

In one school extra maths tutoring is offered to selected learners in year 7 or 8 within the Special Educational Needs Department. Groups of 5 to 9 learners are withdrawn from non maths lessons for 2 hours per week for a half term (6-8 weeks) and study a curriculum designed to find and fill learning gaps in key maths topics.

In 2017-18 the school used timely practice to pre assess and embed learning for their year 7 and 8 intervention groups. In each 60 minute lesson, students completed a personalised assignment and learned something new from one or two (and later, sometimes three) different maths topics. The assignments were PDF documents created by the timely practice app and consisted of a personalised set of carefully targeted questions. Within timely practice, maths topics are split into layers, small “bites” of learning, which are quick and easy to teach and to learn. The timely practice app chooses the questions within each learner’s assignment as follows:

- the pre assess section, headed **learned?**, finds the “goldilocks” layer to begin teaching each topic - so that the teacher can teach on firm learning foundations - not too easy nor too hard.
- the section headed **retrieval practice** applies “increasing interval, responsive retrieval practice” to embed each learner’s learning more deeply as follows:
 - if the learner can independently and accurately answer a question from a layer, the app increases the interval - the wait time - between one practice and the next;
 - if the learner needs help in the lesson or doesn’t answer the question from the layer accurately: the app decreases the interval and the teacher offers feedback to the learner the next lesson.

In the early lessons, learners have only/mainly pre assess questions and in the later lessons only retrieval practice questions within their assignment.

The topics chosen in the tutoring intervention, are chosen:

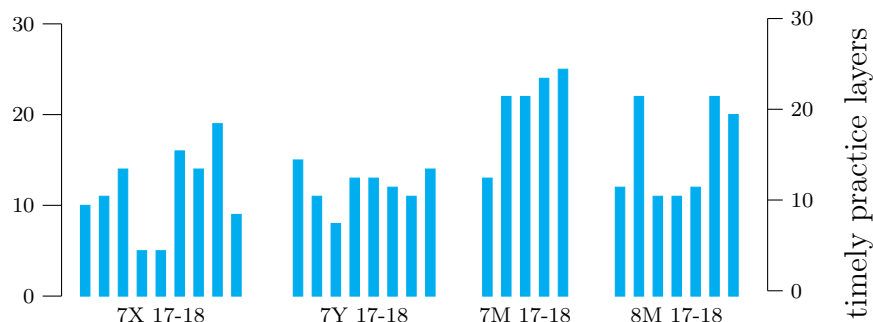
- because they are key topics which learners will need, in order to access future learning in their regular maths lessons;
- to avoid topics taught in regular maths lessons for 3 weeks before and over the period of the trial (so that measurement of learning gain will not be confounded by teaching elsewhere).

There is, of course, no possibility of teaching the whole of the year 7 or year 8 curriculum in 12 to 16 lessons, so learners will not be penalised by the maths tutoring intervention avoiding recently taught/to be taught topics. Ideally, topics taught recently in regular maths lessons, will be fresh in the learners minds. Or will they? We’ll look at this, as best we can, in the 2018-19 intervention analysis.

It seems likely that all (or most) of the layers taught during the intervention programme, have already been taught to the learners, quite possibly several times, during their maths education. However the teaching may not have become learning and/or the learning was not retained. The **proven** raising attainment techniques, which timely practice endeavours to facilitate and encourage are:

1. **Assessment for learning** enable the teacher to only teach new skills that the learners already confidently have the pre requisite skills for - this is **mastery learning**.
 2. **Teach the correct grain size**. For most low attaining learners the correct grain size is small. When learners are taught “too much” from a topic, they often exhibit working memory overload symptoms: muddling methods, missing steps and giving up, when they try to recall learning from previous lessons. Somewhat counterintuitively, by teaching less from a topic at one time, low attaining learners will often embed more learning than if they are taught the larger grain size which suits most learners.
 3. **Spaced learning/retrieval practice** enables learners to retain their learning more durably. FYI What educational researchers call spaced learning, teachers generally call retrieval practice. Encouraging learners to recall (i.e. retrieve from long-term memory) and use learning, has the desired side-effect of embedding the learning more durably in long-term memory. i.e. the space (time interval) between one successful recall and practice and another similar recall and practice can be increased.
 4. **Feedback** between the teacher and the learner is required when teaching has not yet become learning. In the feedback-dialogue, the teacher assists the learner to add to/correct mental schema/chunks in their long-term memory and/or improve their accuracy and/or question reading skills.
 5. Another change relates to attachment theory: helping the learner reduce shame. We believe the learner will be able to allocate more of their working memory to learning maths, if, when teaching has not yet become learning, the responsibility is explicitly shared between the teacher, the learner and the practice provided by the timely practice app.
- Changes 1 and 2 ensure that during the night’s sleep directly after the lesson where new learning takes place, a higher proportion of teaching will become embedded in the learner’s long-term memory.
 - Changes 1, to 5 ensure that a higher proportion of new learning will be durably and accessibly retained. This will be demonstrated by the learner being able to independently recall and accurately apply the skills learned in a lesson in the days, weeks, months and years after the lesson, without the need for reteaching.

