (Table 4). For most of these items, the intervention schools were more favourable than the controls. This was particularly true for the lessons being interesting, something they looked forward to and would like to do more of. The direction of the response suggested intervention schools were having more discussions and doing less writing in science, in accordance with the TDTS model (although there was no difference between the pairs of schools for the likelihood of copying off the board). They were also much more likely to say science lessons made them think, and that they enjoyed the discussions. However, there was very little difference in self-reported level of understanding or enjoyment of solving problems in science.

Table 4: Learning science at school

		Agree a lot % pupils	Comparison of mean item score (school-level)		
			Intervention more favourable	Intervention = Control	Control more favourable
Science lessons are interesting	TDTS control	49 37	15	1	3
Science lessons are boring*	TDTS control	*51* *40*	12		7
Solving science problems is enjoyable	TDTS control	43 36	10		9
I enjoy discussions in science lessons	TDTS control	32 25	13		6
We often have discussions in science lessons	TDTS control	51 41	13		6
We spend a lot of time in science lessons copying from the board*	TDTS control	*33* *24*	9		10
We do a lot of writing in science lessons*	TDTS control	*8* *4*	12		7
Science lessons make me think	TDTS control	40 29	14		5
I understand everything in my science lessons	TDTS control	13 13	8	1	10
I look forward to my science lessons	TDTS control	38 28	15		4
I would like to do more science at school	TDTS control	36 30	13		6

** most favourable rating = "disagree a lot"*

Turning specifically to the practical element of science lessons (Table 5), in all cases more intervention than control schools gave the most favourable responses within the pairs. In line with the TDTS approach, there was confirmation that practical work was done more often than in most of the control schools. Pupils doing TDTS were more likely to look forward to practicals and think they were fun. However, the "agree a lot" figures for these two statements show that practical work is a keenly anticipated and fun aspect of science in both sets of schools.

Table 5: Practical work in school science

		Agree a lot % pupils	Comparison of mean item score (school-level)		
			Intervention more favourable	Intervention = Control	Control more favourable
We do practical work in most science lessons	TDTS control	26 17	15		4
I look forward to doing science practicals	TDTS control	53 46	15		4
Doing practical work in science lessons is fun	TDTS control	61 49	14		5
Practical work in science is boring*	TDTS control	*17* *19*	13		6
We already know what will happen when we do science practical work*	TDTS control	*22* *18*	13		6
I can decide what to do for myself in science practical work	TDTS control	20 16	12		7

** most favourable rating = “disagree a lot”*

Table 6 compares attitudes of the two groups towards science more generally. The figures for pupil agreement show that more than half the pupils agreed ‘a lot’ that it was important to learn science, but within 16 of the 19 pairs of schools this was expressed more strongly in the intervention school. The same balance was seen for ‘science is fun’ in the context of a generally favourable response. The response to ‘I like thinking about scientific ideas’ was more positive in 14 intervention schools compared with just 4 controls. There was no real difference for science being difficult to understand, matching the response to ‘I understand everything in my science lessons’ in Table 4. Around two-thirds of pupils disagreed ‘a lot’ with the gender stereotype that science is for boys, and this was slightly more evident in intervention schools.

Table 6: Attitudes towards science

		Agree a lot % pupils	Comparison of mean item score (school-level)		
			Intervention more favourable	Intervention = Control	Control more favourable
I like thinking about scientific ideas	TDTS control	41 34	14	1	4
Science is fun	TDTS control	49 36	16		3
It is important that we learn science	TDTS control	70 57	16		3
I find science difficult to understand*	TDTS control	17 21	11		8
I am just not good at science	TDTS control	11 14	12		7
I think science is more for boys*	TDTS control	63 62	12		7

** most favourable rating = "disagree a lot"*

Cost

The cost of the approach as delivered in the trial is estimated at £26 per pupil. This estimate is based on two classes of 25 pupils and a group of 21 schools receiving training together. Schools were charged £1,000 each to take part, which included five full INSET days, resources and materials. The estimate also includes the cost of three pilot days, which were used to refine the approach prior to the start of the intervention but which were not passed onto schools (estimated at £6,720 in total).

The financial model for the evaluation was quite complex. Intervention schools were asked to provide funding of £1,000. Half of this was requested at the start of the project (although there was some discretion for schools that were unable to afford this), and half was deducted from their final payment of cover time. In return they received:

- five days of CPD (plus 3 pilot days), including supply cover;
- supply cover funding for up to two days of in-school time per teacher to plan how the project strategies would be best embedded in their school;
- an equipment and resources package for each school, worth £500; and
- a celebration and dissemination conference at the end of the year.

Control schools were expected to make a contribution of £500 (less than intervention schools since they were being offered three fewer training days), which will be deducted from their final cover payment at the end of the year when they receive TDTS. The package they received was the same as that outlined for the intervention schools, without the three pilot sessions.

Process evaluation

Fidelity

Implementation fidelity was not assessed directly through checklists or lesson observations. Instead, comparison was made between the survey responses of teachers from the control and intervention schools about the approaches used in science lessons (see below). Attendance records for the five training sessions that constituted the main phase of the intervention were also examined (see Table 7). The three pilot sessions, which took place the previous year, have not been included because in most schools there was significant teacher change between 2012-13 and 2013-14. In general, attendance was very high with only four out of the 21 schools failing to attend all five sessions (three schools attended four, one school attended three).

Table 7: Teacher attendance at TDTS training sessions 2013-2014

Attendance	Number of schools (21 total)
All sessions attended, same two teachers	6
All sessions attended, same two teachers, occasional absence of one teacher	8
All sessions attended, at least one consistent attendee but not always both Year 5s	2
All sessions attended, not both teachers to every one (illness)	1
Small school so only one attendee (one session missed)	1
Some sessions missed, inconsistency in staff attending (high teacher turnover)	3

Teacher survey

Teacher surveys were sent to all schools in the study. In the intervention sample, all those who had attended training sessions were asked to return them. In control schools, all Year 5 teachers were asked to complete them. Thirty-three teacher surveys were received from 20 intervention schools, and 21 surveys from 15 control schools. Although these represent very good school-level response rates (95% intervention and 75% control), the low number of teachers mean that the findings have to be treated as indicative only.

Comparing responses from TDTS and control teachers shows that the former reported that they were using several approaches more often. These included practical work and pair or small group practical work; whole class discussion and, to a lesser extent, pair or small group discussion; and asking pupils to solve scientific problems. TDTS teachers were also more likely to say that they gave pupils time to think “very often”. These responses fitted with the pattern shown in the pupils’ responses, where those in intervention schools were more likely than those in controls to agree that they had practicals in most science lessons, often had discussions, and that the science lessons made them think. There was little or no difference for making links with literacy and numeracy, using teacher demonstration and teaching scientific facts. This suggests that TDTS prompted teachers to use more practical activities, promote more discussion among pupils, and give more time for reflection.

One of the aims of the project was to encourage teachers to make more links between science, literacy and numeracy. However, teachers who followed the approach did not report making more links than those in the control group.

TDTS and control teachers expressed broadly similar confidence levels on various activities related to science teaching, with the exception of assessing pupils' work where the TDTS teachers were more confident overall. There was also no apparent difference between the groups on their view of their own science knowledge.

However, TDTS teachers were much more likely than control teachers to agree with a range of positive statements about their pupils' ability, confidence and motivation in science over the year. The gap was particularly marked in relation to pupils enjoying their lessons and being engaged with science.

When TDTS teachers were asked about the intervention specifically, around three-quarters of them agreed strongly that they had used the strategies they had learnt; that they had found it inspiring; and that it had benefited their pupils. In terms of abilities, they felt that the project had particularly helped them to develop their understanding of science practical work, their questioning skills and their use of discussion slots in science. They were least likely to agree that it had developed pupils' recording skills in science, or their use of questioning skills and discussion slots in other subjects.

Teachers spoke about being reinvigorated and inspired by the course. The strategies that they had found especially effective were 'Practical Prompts for Thinking', 'Bright Ideas Time' and (within that) the 'Big Question'. The starters were valued as a way to get children into a scientific frame of mind and allowing pupils of different ability levels to take part with all contributions being valued. In many cases, children had been given more freedom to explore and investigate, and had sometimes surprised their teachers: '*Some particularly challenging questions have been asked, leading to discussions about science I never thought would happen in primary school!*' Several teachers appreciated the ideas for practical work and an '*emphasis on practical science and talking as opposed to extensive work in books*.'

The questionnaire did not specifically invite ideas for improvements, although there was a catch-all question at the end. Just two teachers took this opportunity to voice anything negative and both comments related to generic issues with science. One said that resourcing science lessons was always a chore, and the other bemoaned the lack of time to fit in all the topics suggested because science was confined to one afternoon slot a week.

The impact of the course was summed up neatly by this teacher: '*I have always tried to make my science lessons as practical as possible—but the course had given me more confidence with this approach, and made me realise it is not just the doing that is important, but the thinking and giving the time to talk too.'*

Intervention teachers were asked if the TDTS approach had been particularly beneficial to certain groups of pupils, and control teachers were asked the same question about their usual approach. TDTS participants were more inclined to mention those with special educational needs (49% vs 24%). The intervention appeared to be judged effective across the ability range, with 55% (vs 14% control) saying it was beneficial for low ability pupils, 46% (vs 33% control) for middle ability, and 52% (vs 24% control) for high ability.

Conclusion

Key conclusions
1. Thinking, Doing, Talking Science appeared to have a positive impact on the attainment of pupils in science. Overall, Year 5 pupils in schools using the approach made approximately three additional months' progress.
2. There are some indications that the approach had a particularly positive effect on pupils eligible for free school meals, but further research is needed to explore this.
3. The programme had a particularly positive effect on girls and on pupils with low prior attainment.
4. The approach had a positive impact on pupils' attitudes to science, science lessons, and practical work in particular.
5. National test data will be used to assess the English and mathematics outcomes of participating pupils and to measure the long-term impact of the approach. In addition, further research could be conducted to investigate whether this result can be replicated in a larger number of schools.

Limitations

The trial was run in a single local authority area (Oxfordshire), so the sample of schools was drawn from a restricted geographical area. Moreover, the low rates of pupils eligible for free school meals in several participating schools means that the FSM data is based on small sample sizes. This limits the generalisability of the results.

The primary outcome measure, although compiled from questions in a standardised series of assessment units, was not in itself a nationally standardised test. The post-test was administered immediately at the end of the intervention, so there is no measure of the longevity of the impact. Moreover, the post-test was supervised by staff who knew the treatment allocation of the schools and it is possible this may have introduced a source of bias.

