Retrieval practice in primary science lessons

Old Hill Academy

Problem: What challenges do your school(s) have that need to be addressed?

There is strong evidence that demonstrates testing is a powerful technique to enhance learning: the act of retrieving information from memory promotes the ability to recall material again in the future (Carpenter & DeLosh, 2005; Carrier & Pashler, 1992).

In 2010, the end of Key Stage 2 science SATS were aborted. However, sampling tests in Year 6 continue. The table below indicates that the standard in science is low; the gap between FSM children and non-FSM is significant and the results are declining.

	Estimated percentage achieving expected standard in 2014	95% confidence interval in 2014	Estimated percentage achieving expected standard in 2016	95% confidence interval in 2016
All Pupils	28.06	26.82 – 29.31	22.77	21.61 – 23.92
Boys	27.86	26.03 – 29.68	22.73	21.02 – 24.45
Girls	28.28	26.26 – 30.31	22.80	20.80 – 24.80
FSM	13.14	10.75 – 15.53	9.00	6.80 – 11.19
Non-FSM	31.35	29.93 – 32.76	25.28	23.99 – 26.58
EAL	23.17	20.25 – 26.09	17.41	14.64 – 20.17
Non-EAL	29.06	27.63 – 30.49	23.77	22.49 – 25.04

(Key stage 2 science sampling 2016 Methodology note and outcomes July 2017, Standards & Testing Agency)

On a local scale, we have evidence from end of year science assessments in Years 3–6 that mirror these national figures. One reason for this might be that pupils are not being tested enough throughout the year where teachers have not provided pupils with opportunities for retrieval practice.

Consequently, pupils are starting secondary school with a lack of scientific knowledge of the primary curriculum and therefore need to play 'catch up' to stay in touch with the already demanding curriculum. We anticipate that pupils who have regular opportunities for retrieval practice will better retain information long-term, enter secondary school with more embedded

knowledge and will therefore be more successful.

Innovation: How will the innovation help improve the problem you have identified and benefit teachers and learners?

Pupils will access a quiz that will test their retrieval skills. This will be in the form of the app, Socrative, which will be accessed through iPads or laptops. Questions will be aligned to the National Curriculum objectives for each unit of work studied, the format of which will be multiple-choice. Learners will experience both knowledge and application questions in a low-stakes environment.

By assigning pupils to a 15-minute Socrative quiz seven days after they have studied the content, it is hoped that learners will increase retention and consequently perform better in the final test paper.

Existing evidence: What evidence is there that this innovation will improve outcomes?

Evidence from a number of studies revealed that retrieval practice in authentic classroom settings improves long-term learning (McDaniel et al., 2011). The study, *The value of applied research: retrieval practice improves classroom learning and recommendations from a teacher, a principal, and a scientist* (Agarwal et al., 2012) evidenced that 6th- 8th grade pupils (Years 7–9) who undertook multiple-choice quizzes performed better in exams. Furthermore, the study revealed that retrieval practice effects were found for same and different test formats (multiple-choice, written answers etc.) with a concept end of unit exam, but not when the end of unit exam was comprised solely of application questions. To summarise, retrieval practice has greatest effect when pupils complete concept or definition questions. We would like to examine if using retrieval practice with younger children produces similar results. Taking into consideration the outcomes of the above research, our study would involve having a mixture of application and concept multiple-choice questions. Because prior research has shown that the difficulty of initial retrieval is correlated with later retention (Karpicke & Roediger 2007; Benjamin, Bjork, & Schwartz, 1998), as well as direct evidence that delaying an initial retrieval attempt enhances performance on a later end of unit test (Jacoby, 1978; Whitten & Bjork, 1977), our study will leave a seven day interval between retrieval practice.

How does retrieval practice, in the form of multiple-choice quizzing (6 x 10 mins sessions), during the teaching of one science unit impact on performance in science tests for Year 2–5 pupils?

It is expected that the intervention group will have retained more knowledge than the control group by the end of the process. Consequently, the (retrieval practice) intervention group's gains will be higher than the control group's, on completion of the final test.

Method: Include sample, design, measures, intervention, process evaluation, and analysis

<u>Sample/ participants</u>
Participants will be taken from Year 2–5 classes in two different schools. The number of pupils in these year groups will be: Year 2 (60 pupils), Year 3 (60 pupils), Year 4 (60 pupils) and 5 (59 pupils).

Old Hill Primary (taken from School Performance Service.Gov.UK)

Pupil population in 2016/2017

The figures below are for the 2016/2017 academic year, which is the latest year for which performance results have been published.

