# Developing Mathematical Resilience

## Teachers' reflections on working to develop mathematical resilience in learners

Enigma Mathematics Hub

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## The Project

In this booklet are reports from teachers who took part in an academic year-long action research project to introduce mathematical resilience into their classrooms. The teachers worked in pairs in their schools supporting and challenging each other to work differently and to make a difference.

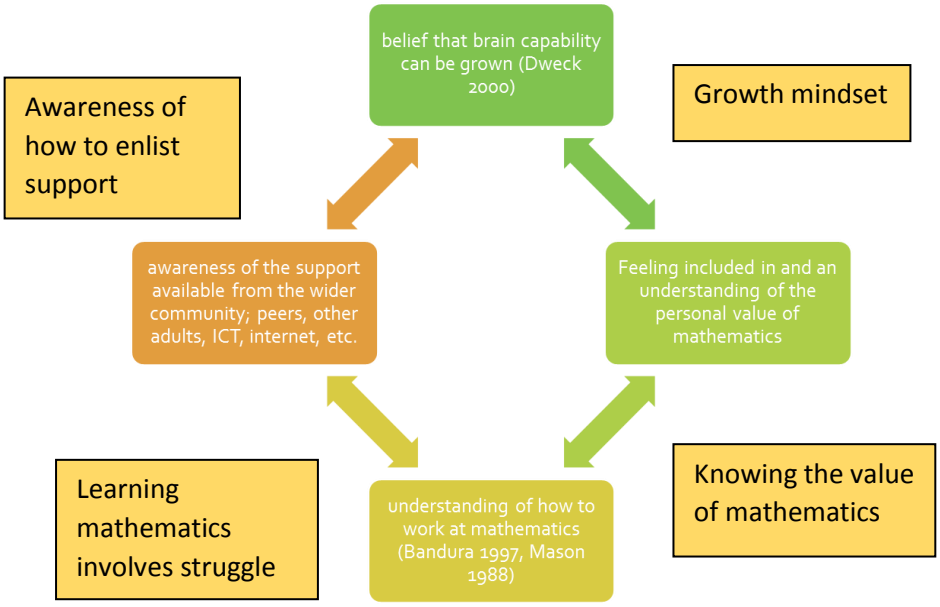
The group of teachers met four times across the year, the first meeting introduced the idea of mathematical resilience and asked the participants to set out an action research project that they felt they could pursue in their school. The following meetings asked the participants to report on what they had done and to bring any issues they had found to the group for discussion. In this way the teachers shared successes and issues, ideas and warnings. The following reports were written by the teachers and show what they did with the ideas and the differences the ideas they used made to their learners.

But first ….

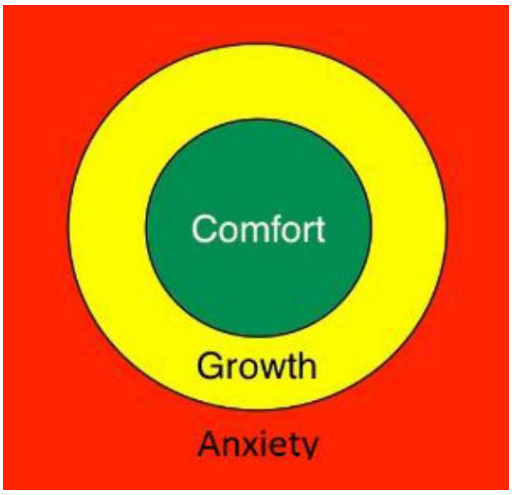
## What is Mathematical Resilience?

Mathematical resilience (Lee and Johnston-Wilder 2013) is a pragmatic construct that shows how to approach mathematics in a classroom so that students learn:

- that everyone can get better at mathematics, it is not just for the elite few;
- that mathematics has value in everyone's life, it is useful and it can be enjoyable. Also that everyone is of value in a well-functioning mathemtical learning environment;
- mathematics sometimes involves struggle and making mistakes, the path to good mathemtical learning is not just about "remembering" it is about connecting ideas and sometimes about battling through to an understanding;
- how to work at mathematics, mathematics does not have to be worked on alone and isolated, many people prefer to work as part of a community and even when you are working alone there is a vast community out there that can help that can and should be accessed.