The process evaluation was limited to a teacher survey. It would be useful to understand more about which elements of the programme teachers used, and how they introduced them into their classrooms.

Interpretation

The results of this cluster RCT provide promising evidence that the TDTS intervention has a positive impact on pupils' science attainment. The effect size was higher for girls to a degree that was unlikely to happen by chance, suggesting that TDTS had a greater effect on girls than boys. This impact on attainment was accompanied by more favourable post-intervention pupil attitudes towards science in TDTS schools compared with the controls, particularly in those areas in line with the project aims. This included science lessons being interesting, making pupils think and science being fun. The differences can be interpreted with reasonable confidence as being a consequence of the TDTS intervention.

The TDTS teachers were more likely than teachers in control schools to report using the type of teaching approaches that were part of the intervention, although there was little conclusive evidence of increases in teacher confidence. Intervention teachers were, however, much more positive than their counterparts in the control group about their pupils' engagement, confidence and ability in science. These findings were supported by the pupils' response to the survey mentioned above. However, caution should be exercised when looking at these findings, both because of low sample sizes and because TDTS may be receiving a 'halo effect' from teachers excited at being involved in the intervention.

Although the feedback received from the TDTS teachers via the survey was overwhelmingly positive, there remains a doubt about the extent to which the strategies have been adopted across the wider curriculum. The question of whether there has been any impact on pupils' performance in literacy or numeracy will be explored by the analysis of the KS2 SATs results later in 2015.

Future research and publications

These uniformly positive findings suggest that TDTS is a very promising intervention. It would be an ideal candidate for a larger, effectiveness trial to ascertain whether such a sizeable impact can be maintained when the intervention is scaled up and possibly delivered using a different model.

References

De Bono, E. (1995). *Serious Creativity: Using the Power of Lateral Thinking to Create New Ideas*. New York: HarperCollins.

Department for Education (2013). Schools, Pupils and their characteristics: June 2013. *Statistical First Release 21/2013*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/207670/Main_text-_SFR21_2013.pdf

Hedges, L. V. (2007). Effect sizes in cluster-randomized designs. *Journal of Educational and Behavioral Statistics*, *32*(4), 341-370.

Hedges, L. V., & Olkin, I. (1985). *Statistical methods for meta-analysis*. Orlando, Florida: Academic Press.

Kind, P**,** Jones, K. & Barmby, P**.** (2007) Developing Attitudes Towards Science Measures, *International Journal of Science Education 29*(7), pp. 871-893.

Mant, J., Wilson, H., & Coates, D. (2007). The effect of increasing conceptual challenge in primary science lessons on pupils' achievement and engagement. *International Journal of Science Education, 29*(14), 1707-1719.

Parliamentary Office for Science and Technology (2003). Primary science. *postnote 202*. Available at: www.parliament.uk/briefing-papers/POST-PN-202.pdf

Snijders, T. A. B., & Bosker, R. J. (2012) *Multilevel analysis: An introduction to basic and advanced multilevel modelling.* 2nd Ed. London: Sage.

Appendix 1: Pupil attitude ratings

Learning science at school (cf Table 4)

		Agree a lot	Agree a bit	Not sure	Disagree a bit	Disagree a lot
Science lessons are interesting	TDTS	49	33	8	7	3
	control	37	31	17	9	6
Science lessons are boring	TDTS	7	11	10	20	51
	control	14	16	11	19	40
Solving science problems is enjoyable	TDTS	43	26	15	8	7
	control	36	24	18	9	12
I enjoy discussions in science lessons	TDTS	32	33	19	9	8
	control	25	28	22	13	12
We often have discussions in science lessons	TDTS	51	31	11	5	2
	control	41	31	18	7	3
We spend a lot of time in science lessons copying from the board	TDTS	10	17	18	22	33
	control	15	18	22	21	24
We do a lot of writing in science lessons	TDTS	22	33	18	19	8
	control	29	31	21	15	4
Science lessons make me think	TDTS	40	42	13	3	1
	control	29	46	18	5	2
I understand everything in my science lessons	TDTS	13	29	18	27	13
	control	13	28	23	26	11
I look forward to my science lessons	TDTS	38	34	16	8	5
	control	28	30	20	13	9
I would like to do more science at school	TDTS	36	24	17	13	10
	control	30	20	22	12	16

Practical work in school science (cf Table 5)

		Agree a lot	Agree a bit	Not sure	Disagree a bit	Disagree a lot
We do practical work in most science lessons	TDTS	26	35	24	11	4
	control	17	22	31	19	12
I look forward to doing science practicals	TDTS	53	22	13	6	5
	control	46	23	15	8	9
Doing practical work in science lessons is fun	TDTS	61	22	10	3	5
	control	49	26	16	5	5
Practical work in science is boring	TDTS	6	6	13	17	58
	control	8	9	15	19	50
We already know what will happen when we do science practical work	TDTS	9	15	34	22	21
	control	11	18	36	18	17
I can decide what to do for myself in science practical work	TDTS	20	25	35	12	8
	control	16	26	34	13	12

Attitudes towards science (cf Table 6)

		Agree a lot	Agree a bit	Not sure	Disagree a bit	Disagree a lot
I like thinking about scientific ideas	TDTS	41	27	17	8	7
	control	34	23	19	13	12
Science is fun	TDTS	49	30	10	7	4
	control	36	32	14	10	9
It is important that we learn science	TDTS	70	15	10	3	2
	control	57	19	15	6	3
I find science difficult to understand	TDTS	7	34	17	24	17
	control	11	27	21	20	21
I am just not good at science	TDTS	11	15	25	24	25
	control	14	14	27	22	23
I think science is more for boys	TDTS	7	7	14	10	63
	control	7	5	18	9	62

Appendix 2: Content of training sessions

Outline of Days: September 2013 – June 2014

During this year each teacher can claim a total of 2 days each to work on this project.

	Content
Day 1 Theme: Materials Fri 13 Sept 2013	• An overview of progress to date • The Bright Ideas Time: Odd One Out at two levels - newcomers and old hands • Challenge in science and higher order thinking contd. • More ideas for practical Scientific Enquiry: What's the Best? • Discovery Dog/Spellbound Science • Drama in science • A practical prompt for pondering
Day 2 Theme: Electricity Fri 8 Nov 2013	• The Bright Ideas Time: PMI at two levels - newcomers and old hands • More problem solving as a means of challenge – the precious jewel • Creative communication • Literacy links • A practical prompt for pondering
Day 3 Theme: Forces and motion Tues 14 Jan	• The Bright Ideas Time: the Big Question at two levels - newcomers and old hands • More practical scientific enquiry for challenge: flippers • Puppets in science • Mathematics links • A practical prompt for pondering
Day 4 Theme: Light and Sound Weds 12 March	• The Bright Ideas Time: Concept Cartoons, • Concept Cartoons as a prompt for an investigation • More drama in science • ICT links • A practical prompt for pondering
Day 5 Theme: Evolution Thurs 5 June	• The Bright Ideas Time: Thinkers' Keys • Content reviewed according to need

Celebration and dissemination event: Friday 20 June

Appendix 3: School memorandum of understanding

The Thinking, Doing and Talking Science Project
Funded by the Education Endowment Foundation
Delivered by Science Oxford and Oxford Brookes University and evaluated by the Institute for Effective Education at the University of York

School Partnership Agreement: For all 'intervention schools'
Please read & sign this agreement & return to Science Oxford at the address below by 30 April 2013.

The project aims to work over 3 years to conduct a trial of the impact of a programme that aims to help primary schools to improve attainment in science by focussing on creative, practical and challenging science lessons that encourage pupils to use higher order thinking skills.

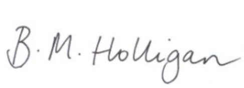
This agreement is between Science Oxford and __ Primary School.

Under this partnership agreement Science Oxford agrees to:

- Deliver a 'launch day' in your school during 2013
- Deliver 3 training days in partnership with Oxford Brookes University from February to July 2013
- Deliver 5 training days in partnership with Oxford Brookes University during the 2013-14 school year
- Deliver 2 project celebration/dissemination events in partnership with Oxford Brookes University
- Provide supply cover funding of £200 per day for up to two teachers for each training day
- Provide supply cover funding of £200 per day for up to two teachers to have 3 days of in-school planning from February 2013 to July 2014
- Provide supply cover funding of £200 per day for up to two teachers to attend 2 project celebration/dissemination events
- Supply the school with an equipment package worth £500 that complements the teacher training

Under this partnership agreement __ Primary School agrees to:

- Pay a contribution of £1000 (£500 in April 2013 & £500 in September 2013) – *or to contact Bridget Holligan to make an alternative arrangement if this is not possible*.
- Send two teachers (unless agreed otherwise) to each of the 8 training days arranged from February 2013 to June 2014
- Use the approaches developed during the training days with 2013-14 Year 5 pupils and provide evaluation feedback
- Attend the celebration/dissemination events
- Administer the post-intervention science test (distributed and collected by the University of York) to all 2013-14 Year 5 pupils before the end of the school year in July 2014

 Bridget Holligan Science Oxford Date: 25/03/2013	 Helen Wilson Oxford Brookes University Date: 25/03/2013	Signature: Print Name: ___ Primary School Date:

Appendix 4: Parental consent letter

January 2013

Dear Parent/Guardian,

We would like to ask permission for your child to take part in an educational research study.
This study is being done to assess the effectiveness of a training course for teachers in helping pupils do better at science.

Your child's school has agreed to participate in the study. In January 2013, the teacher will administer short science questionnaires to the pupils in your child's class. They will be tested again in June 2014.

Your child's answers will be confidential. They will be marked by the research team at York and will not count towards any school assessment. Pupils' names will be replaced with code numbers. No individual pupil's data will appear in any report.

If you do not want your child to take part, please complete and sign the attached opt-out form by INSERT DATE. A pupil's right to withdraw will be respected.

If you have concerns or questions about your child's participation in this study, please contact *Pam Hanley* (e-mail: pam.hanley@york.ac.uk Tel: 01904 328165).

With thanks and best wishes

Pam Hanley
Institute for Effective Education
University of York

THINKING, DOING AND TALKING SCIENCE EVALUATION

Parent/Guardian opt-out form

If you do not permit your child's test scores to be used in the study, please complete this form and return it <u>to your child's teacher</u> by INSERT DATE.

I **do not** wish my child's test scores to be used in the research project.

Pupil's name: ....
(Please print clearly)

Class teacher …………………………………………………………………..

Parent's/Guardian's name: ....
(Please print clearly)

Parent's/Guardian's signature: ....