The learning gain, the number of new timely practice layers each learner can accurately answer in test conditions at the end of the trial, for the four maths tutoring intervention classes in 2017-18, is shown below:



After the teaching of 7X and 7Y but before the teaching of 7M and 8M two changes were made:

- Addition of an extra week to the intervention which was to be used to “cool down”. No new topics will be taught¹, but the class will continue with retrieval practice and feedback. This “cool down” week was introduced to improve the retention of the new learning. For 7X and 7Y we noticed that layers taught within the last 2 weeks were answered less accurately in the end of intervention trial tests, than topics taught earlier. This indicated that topics taught later need more retrieval practice and feedback to embed learning.
- Streamlining the teaching and learning of the lesson. This required preparing an extra topic to teach the faster practising and more accurate learners, in case they finish all their work before the end of the lesson. This enables the teacher and learning assistant to make better use of lesson time because one of them can teach extension work, whilst the other continues to support the other learners.

The Special Needs Department explained that the 8M class will contain learners with a lower attainment than the 7X, 7Y and 7M classes, despite being a year older. This is because learners for 8M were selected to need extra English in year 7 and extra maths in year 8 (so they probably fall below the 5th percentile in maths). Whereas the year 7 learners were only selected to be given extra maths (so probably fall within the 5th to the 15th percentile for maths).

FYI The M in 7M and 8M explains they are a group of learners from a mix of the timetabling blocks X and Y.

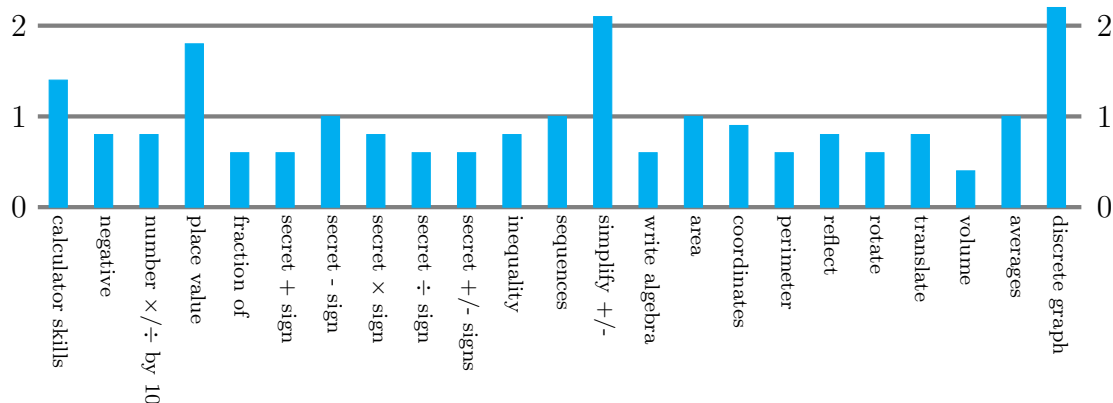
It seems that these 2 changes are likely to improve retention of new learning because

- For 7M and 8M there was far less of a noticeable reduction in learning gain between topics taught earlier and later in the tutoring intervention than for 7X and 7Y.
- 8Ms learning gain is on a par with 7X and 7Ys and 7Ms learning gain is higher.

So these changes should be included in the planning for next year.

¹In fact additional calculator skills were taught, but not included in the assessment of this trial.

The mean learning gain (total new timely practice layers ÷ number of learners) for each of the topics taught to 7M 2017-18 within the half term trial is shown below:



Ideally, the teacher will teach each learner one new layer per topic per curriculum spiral. We often found that learners could answer harder layers, which they hadn't been taught, correctly too. It seems that by fixing the problematic part of a previously learned skill (which had been partially forgotten or muddled), learners could apply this to answer questions from harder layers too. Hence a number of topics have a mean learning gain above 1 layer.