In the reports which follow ideas about the growth mindset seems to have had the biggest impact. Ways to encourage students to think that they can improve the mathematics they can do occur in most reports. Several reports show that developing a growth mindset needs to be a whole school endeavour. In society it is common to hear "I have never been able to do mathematics" and the reports show it is vital that the students do not hear this in school. No-one knows how much students can learn with the right support, and several reports show just how much many common practices may be holding students back. In one report the idea of "the learning pit" is used to help students understand that although learning can be difficult there is help available to enable you to do the learning and get out of the pit. In several others different ideas for using the growth zone model are used to help students to understand the feelings they may experience when they are learning mathematics and to have a language with which to discuss such feelings. The growth zone is shown as sitting between the comfort zone and the anxiety or danger zone.




If you are working in the **comfort zone**, you may be consolidating or gaining fluency with ideas that you have already learned. It can be a good place to be but if you stay there too long you will not be learning anything new. Sometimes you have to get out into the growth zone

In the **growth zone**, you will be learning and as a consequence you may have to struggle to understand and you will feel stress as you meet and overcome barriers. Learning mathematics is not easy for anyone, mistakes will be made and some conjectures will be incorrect. This is all part of learning. But it must not get too much as then you will be in the red zone and that feels dangerous.

In the **red zone**, panic will set in, the freeze, flight or fight reflex is triggered and thinking becomes impossible. Unfortunately many traditional ways of teaching mathematics have not helped students recognise that learning can be stressful and this has led to many students going straight into the red zone when faced with any mathemtical problem.

The difficulties that are known to be faced in our society with recruiting sufficient students into STEM subjects seem to stem from students avoiding the feelings of panic that they have developed as part of learning mathematics. Teachers who tell students to "just remember to do this and it will be easy" seem to indicate that solving mathemtical problems should be trouble-free. As a result when it is not, students think they cannot do mathematics.

Teaching for mathemtical resilience means developing a positive approach to mathematics where learning is known to be of value and where if learning is not happening, that should be recognised and different support or more time offered. Everyone is expected to struggle and make mistakes because that is part of learning and if there is no struggle or mistakes then students will need more challenge. However no-one is expected to struggle alone or in silence, learning is a community responsibility and a communal joy.

# 1. Changing learners' mind-set - becoming more resilient in learning mathematics. Bridge Academy – Karen Williams and Samuel Oki

## The problem

Students' attendance in mathematics lessons was very poor. A large proportion of our learners often gave up without even looking at the task. We also felt that some staff at Bridge Academy Central had a problematic attitude towards mathematics. They were extremely negative and would often say things such as "I didn't get Maths at school", when students talked to them about mathematics, rather than support the student to go back into their lesson. Students were also more interested in getting the correct answers, not in trying to learn and understand the mathematics. If the work was out of their comfort zone, they would refuse to try in case they made a mistake. Some of the learners would struggle to use the feedback they were given to help them to improve their work. They often ripped the pages with feedback on out of their books. If many students did not get the correct answer first time, or even if they felt their approach was not correct, they would often refuse lessons and even verbally abuse mathematics staff, which meant they would be internally excluded and miss the lesson.

## Actions

| | |
|---|---|
| Autumn 2015 | All staff at Bridge Academy Central were trained on how to recognise and challenge a fixed mind-set. If students are to change their mind-set in mathematics a whole school approach was needed. |
| | Students and staff were given a questionnaire that assessed their Mathematical mind-set |
| | An assembly held for all students using videos on changing mind-set |
| | Links were made between students' mind-set in sport, computer games and dance to their mind-set when thinking about mathematics. |
| | The students were trained on how to change their fixed mind-set thoughts to growth mind-set thoughts. |
| | "I don't get this "YET"" became a staff mantra. |
| | A prominent poster was given to all staff for their classrooms. Students were given a mini version for their exercise book. |
| | A large "change your mind-set" display board was put on view in the mathematics classroom. |
| | A 5 question starter was put on the board and the students were asked to try to do what they could without support. The teaching over two weeks was designed to help students complete all the questions. The same 5 question objective was repeated over the two week period so that gradually the students could do more , building confidence and independence and the students could see that they were making progress |
| Spring Term 2016 | Students were encouraged to spot patterns or use previous knowledge to support them with answering questions. The teachers stressed that the method the students used wasn't important, but they needed to explain the strategy/process they used. |
| | In year 11 lesson students were given choice of tasks to complete without support. They were also asked to use 3B4me (Brain/Buddy/Book before the teacher or TA). Hints sheets/revision mats/books were available for additional support. |