Pupil population

	School	National
Total number of pupils on roll (all ages)	243	4998768
Girls on roll	48.1%	48.7%
Boys on roll	51.9%	51.3%
Pupils with a statement of special educational needs (SEN) or education, health and care (EHC) plan	1.2%	2.9%
Pupils whose first language is not English	16.9%	20.8%
Pupils eligible for free school meals at any time during the past 6 years	49%	24.9%

St. James' CofE Primary (taken from School Performance Service.Gov.UK)

Pupil population in 2016/2017

The figures below are for the 2016/2017 academic year, which is the latest year for which performance results have been published.

Pupil population

	School	National
Total number of pupils on roll (all ages)	444	4998768
Girls on roll	47.3%	48.7%
Boys on roll	52.7%	51.3%
Pupils with a statement of special educational needs (SEN) or education, health and care (EHC) plan	1.6%	2.9%
Pupils whose first language is not English	24.9%	20.8%
Pupils eligible for free school meals at any time during the past 6 years	52.6%	24.9%

Exclusion criteria

Pupil data will be discounted from the analysis if:

- Their overall lesson attendance is below 70% (more than two sessions missed)
- Their teacher considers them unable to access the pre- and post-test due to working well below year group National Curriculum expectations. The evaluation lead will speak to teachers about their reasons for discounting pupils to ensure decisions are made consistently across classes.

Design and assignment to condition

Classes will be randomly assigned to either the intervention or control group across both schools by flipping a coin over four rounds: heads = control group, tails = intervention group. One class in each year group will be the control, with the other the intervention, to ensure comparable age groups.

Year groups	Old Hill Primary	St James' Primary
Year 2	Intervention	Control
Year 3	Intervention	Control

| Year 4 | Control | Intervention |
| Year 5 | Intervention | Control |

Measures

Pre-test

Questions from science baseline test for the unit of work pupils will be studying. Test A. Tests will be created using a culmination of previous national test questions from Key Stage 1 and Key Stage 2, as well questions produced in line with national expectations. Questions will consist of concept, knowledge (definition) and application questions.

Pre-tests will be examined through mean comparison to ensure similar levels of prior knowledge between intervention and control groups.

Post-tests

After the pupils have completed the unit of work, they will be given two formal tests relating to this unit of work after:

- one week (Test B)
- three months (Test A)

The test will be structured to find out whether the pupils have retained scientific content taught in the unit. Questions will consist of knowledge, concept and application questions and will not be in the same format as Socrative, to avoid bias. The content of Test A and B will be broadly equivalent.

Marking

To ensure no bias:

- pupils will be assigned random numbers so markers cannot identify tests
- markers will not teach any participating year group in either school
- intervention and control group papers will be collated and shuffled before marking

Intervention

The intervention will take place during a unit of work in science. Teachers will be given a breakdown of the science unit so that objectives can be delivered in a similar manner. Teachers will use their typical method of delivering science in their school. During the intervention, the

pupils will complete the quiz questions individually. Whilst we can keep strict controls during the interventions, during the remainder of the lesson, there may be times when the teacher asks the pupils questions about their knowledge from previous lessons. It is likely that these will be in the form of verbal questions.

Any new staff member, working in an intervention group, would be trained in using the Socrative app to ensure log-ons and access transition smoothly, as well as knowing clear procedures for answering questions. Thirty iPads/computers are required to ensure that the pupils in the intervention groups are able to access the Socrative quiz.

Pupils will complete a baseline science test prior to studying the National Curriculum unit of work as follows:

- Year 2: Living things & their habitats
- Year 3: Rocks
- Year 4: States of matter
- Year 5: Properties & changes of materials

Pupils will complete 1 x 90mins of science study per week for seven weeks.

Group 1 (Intervention)

The intervention group will be sat at their tables and given an iPad. They will use the software program, Socrative, to complete an independent low-stakes, multiple-choice quiz. The teacher must minimise the teacher screen before the children begin their test to avoid accessing information about misconceptions. After each question the app will reveal the correct answer to the pupils. If the children have questions, the teacher may answer/address them. The teacher will close the teacher screen, without looking at the data, after all pupils have completed their quiz. The Socrative quiz will be accessed during the allotted time at the beginning of the lesson. Pupils should complete the Socrative quiz as many times as they can in the allotted time. Pupils will be told there is no scoring system for the Socrative quiz.