It is expected that even the lowest attaining/slowest working learners can learn one layer per lesson (because the "bite" size of each layer is deliberately small). Most learners can learn more than one layer per lesson and the scheme of learning should allow this. The scheme of learning used to teach each lesson:

- has one topic that everyone will learn,
- a second topic which most learners will learn and
- a third topic for learners who finish early and have capacity to learn more.

When we look at the layers learned by the learner with the lowest pace of work in this group:

lesson	1	2	3	4	5	6	7	8	9	10	Key
1st topic	■	■	■	■	■	■	■	■	□	■	■ learned
2nd topic	□	□	■	■	□	■	■	■	□	□	□ not learned

we see she has learned slightly over one layer per lesson. This scheme of learning allowed the teacher to teach a second topic to most of the other learners in this group and sometimes this learner was able to learn this second topic too.

Question: Why not teach more layers from key topics, rather than one layer from more topics?

Answer: Because of the proven raising attainment technique 4: **Teach the correct grain size**

Please read on to the 2018-19 summary, for more detail on this.

In 2018-19 two additional tweaks to the intervention were made:

- measure the learners' prior learning and learning gain in their maths lessons for the same time period;
- increase the duration of the “cool down” by 1 lesson but reduce the frequency of lessons in the cool down phase, from 2 to 1 lesson per week.

However, the year 8 group was taught so close to the end of term, and this together with rooming and timetabling problems unfortunately meant a cool down period was not possible.

Here is a summary of the differences between the maths tutoring intervention programs used:

The intervention groups (number of 1 hour lessons)	7X, 7Y 2017-18	7M, 8M 2017-18	7M 2018-19	8M 2018-19
Pre assess phase i.e. pre assess + teach + retrieval practice	4	5	4	4
Efficient teaching phase i.e. teach + retrieval practice	8	5	6	6
Cool down phase i.e. retrieval practice + filler activity	0	2	3	1
End of intervention trial tests	2	2	2	2

Question: Why not teach more layers from key topics, rather than one layer from more topics?

Answer: Because of the proven raising attainment technique 4: **Teach the correct grain size**

A “depth first” scheme of learning, used by this school and most schools in the U.K./world wide, encourages teachers to teach a “large bite” (several layers), per learner, per topic, per curriculum spiral. A spiral of the curriculum usually takes 1 (sometimes 2) academic year(s).

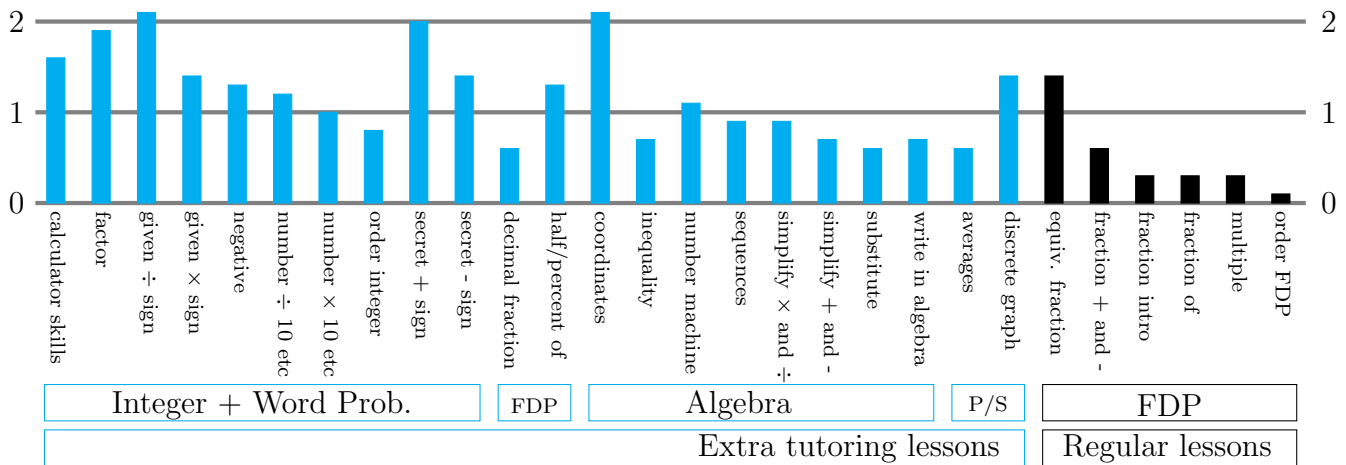
The “breadth first” scheme of learning, recommended and facilitated by timely practice, encourages teachers to teach 1 layer, per learner, per topic, per curriculum spiral. Several spirals per year are then possible. This ensures that for low attaining learners, despite the small bite size, more teaching can become more durably embedded learning.