Date………………

Appendix 5: Pupil pre-test

THE UNIVERSITY of York

Science knowledge questionnaire

Year 4

First name ____

Last name ____

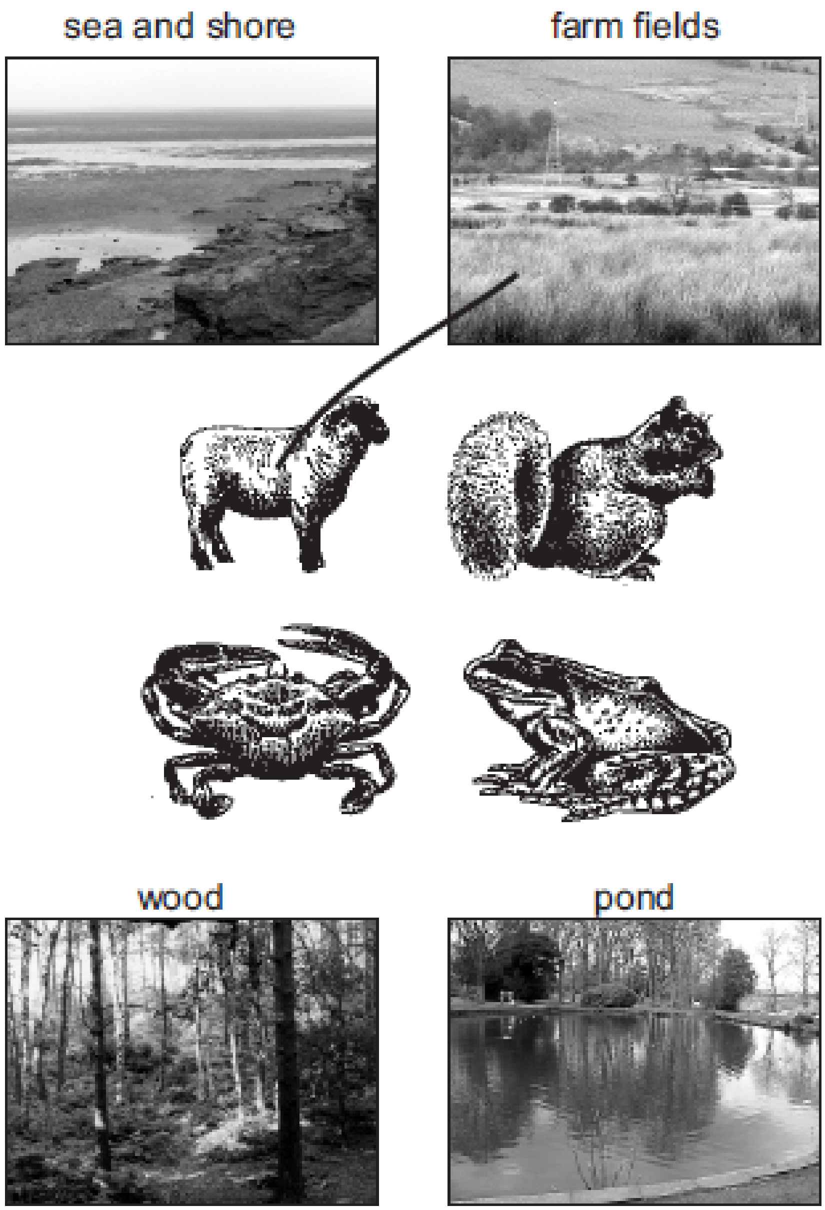
School ____

- The test is 40 minutes long.
- You will need: pen, pencil, rubber, ruler, protractor and calculator.
- The test starts with easier questions.
- Try to answer all of the questions.
- Write all your answers on the test paper – do not use any rough paper.
- Check your work carefully.
- Ask your teacher if you are not sure what to do.

For marker's use only

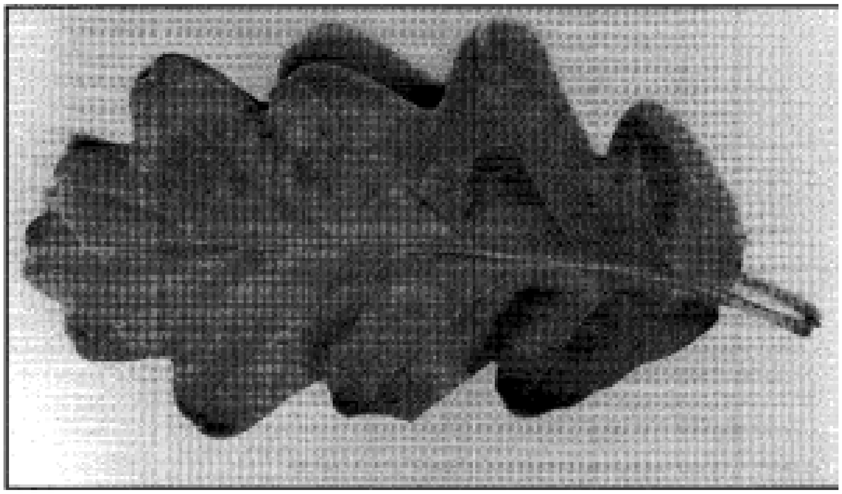
Total Marks	

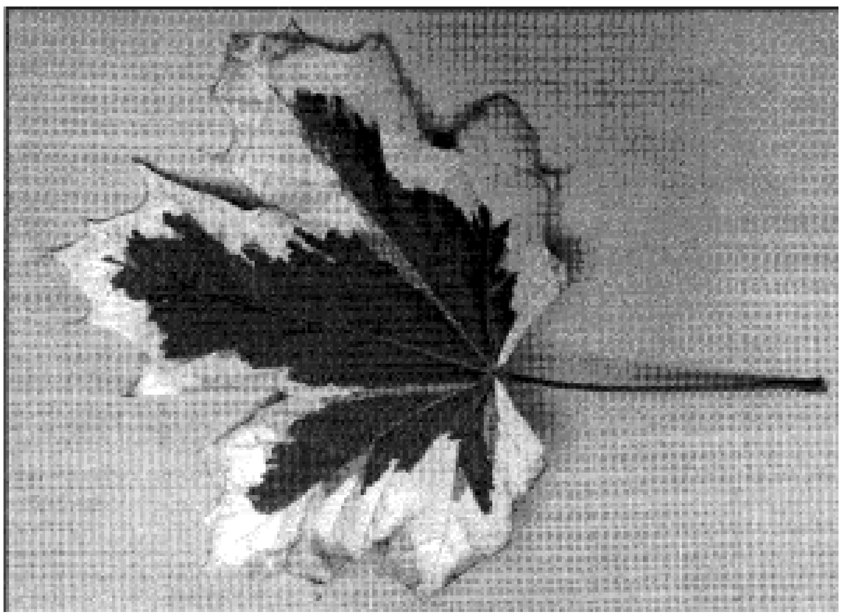
Q1 Draw a line to put each animal in the place where you could find it. One has been done for you.



Total out of 1

Q2 Look at these two objects.





a Write one way in which these two objects are different.

……………………………………………………………………………………………..

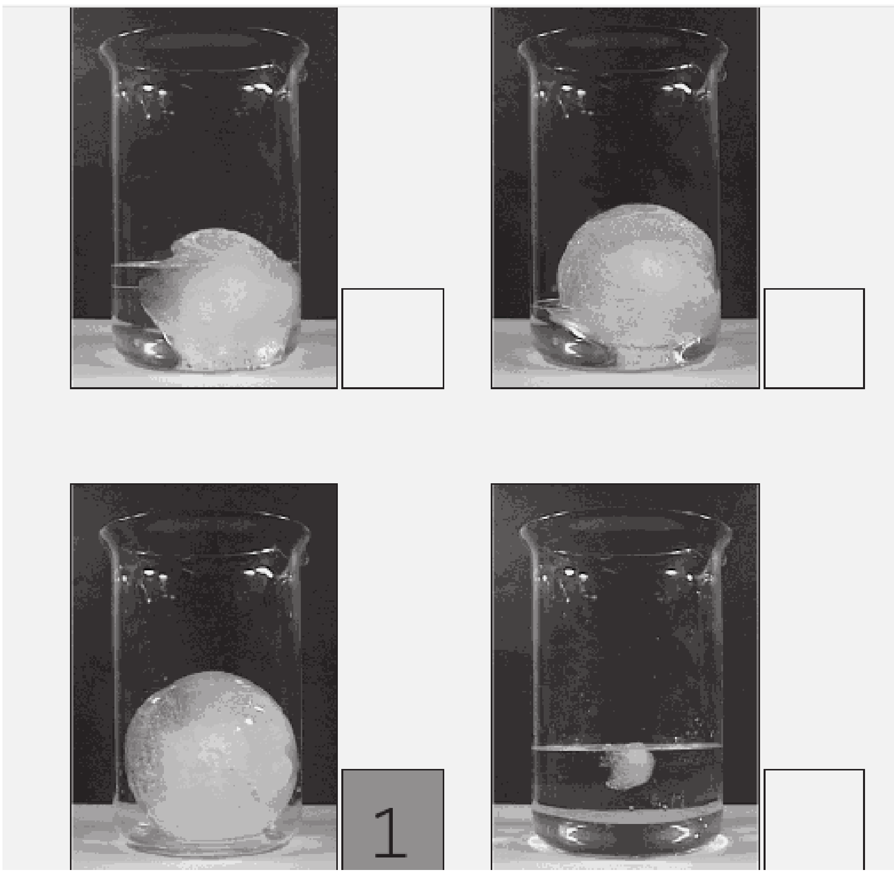
1 mark

b Write one way in which they are the same.

……………………………………………………………………………………………..

1 mark

Q3 a Put numbers on the pictures in the correct order to show how the ice ball changed. The first one has been done for you.



1 mark

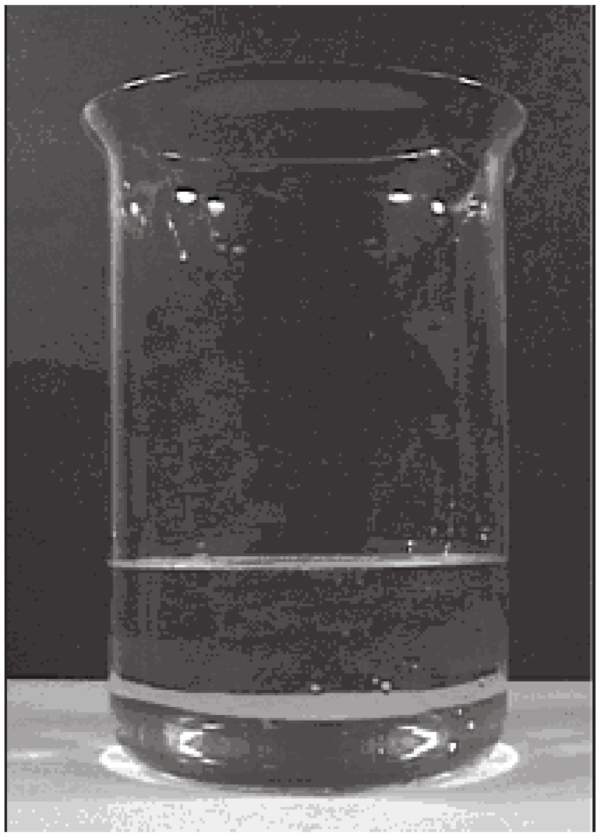
b What happened to the size of the ice as it melted?