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| Summer Term 2016 | Reports to year 10 (current 11) ended with a growth mind-set thought e.g. remember mistakes are proof that you are trying or it's ok not to know but it's not ok not to try. |
| Ongoing throughout | Lesson plenaries which helped the students to reflect and assess which steps they have achieved during the lesson. |
| | In mathematics lessons whenever the teaching assistant or teacher heard any fixed mind-set thoughts expressed by the students they immediately challenged it. |
| | Students are not allowed to use negative language about mathematics to themselves or others e.g. "I am dumb" "you are stupid". I believe that this can lead to the self-fulfilling prophecy and will not support changing mind-set. |

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Our students are taught in mixed ability groups and topics are often planned to meet the specific needs of individuals. The students are expected to progress at their own pace, taking on more and more difficult/challenging problems to achieve the learning objectives of the unit, which is shared at the start of the unit. Teaching of a unit is done over a period of approximately three weeks and concrete resources are usually available for the students until they have developed their own strategies and are confident in solving a problem.

## Impact

*Student A female* - seemed to totally lack confidence in Mathematics in year 10 and at the start of year 11, she would often rip pages out of her exercise book if there was a minor error in her work. Throughout a task, she required either myself or the Teaching Assistant to sit next to her while she attempted to complete a task. Student A will seek reassurance constantly and was only interested in whether her answer was correct. She avoided tasks that were outside of her comfort zone, and would never answer a question in front of the whole class. If she got a question wrong she would often swear at staff and sulk, but would often correct it before the end of lesson.

Student A received 19 negatives (level 3) in year 10 and following the intervention only 4 in year 11 with 34 positives. Furthermore student A moved from a U-grade student to being able to successfully pass her functional skills level 1 Maths paper by Spring Term 1. Student A's confidence increased to such an extent that she was able to stand at the board and explain her answers to a question, to the whole class. Student A became more independent and less reliant on staff, she was more interested in figuring out where she went wrong when answering a question than just getting the correct answer.

*Student B female* - currently in year 10, negatives between September and October 2015 (9 Level 3s); October and December 2015 (6 Level 3s); January to March 2016 (0 level 3s). She is now reintegrated to main stream and has come to me for support with her mathematics homework. However, at the start of the academic year, she would not let me look at her work during lessons to try and support her, She would often scream "what is the answer?" during lesson. The Maths TA and I needed to constantly restate, "it's not about the answer, mistakes are proof that you are trying, its ok not to know but it's not okay not to try." We learn from our mistakes. When I marked her work she would tear out any page(s) with feedback on them. If any task had an error that required correction or improvement, she would remove it without even checking to see if she could correct it. However, at the start of the spring term, she requested that the teaching assistant sat next to her. The TA did this but slowly withdrew herself and I would support her when she asked for it. However, I wasn't allowed to explain work on the board to her or write in her exercise book, I wrote in a separate note book which was our compromise.

She would often become extremely frustrated when the work was out of her comfort zone and would scream, shout and swear directly at me when I tried to challenge her. However, the TA and I continued to repeat some of the growth mind-set phrases. By spring term 2 she started coming back the next day saying to me, “miss could you re-explain what you were trying to teach me yesterday?” I recall the unit on fractions where she was comfortable on cancelling numeric fractions. By the end of the unit, she could cancel algebraic fractions. In addition, she also completed all four operations on fractions with mixed numbers. Student B had become a much more confident learner by the end of term 4. I recall hearing “miss let me try” from her, and she started to seek support when needed rather than relying on continuous support. Furthermore, by the end of spring term1, I was allowed to give constructive feedback in her exercise book and she started to come back to challenging tasks rather than giving up completely. Students B was able to access her Functional skills level 1 Maths paper independently this summer and I am confident that she would have passed this. This is a great accomplishment for this student since at the start of a year she would panic at the mere mention of a test/assessment/ exam and she would have totally refused to attempt one.