We can begin to compare outcomes for the “breadth first, tutoring with timely practice” curriculum and the “depth first, regular maths lessons” curriculum. However, there are

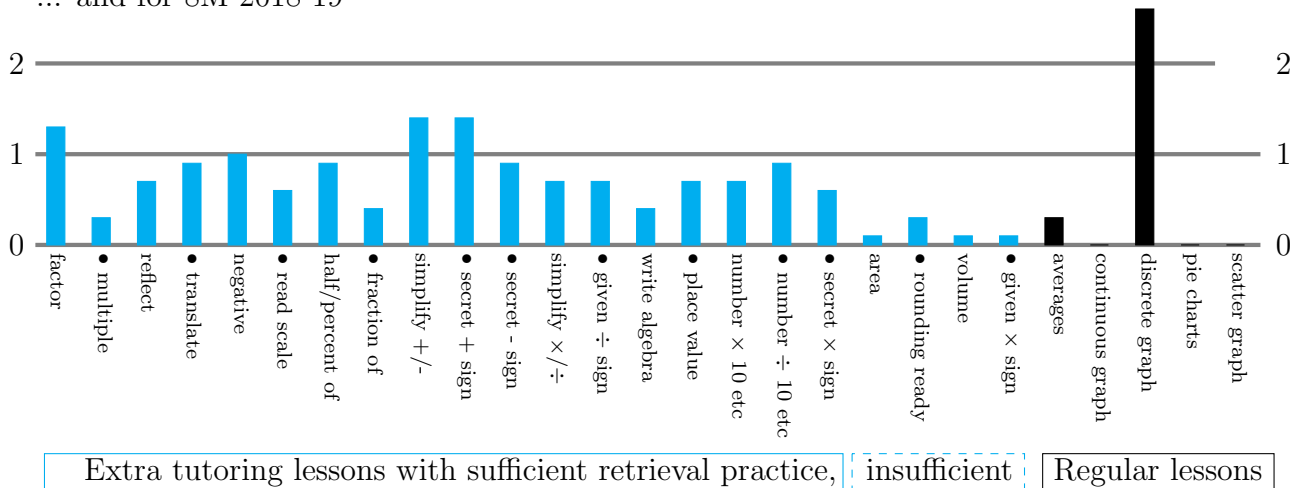
- 2 undesirable differences: class size and number of lessons, alongside the
- 2 desirable differences: schema of learning spiral and method to embed learning.

Type of maths lessons	Tutoring	Regular
Teaching and learning time within trial	10 hours	23 hours
Number of teachers, teaching assistants and learners	1, 1 and 9	1, 1 and 20
Number of topics taught	22	6
Mean time to teach/learn/practise a topic	27 minutes	3 hours 50 minutes
Mean personal teacher time (hours ÷ learners)	67 minutes	69 minutes
Scheme of learning spiral	breadth first	depth first
Method to embed learning	retrieval practice	homework + unit test

The mean learning gain (total extra timely practice layers ÷ number of learners) for each of the topics taught to 7M 2018-19 within the half term trial is shown below:

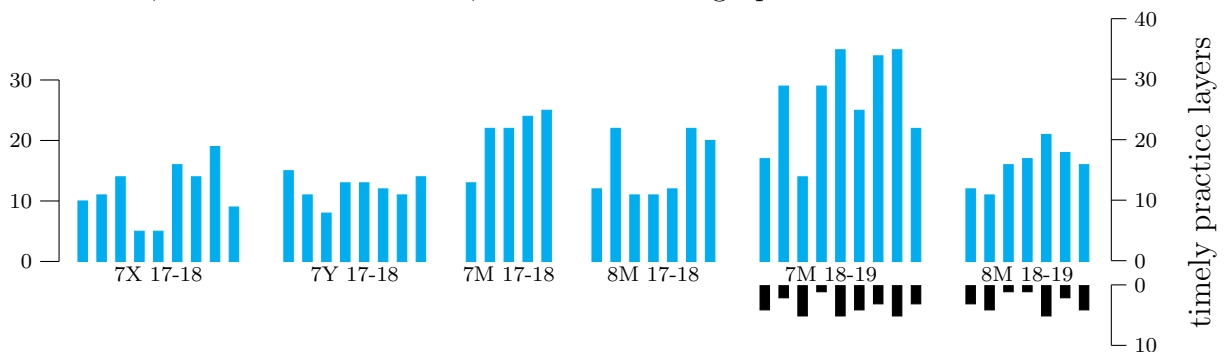


... and for 8M 2018-19

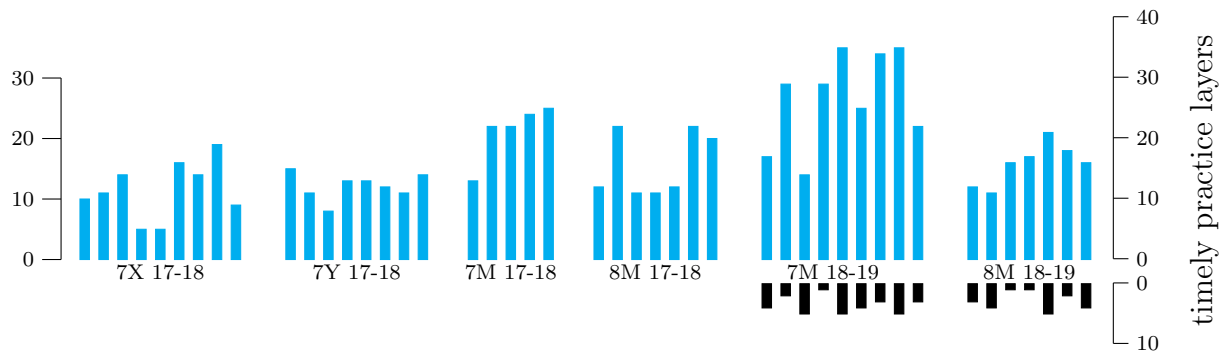


8M 2018-19, did not enjoy learning maths, they hated doing tests, and due to room changes for the exam period, they often arrived late to lesson because they “couldn’t find the lesson” or “forgot they had extra maths”. To compensate the order of the latecomers lesson was swapped from: retrieval practice, new learning, more new learning to new learning, retrieval practice, more new learning. (The ● shows the 2nd or 3rd topic taught in each lesson). The class did not have time for a cool down, so the topics are shown in teaching order and the dashed line around the word **insufficient** indicates topics which had insufficient retrieval practice and feedback.

Despite all this negativity about learning maths, 8M 2018-19 learning gain per learner is similar, if not better than, 7X and 7Y in 2017-18, as shown in the graphs below.



It seems that learners are learning, and retaining for at least a few weeks, far more within the tutoring than the regular maths lessons. The graphs of learning gain per learner for all 6 classes are repeated below:



The learners in 7M 2018-19 learned a mean of

- 27 layers per learner in 10 tutor and 3 cool down lessons when in a class of 9 learners
- 4 layers per learner in their 23 maths lessons when they were in a class of 20 learners

The learners in 8M 2018-19 learned a mean of

- 16 layers per learner in 10 tutor and 1 cool down lessons when in a class of 7 learners
- 3 layers per learner in their 22 maths lessons when they were in a class of 20 learners

There are a number of factors which could cause more learning in the tutoring lessons:

1. smaller class size,
2. bespoke “breadth first” scheme of learning,
3. more accurate assessment for learning data,
4. teaching a small size bite per topic,
5. retrieval practice,
6. time to give feedback to every learner, every lesson.

Of course, having **less than half the number of lessons** mitigates against the smaller class size. To remove the class size/number of lessons factor from the desired changes made to more deeply and durably embed learning, we could compare two similar size and ability:

- regular maths classes, taught with/without 2. to 6 and/or
- intervention tutoring classes taught with/without 2. to 6.

However what we can say is that:

- (a) Intervention tutoring with timely practice is effective at adding new learning.
- (b) Without continued retrieval practice most low attaining learners will forget some/most of their new maths learning, over the subsequent weeks/months.
- (c) Our trials using timely practice within regular maths lessons, show low attaining learners can close the learning gap, and often overtake their more highly attaining peers within a year.

Tentative conclusions:

- Personalised retrieval practice, appears to be effective for withdrawal tutor intervention.
- “Tutoring within maths lessons” is a cheaper and more sustainable option than withdrawal tutoring, so this shows greater promise in closing the learning gap.

Requirements to efficiently embedding learning in low attaining learners

- (i) Use accurate assessment for learning data to teach a small bite per learner per topic.
- (ii) At least thrice a week allocate 15 minutes for personalised retrieval practice.
- (iii) Assess don't mark the retrieval practice and give feedback the lesson after errors.

timely practice was built to make these requirements easy for teachers to apply.