……………………………………………………………………………………………….

……………………………………………………………………………………………

1 mark

c Which word describes the water left when the ice has all melted? Tick ONE box.



Hot ☐ bendy ☐

Hard ☐ runny ☐

Sharp ☐

1 mark

Total out of 3

Q4 Sam and Anna find out how the sound changes as they move away from a sound maker.

a Use these words to complete their table.

loud **quiet**

very loud **very quiet**

distance from sound maker (metres)	sound I heard
1	loud
10	....
20	....

2 marks

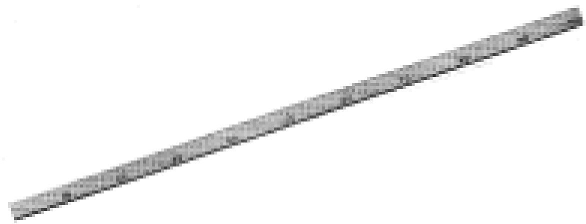
b Look at the table. What was the sound like at 1 metre from the sound maker?

……………………………………………………………………………………………

1 mark

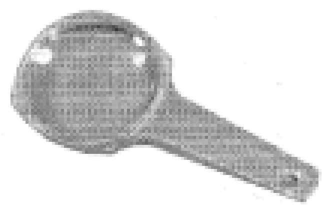
c What would Sam and Anna use to measure how far they move from the sound maker? Tick ONE box.

metre stick



☐

hand lens



☐

balance scale

☐

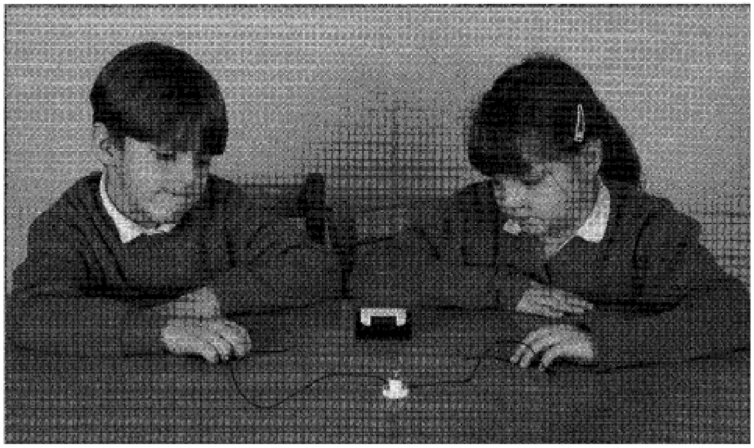
thermometer

☐

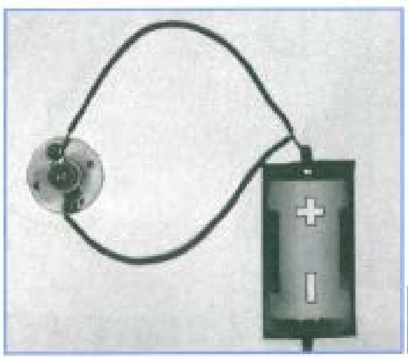
1 mark

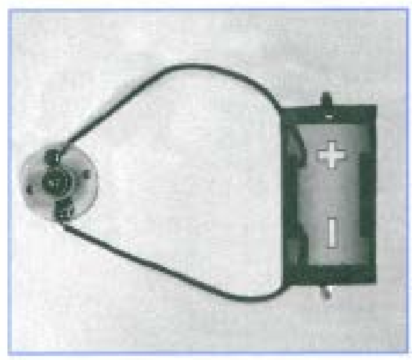
Total out of 4

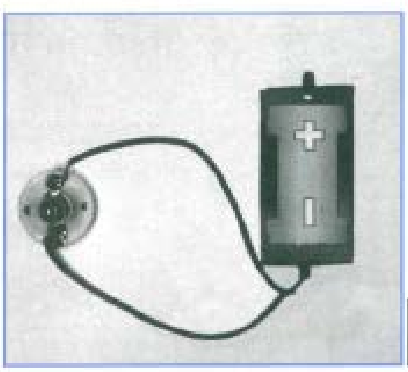
Q5 Helen wants to make the bulb light.

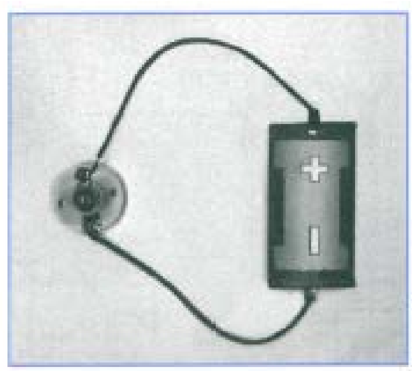


How should she connect the wires to the battery? Tick ONE box.

 ☐

 ☐

 ☐

 ☐

Total out of 1 ☐

Q6

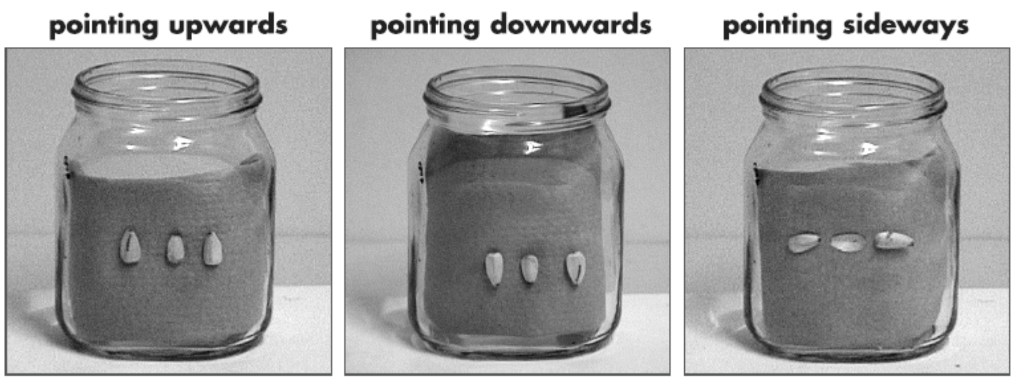
What three things do ALL animals do? Tick THREE boxes.

move	☐	swim	☐
reproduce	☐	run	☐
smile	☐	grow	☐
read	☐	cry	☐

Total out of 3 ☐

Q7 Dylan and Gemma want to know if the root always grows downwards from a seed.

They place some sunflower seeds in different positions on a paper towel. They water them.



This is how the seeds grew.

a Complete this table to show their results.

starting position of seeds	pointing upwards	pointing	pointing ....
direction roots grew	down	....	....

2 marks

b Dylan said they could use just one seed pointing each way. Gemma said it was better to use three seeds in each position.

Why is Gemma's suggestion better?

……………………………………………………………………………………………….

1 mark

c What did they find out about the starting position of the seeds and the direction in which the roots grew?

……………………………………………………………………………………………….

1 mark

Total out of 4

Q8 Peter sorted these objects into sets according to the material from which they are made. He called this set 'wood'.

table gate chair

wood

a Write the name of the material for this set.

envelope tissue comic

....

1 mark

b Write the name of the material for this set.

key ring coin

....

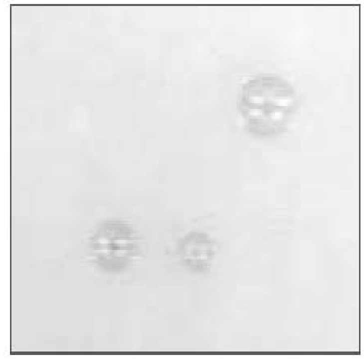
1 mark

Q9 Jack shone a torch onto some objects to see what happened to the light.

Book

Coin

Bubbles



Complete these sentences. Use each object only once.

a The light went through the ……………………………………………

1 mark

b The light made the …………………………………………… look shiny.

1 mark

c The light made the …………………………………………… make a dark shadow.

1 mark

Total out of 3

Q10 Colin pushed his car twice. It went much further the second time.

Explain why the car went further on the second push.

Tick ONE box.

Colin pushed harder the second time.	☐
The car was heavier the first time.	☐
Cars sometimes do that.	☐
The wheels on the car are not straight.	☐

Total out of 1 ☐

Q11

Which organ of the body is most likely to be damaged by too much alcohol over a long time? Tick ONE box.

eye	☐	lungs	☐
tongue	☐	liver	☐
nose	☐		

Total out of 1 ☐

Q12 The fern is a plant that grows well in woods.

Name TWO conditions in woods which would suit ferns.

i ……………………………………………………………………………………………………….