*Student C male* – currently in year 10. At the start of the academic year he wouldn’t even come to the mathematics room and if he was given a mathematics task would not look at it, but would put it straight into the bin. The teaching assistant, over a period of approximately one month, worked with him on a one-to-one basis in a different location, once the rest of the class was settled. Following this student C was gradually re-introduced to the classroom, supported by the teaching assistant, almost like a safety net, as he totally refused to work with me, the mathematics teacher.

Gradually I tried to build my relationship with this student so he didn’t only see me has the mathematics teacher. While the student was supported by the teaching assistant I would gradually move to his proximity and respond to a question he had directed to the teaching assistant. The first few weeks after this student was reintegrated to mathematics, he only attempted work he already knew how to do, staying in his comfort zone. Lessons during this time were for him almost like revision sessions with very limited progress being made. For example in a unit on Factors, Multiples and Primes, he would just find the factors of a number using factor pairs and when the class moved on to prime factors he refused to try this.

Both the teaching assistant and I used the language of growth mind-set with him, making him aware that it is “OK not to know, it’s OK to make mistakes” so that he can become more mathematically resilient. The teaching assistant and I agreed that we would also utilise the reward system to try to get him to try to achieve the learning outcomes in the lesson. Thus, when he first returned to the classroom he received 5 points for his work in mathematics. However, in conversation with him, we agreed that unless he tried to meet the learning objective, using support if required, this would not continue to be the case. He challenged this, ripping of pages out of his exercise book and verbally abusing staff. However when I reviewed his behaviour log for mathematics his negative points had diminished from 15 in the autumn/winter term to 3 between January and April. At the end of each lesson the teaching assistant and I discussed with the student how much progress he felt he had made and whether we agreed. The student relapsed during this time, he often said to us “you just want me to try and be able to explain my work don’t you?” We have identified that at the start of the term he regressed to a fix mind-set thought process, but he started to overcome this much more quickly in the summer than in January/February. The time to establish a growth mind-set has reduced from days to minutes now, for example at the start of summer term 2 , even though we no longer have the same TA, (our students don’t cope well with change) it took just 20 minutes for him to believe that he could try to solve mathematics problem. Thus he is showing that he is becoming more mathematically

resilient. Recently, in the space of 30 minutes, he was able to move from finding the next two terms in a linear sequence to finding the position–to-term rule.

*Student D, male* - Reviewing the behaviour log and comparing academic term 1 and term 2 has shown a vast reduction in this student's negative behaviour by 51%. However, this case isn't as successful as it appears, due to a member of staff who wasn't trained on growth mind-set projecting their fix-mind set about mathematics to this student on a number of occasions. This is a prime example of when the whole team doesn't work together it can lead to some regression and the need for further interventions. Some of the problems we faced were that the student refused to engage when the work got challenging or he felt he was out of his comfort zone and he would go to the member of staff who was his designated mentor. The Maths TA and I started hearing this student make comments like, Ms X didn't like maths in school; Ms X said not everyone is good at Maths and he would then use Ms X as a means of getting out of lessons. I spoke to the Mrs X and tried to get her into lessons with him and I offered her support with mathematics. I recall her coming into a lesson on fractions and she actually made very good progress; she made a positive comment which the students were able to hear. The student is currently attempting some thinking tasks with the support of either the TA or myself and I am trying more and more to offer hint cards when he gets stuck and to remind him to use 3Bs4me. This reduces the need to say, "What do I write?" The language of growth mind-set is constantly being used and hopefully over time this student will become more confident, more resilient in mathematics and acknowledge it's ok to make mistakes.

## What others can take from this

I believe that routine, consistency, and letting the students know it's ok to make mistakes has had a positive impact of raising the resilience of students at BAC. More students are in Maths lessons, therefore more students are learning Mathematics. Changing the mind-set of our students at Bridge Academy Central is an on-going process; some of our learners' attitude towards maths and their self-belief that they "can't do Maths" is extreme, therefore, this will take much longer to change.