Group 2 (Control)

At the beginning of each lesson these pupils will be tasked with re-reading notes from previous lessons or the re-reading of an appropriate science text based on the study unit. The notes/information the control group will re-read will contain the same information as the Socrative quiz. If the children have questions, the teacher may answer/address them. The teacher must not ask pupils retrieval questions about their unit of study during the re-reading session.

Intervention group		Control group	
Week 1	Pupil and teacher questionnaire **before** baseline science test A	Week 1	Pupil and teacher questionnaire **before** baseline science test A
Week 2 Observations	Begin teaching science unit, no retrieval practice.	Week 2	Begin teaching science unit, no re-reading.
Week 3	5 mins retrieval practice via Socrative. Continue teaching of new content in unit.	Week 3	5 mins re-reading. Continue teaching of new content in unit.
Week 4	10 mins retrieval practice via Socrative. Continue teaching of new content in unit.	Week 4	10 mins re-reading. Continue teaching of new content in unit.
Week 5	10 mins retrieval practice via Socrative. Continue teaching of new content in unit.	Week 5	10 mins re-reading. Continue teaching of new content in unit.
Week 6	10 mins retrieval practice via Socrative. Continue teaching of new content in unit. Pupil questionnaire.	Week 6	10 mins re-reading. Continue teaching of new content in unit. Pupil questionnaire.
Week 7	10 mins retrieval practice via Socrative. Continue teaching of new content in unit.	Week 7	10 mins re-reading. Continue teaching of new content in unit.
Week 8	10 mins retrieval practice via Socrative. Continue teaching of new content in unit.	Week 8	10 mins re-reading. Continue teaching of new content in unit.
Week 9	End of unit test B	Week 9	End of unit test B
Week 20	Pupil questionnaire. Repeat end of unit test A Teacher questionnaire	Week 20	Pupil questionnaire. Repeat end of unit test A Teacher questionnaire

Process evaluation

Lead researchers will monitor the application of the intervention and control to ensure consistency of delivery during the retrieval practice and re-reading stage of the lesson (the first 5 to 10 minutes of the science lesson). The following observation schedule will be used:

Intervention		Control	
Do	Don't	Do	Don't
- Insist on silence in the classroom - Support the reading of words - The teacher must minimise and close the teacher feedback screen - Where at all possible pupils should work independently - After the 10mins Socrative quizzing, new learning should commence - Science must only be taught in the 90min lessons	- Pupils must not discuss questions or answers with each other - Ask retrieval-based questions to pupils from previous lessons (Can you remember from last week, what the function of the roots are?) - Remove children from lessons (if any pupil needs to leave the lesson, record on your science register)	- Insist on silence in the classroom - Support the reading of words - Allow pupils to reread notes/materials that already have been studied - Where at all possible pupils should work independently - After 10mins rereading, new learning should commence - Science must only be taught in the 90min lessons	- Pupils must not discuss questions or answers with each other - Ask retrieval-based questions to pupils from previous lessons (Can you remember from last week, what the function of the roots are?) - Remove children from lessons (if any pupil needs to leave the lesson, record on your science register)

Pupils and teachers will complete a short questionnaire prior to the pre-test. Pupils will repeat the questionnaire at week six and then again at week 20 before the test to explore changes in anxiety and attitude. Teachers will repeat the questionnaire at week 20. Questionnaires will include rating scales for pupil self-perception and reflection about testing, as well as anxiety levels. Questions for teachers will include rating scales relating to teaching methods, workload, pupil retention and pupil motivation.

Data analysis

On completion of the science unit, all selected pupils from both groups will undertake a formal science test:

- one week after unit completion

- threemonths after unit completion

Results from each group will then be analysed and compared. The principle area of examination will be the comparison of performance between the control group and intervention group across the academic year groups, using mean progress and effect size.

Data analysis will also be conducted on:

- pupil premium
- low, middle, high prior attainment (from science pre-test)

Staff and pupil questionnaires will be analysed using median average.

Conclusion: What will happen if your innovation improves outcomes, or not? What are the limitations of your evaluation?

Due to the low sample-size, we will be cautious when evaluating the intervention. If the innovation improves the outcomes for pupils a larger trial across multiple schools, with an increased sample-size, would be planned. When studying something as complex as learning, there are many factors that may have an effect on outcomes, such as: teaching methods; what occurs in lessons outside of the intervention session; how often a pupil is exposed to scientific knowledge in their wider reading; parental support, to name but a few. It is because of this, several further studies will be necessary to reduce noise.

Findings from the innovation will be shared with schools through the Research Schools Network via a written document outlining the study and results.

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