1 mark

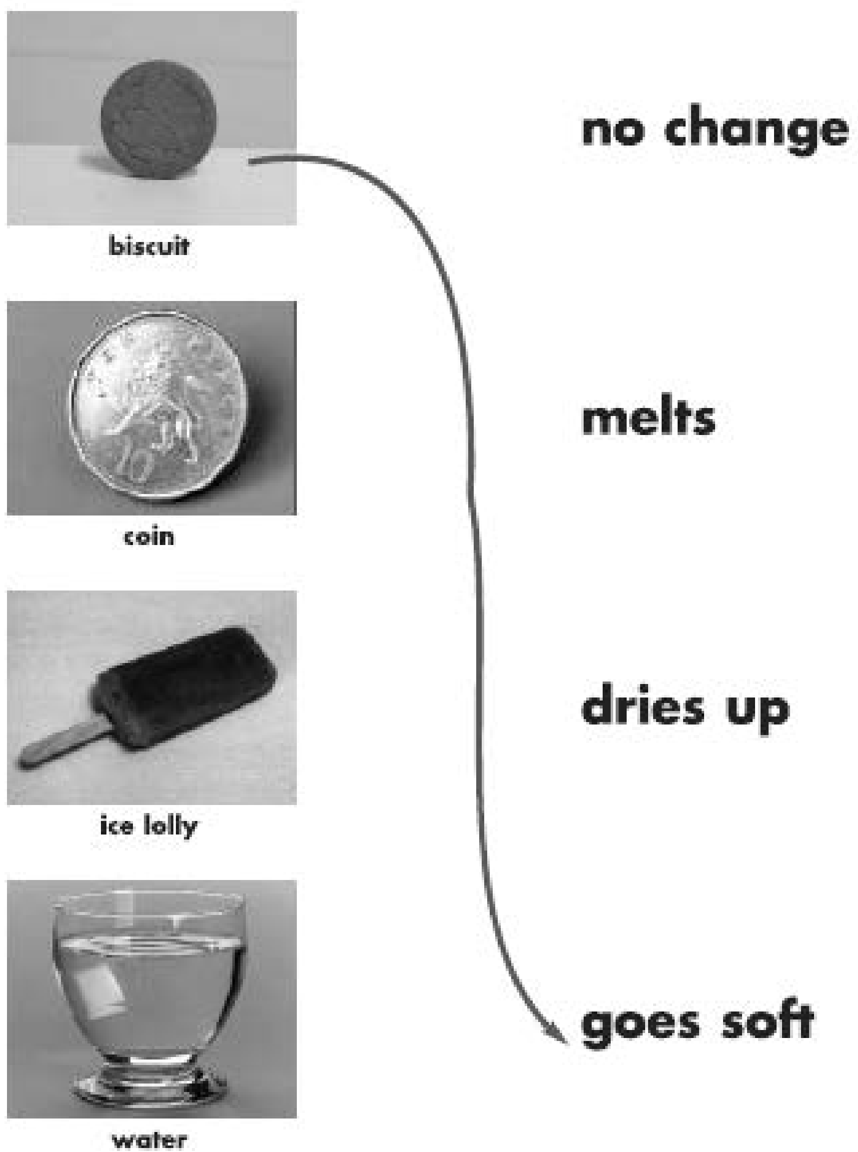
ii ……………………………………………………………………………………………………….

1 mark

Total out of 2

Q13 Emma and Sam left these materials on the window sill for one week. How did they change?

Draw a line from the material to the correct word. Use each word only once. The first one has been done for you.



Total out of 1

Q14

Olivia wanted to find a good material for blocking out sounds.

She held tubes over her ears and filled them with different materials.

tissue cotton wool newspaper straw

a Write down the question that she is investigating.

……………………………………………………………………………………………

……………………………………………………………………………………………

1 mark

b Michael made the sounds to see whether Olivia could hear them. Why did he tell Olivia to close her eyes as he made the sounds?

……………………………………………………………………………………………

……………………………………………………………………………………………

1 mark

Total out of 2

Q15 Jane gives the same sized push to two toy cars on the table. The second car is much heavier than the first car.

How will the cars move? Tick ONE box.

The two cars move the same distance.	☐
The first car moves more slowly than the second car.	☐
The two cars move at the same speed.	☐
The second car does not move as far as the first car.	☐
You can't tell how the cars will move.	☐

Total out of 1 ☐

Q16 "A healthy diet contains a **balance** of carbohydrates, fats, proteins, vitamins, minerals, fibre and water."

Explain what 'balance' means in this sentence.

…………………………………………………………………………………………………….

Total out of 1

Q17 Anne and George go pond-dipping. They look for animals at the surface of the pond and deeper down in the pond. Here is a table of their findings.

Animal	Found at the pond surface	Found deep in the pond
water beetle	1	4
leech	0	2
pond skater	3	0
great diving beetle	1	3
gnat larva	6	0
water flea	3	8
phantom midge larva	0	3

a Which animal did they find most of?

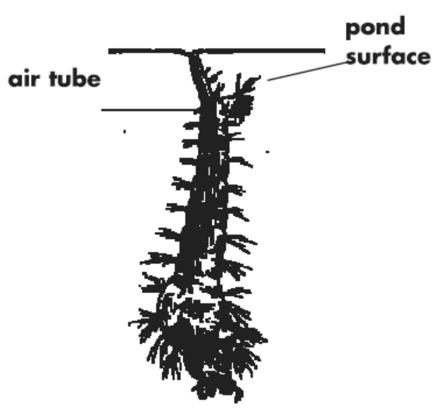
……………………………………………………………………………………………….

1 mark

b Write the name of one of the animals found only at the pond's surface.

……………………………………………………………………………………………….

1 mark



c Look at the drawing of the gnat larva. Why is this animal not found in the deep water?

……………………………………………………………………………………………….

1 mark

Q18 Chris and Sarah have four materials to make a temporary shelter from the rain. They investigate which would be the best to use to keep them dry.

cotton

polyester

wool

silk

They poured the same amount of water on to each material.

a Why did they pour the SAME AMOUNT of water on to each material?

....

....

1 mark

b What should they look for to find out whether each material is waterproof?

....

1 mark

Total out of 2

Q19 Emma made a shadow in the shape of a rabbit on the screen.

a Explain how a shadow is formed.

……………………………………………………………………………………………….

……………………………………………………………………………………………….

1 mark

b Explain how Emma uses light and shadow to make the rabbit's eye.

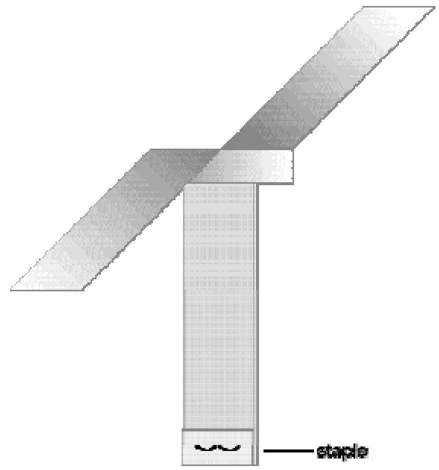
……………………………………………………………………………………………….

……………………………………………………………………………………………….

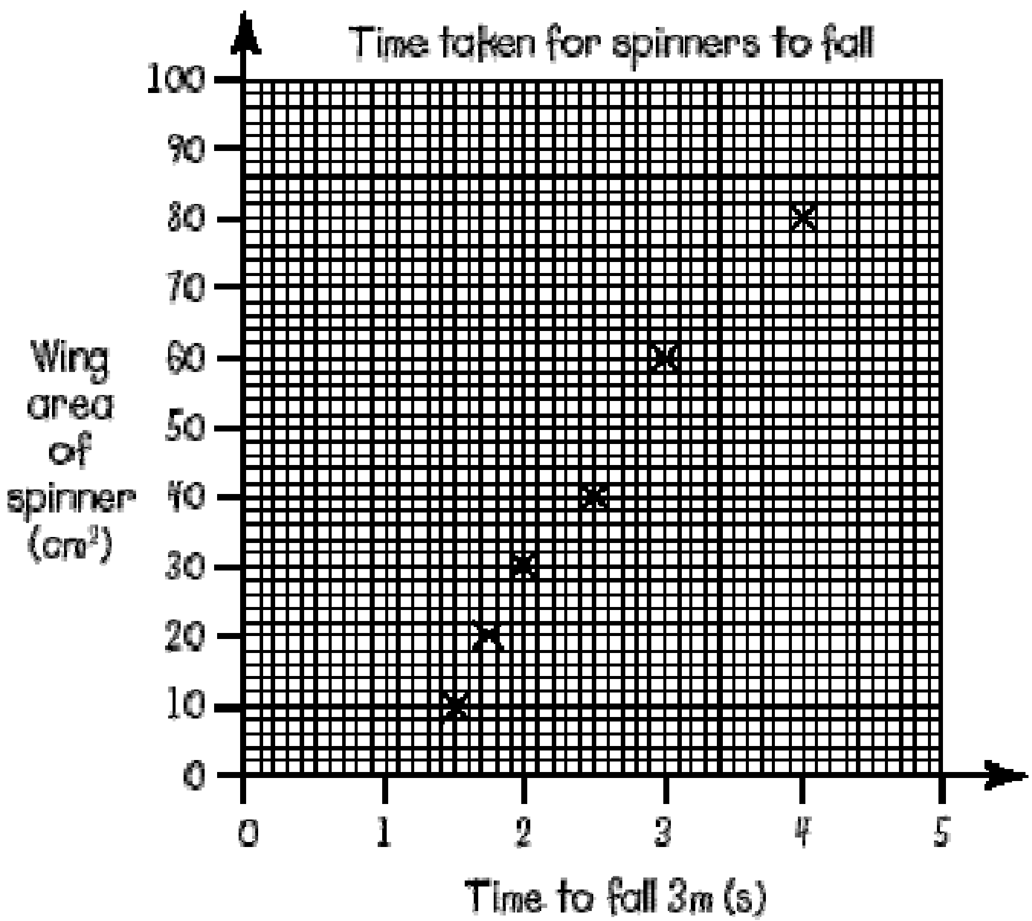
1 mark

Total out of 2

Q20 The children investigate the time it takes different sized spinners to fall 3 metres.



Here is a graph of their results.



a What would be the wing area of a spinner which took 3 second to fall 3 metres?

………………………………………………………………………………… cm2

1 mark

b Describe how the wing area of the spinners affects the time taken to fall.

……………………………………………………………………………………………

……………………………………………………………………………………………

2 marks

c What is it that causes the area of the wing to affect the time taken for the spinner to fall?

……………………………………………………………………………………………

……………………………………………………………………………………………

1 mark

d Name the force which pulls down on the spinner.

……………………………………………………………………………………………

1 mark

Total out of 5

End of test

Appendix 6: Pupil post-test

THE UNIVERSITY of York

Science knowledge questionnaire

Year 5

First name__________________________________

Last name __________________________________

School __________________________________

- The test is 40 minutes long
- You will need: pen, pencil, rubber, ruler, protractor and calculator
- The test starts with easier questions.
- Try to answer all of the questions.
- Write all your answers on the test paper – do not use any rough paper
- Check your work carefully
- Ask your teacher if you are not sure what to do

For marker's use only

Total Marks	

Q1

What three things do ALL animals do? Tick THREE boxes.

move	☐	swim	☐
reproduce	☐	run	☐
smile	☐	grow	☐
read	☐	cry	☐

Total out of 3 ☐

Q2 Peter sorted these objects into sets according to the material from which they are made. He called this set 'wood'.

table gate chair

wood

a Write the name of the material for this set.

envelope tissue comic

....

1 mark

b Write the name of the material for this set.