I have had staff comment that the Maths they have seen in the student's exercise books is the most they have ever seen. A majority of students are now trying summative assessment without screaming or throwing a tantrum or complete refusal. Now they understand that assessments are used to support my planning to help them to make further progress. More students are reflecting on the next step to move their learning further in lessons. More students are starting to spot patterns and apply prior knowledge when solving problems. As a practitioner this progress has made me more conscious in the language I used, so language like "you are clever" has now been totally eradicated from my speech and now I praise the effort. I now wholeheartedly believe that anyone can learn mathematics or indeed anything they put their mind to, with hard work and practise anything is possible. I often give the example of me learning to drive at age 40. At age 18 I didn't believe I could do it, but after three driving tests and lots of practise, I overcome the self-doubt. The students have also seen me trying to learn something new - Art. I have gone into Art lessons during my free time and attempted the task in class with support of the class teacher since I used to believe that I was not a natural artist and in the past would not dare to try. I believe that the challenge academics/teachers of Mathematics have is changing a culture that embeds the notion that "maths isn't his/her forte" I personally will challenge this perception every time I hear it based upon this experience.

## 2. Students Becoming Pro-active and Resilient Leaners of Mathematics - Caroline Chisholm School - Natalie Smith and Ian Armstrong

### Aim

The students at CCS are passive learners who don't ask questions. They do not speak mathematically. We wanted to encourage an environment where students become more pro-active in their learnings, where they are more able and willing to communicate mathematically and become more self-reliant and resilient. Our aim was: To make the students more pro- active and resilient in their approach to mathematics

### Action

Four year 8 groups were involved all from the bottom third of the year group as well as one high ability year 10 class.

The plan of action was to use questionnaires and lesson observations over time to assess the impact of:

- Introducing growth mind set practices within our lessons
- Displaying posters around our classrooms
- Using vocabulary sheets, identifying and using key terms and encouraging the students to use them too
- Using tasks designed to establish and train a growth mind set

| | |
|---|---|
| November 2015 | • Gave the students a questionnaire based on what they thought about Maths and what they currently do when they are stuck.<br>• Put posters around each classroom and gave students mini version for their books<br>• Classes given a presentation to introduce the posters<br>• Culture of NANA (Notes, Answer, Neighbour, Ask) introduced<br>• Refused to help when the words "I don't get" are used, students must find out using the information available. |
| January 2016 | • Getting to know the students on a non-mathematical level. "I wish my teacher knew …"<br>• Hint cards around the room for students to use when solving complex problems.<br>• Working on getting the students to understand what a problem is and how to go about starting to solve it.<br>• Exam questions for the new GCSE, what do you know, what can you put down – You don't need to have a full answers to get marks. Try not to leave a question blank. |
| May 2016 | • Questionnaire re-done with the same classes<br>• Looked at exam papers to see how many questions they have attempted.<br>• Compared our results to school wide results of resilience survey |
| Further actions | • Compare how the students in our classes have answered questions compared with peers from other teachers.<br>• Disseminate results within the department and wider school environment |

## The Questionnaire

The questionnaire design contained a line for each question where students ranked their responses to the questions below, whereby - 0 is all the time and 1 was never. The line was 15cm long.

A. I am confident in most lessons
B. My mind goes blank
C. Maths is something I enjoy
D. Maths makes me uncomfortable and nervous
E. I don't mind getting stuck in maths lessons
F. Maths makes me feel uneasy and confused

In order to see whether the students had understood the questions and answering honestly several questions were similar but worded differently. The mark on the line was measured and an average was taken for the year 8 and the year 10 students. 0cm all the time – 15 cm never.

## Results before intervention

| | Year 8 | Year 10 |
|---|---|---|
| A. I am confident in most lessons | 5.89 | 5.50 |
| B. My mind goes blank | 9.21 | 6.82 |
| C. Maths is something I enjoy | 6.79 | 8.04 |
| D. Maths makes me uncomfortable and nervous | 9.32 | 6.93 |
| E. I don't mind getting stuck in maths lesson | 5.00 | 6.50 |
| F. Maths makes me feel uneasy and confused | 9.63 | 6.39 |

**I am confident in most lessons**: Both year groups have a similar average, marking just over a third of the line away from all the time. This would suggest that the students are feeling fairly confident in their Maths lessons. I found this surprising for the year 8s as they are part of small group of the lowest ability students who have been chosen to be in that class as they need support and help building their confidence. However, the majority of the students have been with me in a small group since January 2015 and therefore their confidence has probably grown since then but also they may have been trying to please me.

**My mind goes blank:** Both averages would be in the middle third of the line suggesting that this can happen to them on a fairly regular basis. The year 10 class finds that this happens more often than my year 8s but again it maybe that the year 8s do not realise that this is happening to them but the year 10s are more aware of this.