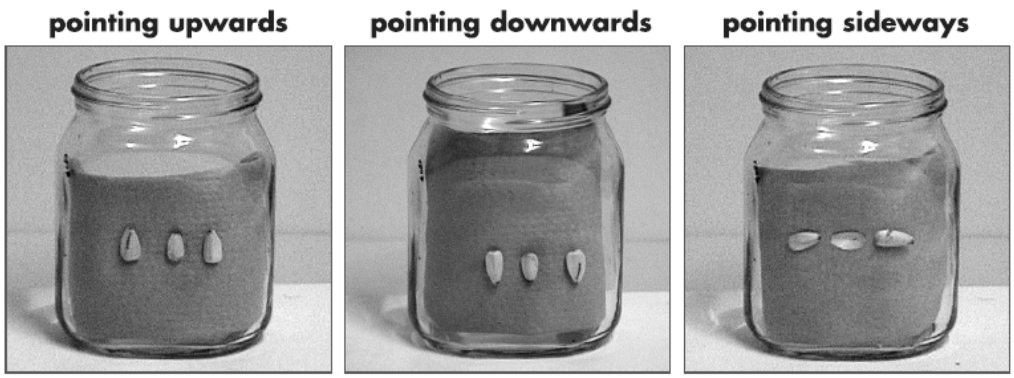
key ring coin

....

1 mark

Q3 Dylan and Gemma want to know if the root always grows downwards from a seed.

They place some sunflower seeds in different positions on a paper towel. They water them.



This is how the seeds grew.

a Complete this table to show their results.

starting position of seeds	pointing upwards	pointing	pointing ....
direction roots grew	down	....	....

2 marks

b Dylan said they could use just one seed pointing each way. Gemma said it was better to use three seeds in each position.

Why is Gemma's suggestion better?

…………………………………………………………………………………………………

1 mark

c What did they find out about the starting position of the seeds and the direction in which the roots grew?

…………………………………………………………………………………………………

1 mark

Total out of 4

Q4

Olivia wanted to find a good material for blocking out sounds.

She held tubes over her ears and filled them with different materials.

tissue cotton wool newspaper straw

a Write down the question that she is investigating.

…………………………………………………………………………………………

………………………………………………………………………………………… 1 mark

b Michael made the sounds to see whether Olivia could hear them. Why did he tell Olivia to close her eyes as he made the sounds?

…………………………………………………………………………………………

………………………………………………………………………………………… 1 mark

Q5 Colin pushed his car twice. It went much further the second time.

Explain why the car went further on the second push.

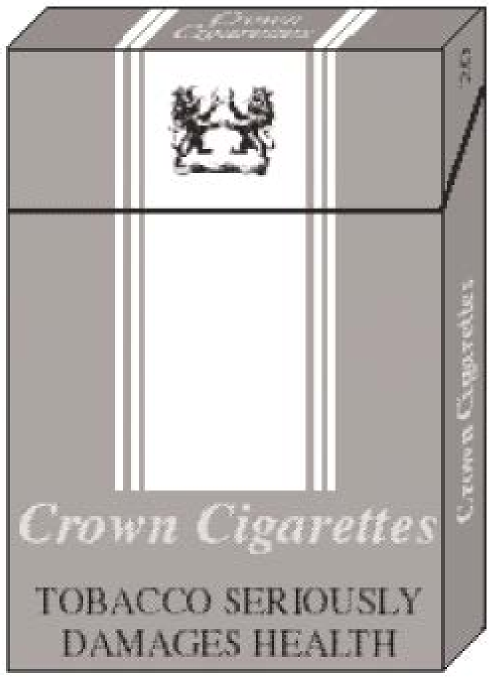
Tick ONE box.

Colin pushed harder the second time.	☐
The car was heavier the first time.	☐
Cars sometimes do that.	☐
The wheels on the car are not straight.	☐

Total out of 1 ☐

Q6 Dan saw this warning printed on a cigarette packet.

TOBACCO SERIOUSLY DAMAGES HEALTH



Which body organ is most likely to be damaged by contact with inhaled tobacco smoke?

……………………………………………………………………………………………………

Total out of 1

Q7 One year a farmer killed all the foxes on his land because they were killing his chickens. Later in the year he found that his lettuces were being eaten by rabbits.

Why were there so many more rabbits on his land later in the year?

………
.....

………
.....

………
......

Total out of 1

Q8 Sam and Hannah put 150g of each crushed rock into a separate jar. They covered each material with water.

Next they remove the materials from the water and measure the mass of each again.

a What property of the materials were they investigating? Tick ONE box.

absorbency	☐	hardness	☐
solubility	☐	transparency	☐

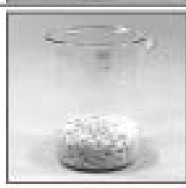
1 mark

b What would they need to keep the same to make sure their test was fair? Tick ONE box.

Time of day the investigation is done	☐
The shape of the containers	☐
How long the rocks are kept in the water	☐
The colour of the containers	☐

1 mark

Results

material		mass when dry (grams)	mass when wet (grams)
	brick	150	180
	sandstone	150	165
	slate	150	155
	marble	150	160

c What was the mass of the brick when wet?

…………………………………………………………… grams

1 mark

d Which building material would you predict is least permeable to water? Tick ONE box.

brick ☐ slate ☐

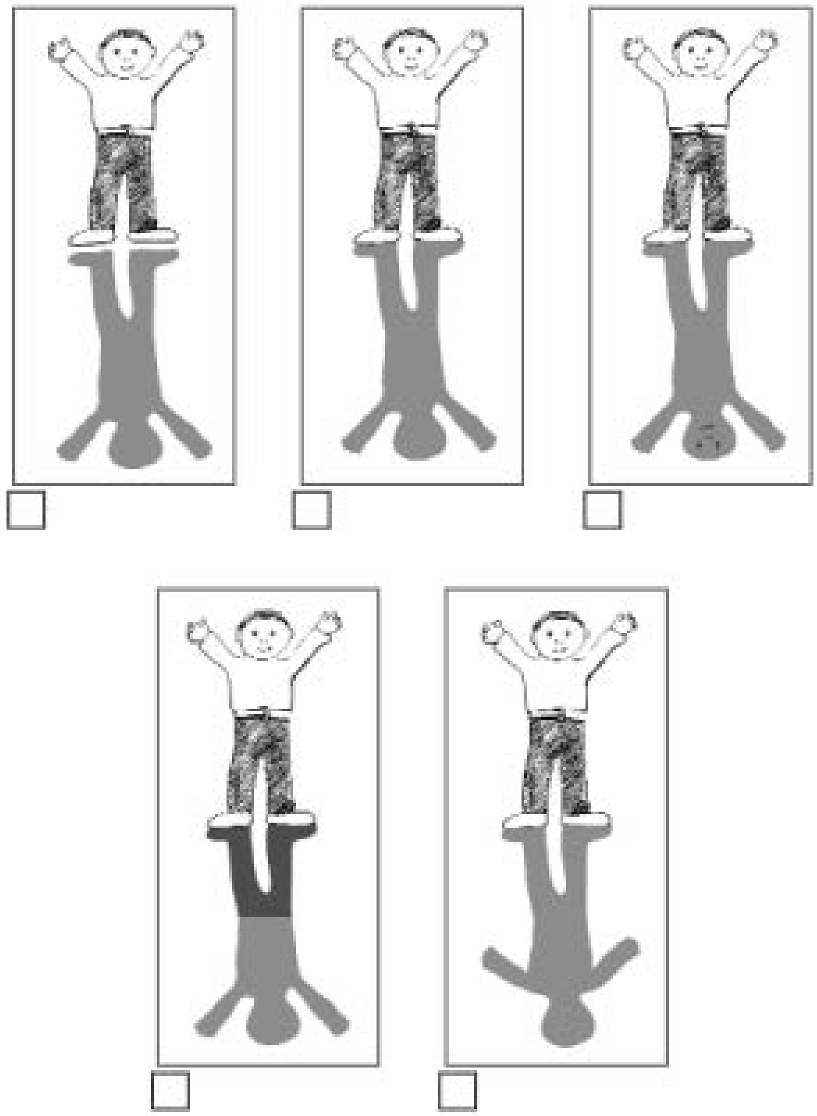
sandstone ☐ marble ☐

1 mark

Total out of 4 ☐

Q9 Which of these drawings correctly shows a boy and the shadow he makes standing in the playground on a sunny day?

Tick ONE box.

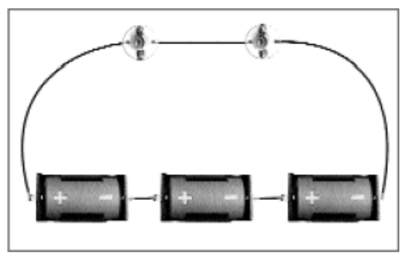


Total out of 1

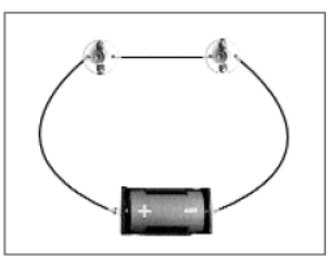
Q10 Claire and Jane test the brightness of the light with one bulb and then two bulbs in their circuits.

a Which TWO circuits should they use to make their test fair? Tick TWO boxes.

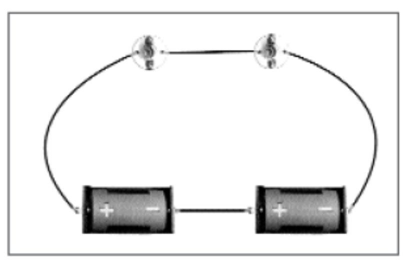
☐



☐



☐



☐

1 mark

b What is the ONE and ONLY thing they should change as they carry out their test?

……………………………………………………………………………………………………

1 mark

Q11 Yeast is a micro-organism that is useful to humans.
Tick ONE correct way in which it is used.

- Spread on cuts ☐
- Use in baking bread ☐
- Use for sunburn ☐
- Makes hair grow ☐
- Use for plant fertiliser ☐

Total out of 1 ☐

Q12 Look at the photograph of the flower below.

a Label the part of the flower at A.

1 mark

b Seeds need water to germinate. Yet in Britain many seeds produced by wild plants in the autumn do not germinate until the following spring. Why do seeds germinate and grow better in spring?

…………………………………………………………………………………………………….

1 mark

c What must happen to the pollen in order for a flower to be pollinated?

…………………………………………………………………………………………………….

1 mark

Total out of 3

Q13 Look at the table below. Some of these changes are reversible and others are not.

Complete the table to show the reversible changes and the irreversible changes.

The first one has been done for you.

	Reversible Change	OR	Irreversible change
Burning paper	☐		✓
Melting an ice cube	☐		☐
Boiling an egg	☐		☐
Stretching elastic	☐		☐

Total out of 1 ☐

Q14 Megan is plucking a string of her guitar to make a sound.

a How does plucking the string cause it to make a sound?

....

....

1 mark

b Tick TWO boxes to show how she could make a sound with a higher pitch.

She could pluck the same string harder. ☐

She could pluck the same string more softly. ☐

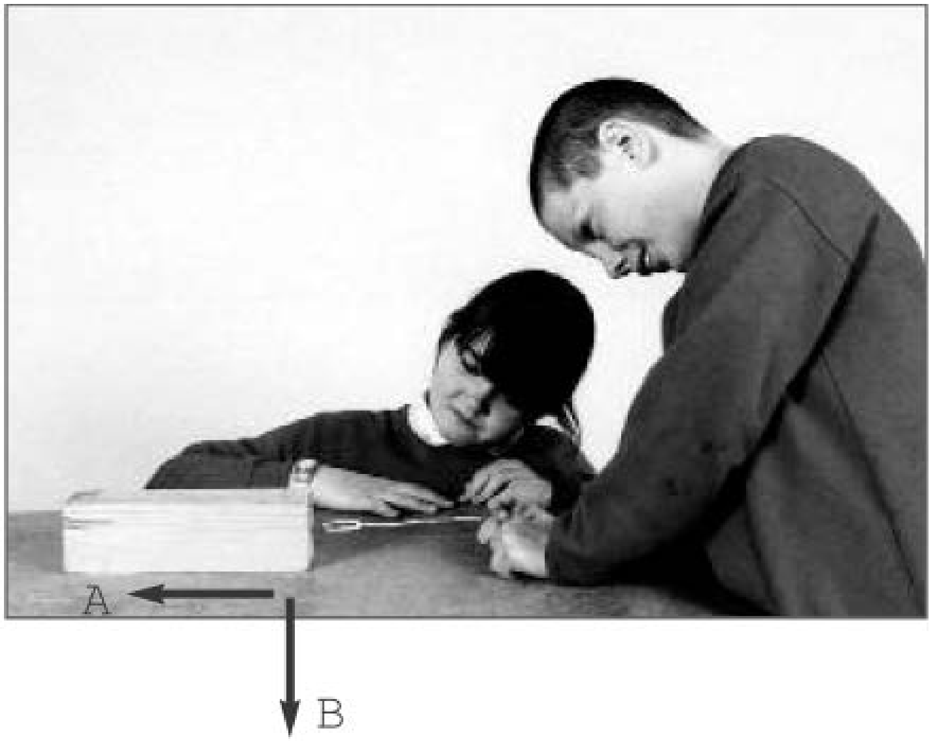
She could tighten the same string before she plucks it. ☐

She could pluck one of the thicker strings. ☐

She could pluck one of the thinner strings. ☐

1 mark

Q15 The arrows on the photograph show two of the forces acting on the block when it is being pulled across the table.



Complete the following sentences to name the forces A and B.

a Force A is

…………………………………………………………………………………………

1 mark

b Force B is

…………………………………………………………………………………………

1 mark

Total out of 2

Q16 One of the functions of your skeleton is to protect some of your body's organs.

Complete these sentences.

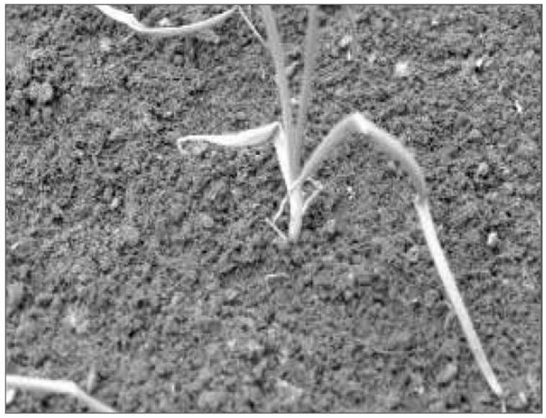
a Your skull protects your ……………………………………………………

b Your …………………………………………………… protect your heart and your lungs.

Total out of 1

Q17 Look at the two photographs of the same part of a garden where an onion had been planted.
All the weeds were cleared.

first photo



second photo

The second photograph was taken after one week.
Many small plants have grown, although none of them were planted.

Where did all the small plants come from?

....

....

Total out of 1

Q18 The children observe water droplets forming inside the window.

a What is the name of the process by which droplets of water form inside the window?

………………………………………………………………………………………………………

1 mark

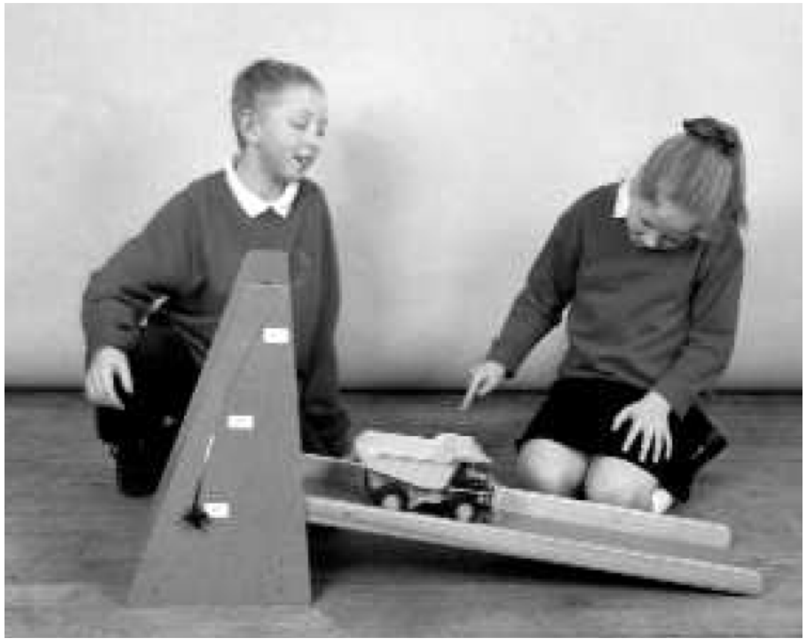
b Where do the droplets of water come from?

………………………………………………………………………………………………………

1 mark

Total out of 2

Q19 The children investigate the effect of changing the angle of the slope on the distance the car travels.



They want to be sure that their test is fair.

a What is the ONE and ONLY thing they should change as they do their investigation?

…………………………………………………………………………………………………….

1 mark

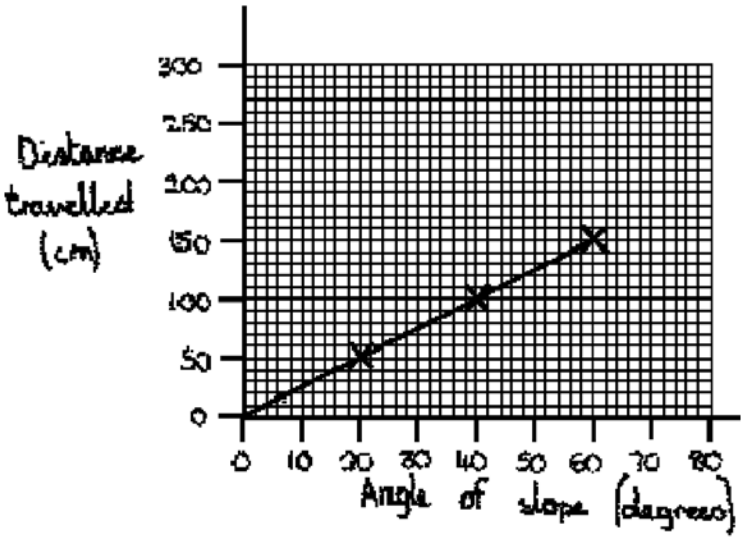
b Write TWO things they should keep the same.

i ………………………………………………………………………………………………… 1 mark

ii ………………………………………………………………………………………………… 1 mark c Results

angle of slope (degrees)	distance travelled (cm)
20	50
40	100
60	150

They made a line graph of the results.



Use the graph to predict the angle of the slope which would make the car travel 200cm.

………………………………………………… degrees

1 mark

d Mary suggests that they should measure the distance travelled three times for each angle.

Why is it a good idea to measure the distance three times?

……………………………………………………………………………………………………

1 mark

Q20 Yasmin can see the bulb reflected in the mirror.

Draw arrows on the picture to show how light travels to allow her to see the reflection of the bulb.

Total out of 2

End of test

Appendix 7: Pupil survey

What do you think of

This booklet asks questions about you and your interest in science.

There are no right or wrong answers. We want to know what you think.

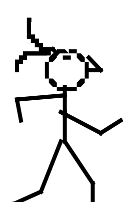
My name is ____________________

I am a ☐ girl ☐ boy

My teacher is ____________________

My school is ____________________

...........follow Science Runner..........



Q1 Learning science at school

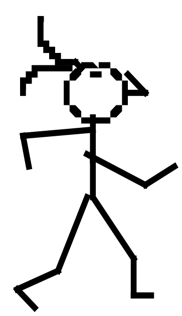
Do you agree with these views?

(Please tick only one box in each row.)

	Agree a lot	*Agree a bit*	*Not sure*	*Disagree a bit*	*Disagree a lot*
a) Science lessons make me think.	☐	☐	☐	☐	☐
b) I look forward to my science lessons.	☐	☐	☐	☐	☐
c) Science lessons are interesting.	☐	☐	☐	☐	☐
d) I would like to do more science at school. ..	☐	☐	☐	☐	☐
e) Science is fun	☐	☐	☐	☐	☐
f) We spend a lot of time in science lessons copying from the board……………………	☐	☐	☐	☐	☐
g) I enjoy discussions in science lessons……	☐	☐	☐	☐	☐
h) Science lessons are boring………………..	☐	☐	☐	☐	☐

Well done!

Now off you go to the next one . . . .

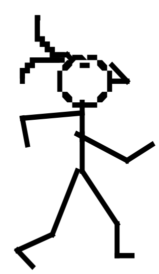


Q2 Learning science at school

Do you agree with the following statements?

(Please tick only one box in each row.)

	Agree a lot	*Agree a bit*	*Not sure*	*Disagree a bit*	*Disagree a lot*
a) I find science difficult to understand.	☐	☐	☐	☐	☐
b) I am just not good at science......................	☐	☐	☐	☐	☐
c) I think science is more for boys..............	☐	☐	☐	☐	☐
d) I understand everything in my science lessons	☐	☐	☐	☐	☐
e) We often have discussions in science lessons	☐	☐	☐	☐	☐
f) We do a lot of writing in science lessons…	☐	☐	☐	☐	☐
g) It is important that we learn science……….	☐	☐	☐	☐	☐
h) I like thinking about scientific ideas………..	☐	☐	☐	☐	☐



Phew! Nearly finished …

Q3 About practical work in school science

Do you agree with these views?

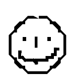
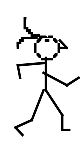
(Please tick only one box in each row.)

		Agree a lot	*Agree a bit*	*Not sure*	*Disagree a bit*	*Disagree a lot*
a)	Doing practical work in science lessons is fun…………………………………………	☐	☐	☐	☐	☐
b)	We already know what will happen when we do science practical work…………………	☐	☐	☐	☐	☐
c)	I can decide what to do for myself in science practical work………………………	☐	☐	☐	☐	☐
d)	We do practical work in most science lessons ………………………………………	☐	☐	☐	☐	☐
e)	I look forward to doing science practicals….	☐	☐	☐	☐	☐
f)	Practical work in science is boring………	☐	☐	☐	☐	☐
g)	Solving science problems is enjoyable……	☐	☐	☐	☐	☐

Q4 Finally, is there anything you would like to say about your science lessons this year?

Did you answer every one ? You did ? Then, you have finished !

Science Runner says

Thank you very much  ***and good luck!*** 

Appendix 8: Teacher survey

Oxford Thinking, Doing and Talking Science evaluation

Teacher survey

1. **Please describe your role in the school (you can tick more than one):**
   - ☐ **Year 5 teacher**
   - ☐ **Teacher of another KS2 year group**
   - ☐ **Teacher of a KS1 year group**
   - ☐ **Science co-ordinator**
   - ☐ **Other (please write in)** ____

2. **How often do you teach science to Year 5 pupils?**
   - ☐ **once a week or more often**
   - ☐ **once a fortnight**
   - ☐ **once a month**
   - ☐ **less often**
   - ☐ **never**

3. **How often do you do the following in science lessons?**

		Very often	Quite often	Not very often	Rarely	Never
a)	Pupil practical work	☐	☐	☐	☐	☐
b)	Teacher demonstration	☐	☐	☐	☐	☐
c)	Pupil discussion in whole class	☐	☐	☐	☐	☐
d)	Pair or small group practical work	☐	☐	☐	☐	☐
e)	Pair or small group discussion	☐	☐	☐	☐	☐
f)	Give pupils time just to think	☐	☐	☐	☐	☐
g)	Make links with literacy and numeracy	☐	☐	☐	☐	☐
h)	Teach scientific facts	☐	☐	☐	☐	☐
i)	Ask pupils to solve scientific problems	☐	☐	☐	☐	☐

4. **How confident do you feel doing the following?**

		Very confident	Quite confident	Not very confident	Not at all confident
a)	Teaching science overall	☐	☐	☐	☐
b)	Planning science lessons	☐	☐	☐	☐
c)	Assessing pupils' science work	☐	☐	☐	☐
d)	Running science practicals	☐	☐	☐	☐
e)	Teaching scientific facts	☐	☐	☐	☐
f)	Explaining scientific ideas	☐	☐	☐	☐
g)	Showing pupils how to record their practicals	☐	☐	☐	☐
h)	Helping pupils discuss scientific ideas	☐	☐	☐	☐

5. **Do you think your approach to teaching science is particularly beneficial for certain groups of pupils?** Please tick which one(s):

- ☐ English as an Additional Language (EAL)
- ☐ Special Educational Needs (SEN)
- ☐ Disadvantaged pupils
- ☐ Boys
- ☐ Girls
- ☐ Low ability
- ☐ Middle ability
- ☐ High ability
- ☐ None in particular
- ☐ Other (please write in): _______________

6. **Do you find any particular groups of pupils struggle with your approach to teaching science? Please tick which one(s):**

- ☐ English as an Additional Language (EAL)
- ☐ Special Educational Needs (SEN)
- ☐ Disadvantaged pupils
- ☐ Boys
- ☐ Girls
- ☐ Low ability
- ☐ Middle ability
- ☐ High ability
- ☐ None in particular
- ☐ Other (please write in): _______

7. **Reflecting on your experience of teaching science this year, how much would you agree or disagree with the following statements?**

		Agree strongly	Agree slightly	Disagree slightly	Disagree strongly
a)	My pupils have enjoyed their science lessons	☐	☐	☐	☐
b)	My pupils have made good progress in science	☐	☐	☐	☐
c)	My pupils are confident in science	☐	☐	☐	☐
d)	My pupils can work on their own in science	☐	☐	☐	☐
e)	My pupils come up with their own scientific ideas	☐	☐	☐	☐
f)	My pupils do a lot of writing in science	☐	☐	☐	☐
g)	I have changed the way I teach science	☐	☐	☐	☐
h)	I enjoy teaching science	☐	☐	☐	☐
i)	I have a good knowledge of science	☐	☐	☐	☐
j)	My pupils have been engaged with science	☐	☐	☐	☐

These questions are specifically about the Thinking, Doing, Talking Science project that your school has been involved in. [NB Qs 8-12 asked of intervention teachers only**]**

8. **Are you aware of the Thinking, Doing, Talking Science project?**
   - ☐ Yes – please answer all following questions
   - ☐ No – please skip to Q13

9. **How many of the 8 days training involved in the Thinking, Doing, Talking Science project since February 2013 have you personally attended?**
   - ☐ none
   - ☐ one or two
   - ☐ a few (3-5)
   - ☐ most (6-7)
   - ☐ all (8)

10. How much would you agree or disagree with the following statements about the Thinking, Doing, Talking Science project and strategies?

		Agree strongly	Agree slightly	Disagree slightly	Disagree strongly
a)	I have used the strategies I learnt	☐	☐	☐	☐
b)	It has made me more effective teaching science	☐	☐	☐	☐
c)	I learnt nothing new	☐	☐	☐	☐
d)	I found it inspiring	☐	☐	☐	☐
e)	It has been useful in subjects other than science	☐	☐	☐	☐
f)	It has benefited my pupils	☐	☐	☐	☐

11. How much has the Thinking, Doing, Talking Science project helped you develop the following?

		A lot	Quite a lot	Not very much	Not at all
a)	My questioning skills in science	☐	☐	☐	☐
b)	My questioning skills in other subjects	☐	☐	☐	☐
c)	My use of discussion slots in science	☐	☐	☐	☐
d)	My use of discussion slots in other subjects	☐	☐	☐	☐
e)	Pupils' recording skills in science	☐	☐	☐	☐
f)	My understanding of science practical work	☐	☐	☐	☐
g)	My own science subject knowledge	☐	☐	☐	☐

Please turn over….

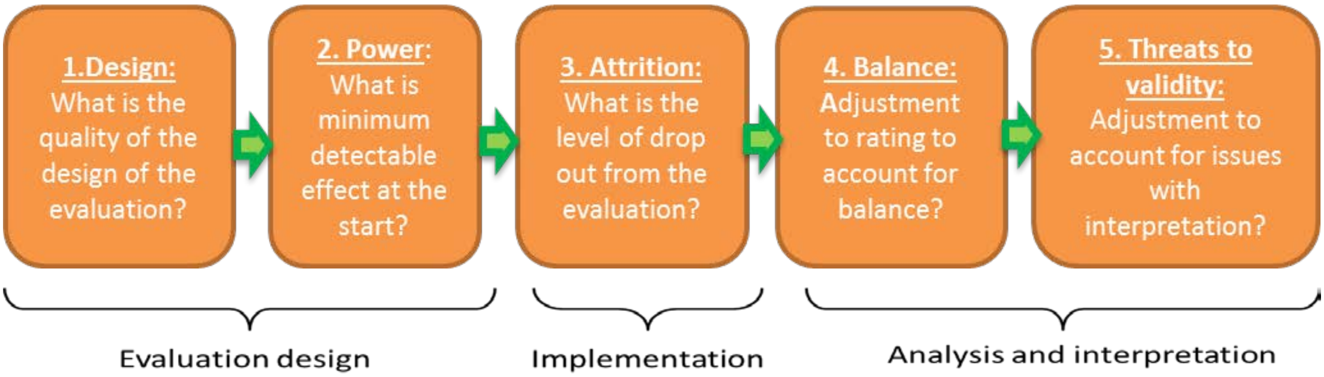
12. Which of the strategies that the project has promoted have you found to be the most effective, and why?

13. Finally, is there anything else you want to say about your experience of the teaching and learning of science this year? [**NB: asked of all teachers]**

14. Name of your school: ____

Many thanks for your help. Please return this questionnaire to the IEE with the pupil papers.

Appendix 9: Security classification of trial findings



Rating	1. Design	2. Power (MDES)	3. Attrition	4. Balance	5. Threats to validity
5 🔒	Fair and clear experimental design (RCT)	< 0.2	< 10%	Well-balanced on observables	No threats to validity
4 🔒	Fair and clear experimental design (RCT, RDD)	< 0.3	< 20%		
3 🔒	Well-matched comparison (quasi-experiment)	< 0.4	< 30%		
2 🔒	Matched comparison (quasi-experiment)	< 0.5	< 40%		
1 🔒	Comparison group with poor or no matching	< 0.6	< 50%		
0 🔒	No comparator	> 0.6	> 50%	Imbalanced on observables	Significant threats

The final security rating for this trial is 3 🔒. This means that the conclusions have moderate security.

- This evaluation was designed as a randomised controlled trial.
- The sample size was designed to detect a MDES of less than 0.3, by design, reducing the security rating to 4 🔒.
- At the unit of randomisation (school), there was very low attrition (1 school out of 42).
- Balance at baseline was high.
- The post-tests were administered by the schools by teachers who were aware of the treatment allocation, reducing the security of the findings by a further padlock.

Therefore, the final security rating is 3 🔒.

Appendix 10: Cost rating

Cost ratings are based on the approximate cost per pupil per year of implementing the intervention over three years. More information about the EEF's approach to cost evaluation can be found on the EEF website. Cost ratings are awarded as follows:

Cost rating	Description
£	*Very low:* less than £80 per pupil per year.
£ £	*Low:* up to about £200 per pupil per year.
£ £ £	*Moderate:* up to about £700 per pupil per year.
£ £ £ £	*High:* up to £1,200 per pupil per year.
£ £ £ £ £	*Very high:* over £1,200 per pupil per year.

This document is available for download at **www.educationendowmentfoundation.org.uk**

Education
Endowment
Foundation

The Education Endowment Foundation
9th Floor, Millbank Tower
21–24 Millbank
London
SW1P 4QP
www.educationendowmentfoundation.org.uk