**Maths is something I enjoy**: Both year groups were again within the middle third of the line with year 8 leaning more towards enjoying Maths lessons than not and year 10 leaning more not to enjoying their Maths lessons. This did not surprise me, I had been finding relationships with that group strained. I often got frustrated with their lack of effort and because they were often not proactive in lessons. I had found that I had stopped trying to make the Year 10 lessons interesting as they wanted to just be told methods, rather than explore them.

**Maths makes me uncomfortable and nervous:** The year 8s felt more nervous and uncomfortable around Maths. Again this did not surprise me due to the nature and ability of the group. They would often say, "I have never understood Maths at primary school". Certain members of the class seemed to freeze if they were asked a simple question.

**I don't mind getting stuck in maths lesson:** Both year groups were not too concerned about being stuck in lessons with the year 8s slightly more comfortable than the year 10s. When questioned further about this the year 8 said that if they got stuck they knew they would get help – which to me showed an over reliance on the teacher. Year 10 were split on their response. Some said they found it very stressful not knowing what to do saying they, 'hated it.' Others were not concerned at all, 'as it something that happens in Maths.'

**Maths makes me feel uneasy and confused:** The year 10 felt uneasy and confused in Maths more often than the year 8s. This may be due to the harder content that the year 10 have to cover, particularly with the new curriculum for KS4 being perceived as more difficult and a greater step up from year 9.

The three questions B, D, F were deliberately all very similar and on inspection the students answered them in a similar fashion. If the students had been filling out their responses honestly similar answers are expected and they were. The questionnaire also contained a multiple choice of actions that the students take when they are stuck. The students decided if they did this always, most of the time, sometimes or never.

**Figure 2:**

| | Year 8 Percentage | | | | Year 10 Percentage | | | |
|---|---|---|---|---|---|---|---|---|
| | A | MT | ST | N | A | MT | ST | N |
| Look back in my book | 0 | 21 | 74 | 5 | 18 | 18 | 54 | 11 |
| Discuss with the person next to me | 5 | 32 | 47 | 16 | 54 | 36 | 11 | 0 |
| Ask the teacher | 32 | 47 | 21 | 0 | 0 | 14 | 57 | 11 |
| Do nothing | 0 | 5 | 32 | 63 | 14 | 11 | 39 | 50 |
| Check answers | 16 | 58 | 26 | 0 | 4 | 11 | 64 | 21 |

I was surprised with the percentage of year 10s who 'never' looked backed in their books. I was pleased that the year 10s discussed their work with the person next to them but would prefer them to look back in their books first. Year 8s will often ask the teacher for help when stuck which was as expected but I would like them to use the other methods too.

## The interventions

In order for my students to enjoy their lessons more in year 10 I realised I needed to get to know the students better and build on our relationship. I decided to use a "I wish my teacher knew …" activity, where the students had to write something I could not guess about them on a piece of paper. They could put their name or not. To start with the students did not know what to put down so a shared some personal information with them to do with my husband who has a life limiting illness. The responses I then got were very enlightening with most including their names. One student finds it difficult to complete their Maths homework as they have to train 4 evenings a week. Another student suffers from chronic back pain and has on-going hospital visits which can make it very difficult to concentrate at times. Another student often felt that she as not as clever as her friends and this had caused friendship issues. One student simply wrote, 'I always try my hardest in

Maths.' These notes created a starting point for conversations with the students on a one to one level.

Time was given in the lessons to explain a growth mindset and how we can retrain our brain by changing simple words. Posters were put on display in the classroom and mini versions were stuck into their book. I chose questions for them to work on which would encourage the students to get stuck. I put "hint cards" around the room with answers, help or supportive ideas on them so that the students could use them as they chose and compare the ideas with their work. The words 'I don't get it' were banned to encourage the students to verbalise what they did not actually understand.

To increase students' resilience when they are stuck, we introduced the NANA strategy. We told the students they must first look at their notes, secondly look at the answer to see if they can figure out how to get it, then ask their neighbour and finally ask the teacher. We wanted them all to become more independent and develop ways that they could help themselves and not be so dependent on the teacher. Therefore I wanted:

- the number of students who 'always' or 'most of the time' looked back in their books to increase.
- the "discuss with your neighbour" to decrease for always for the year 10 and increase for the year 8.
- the "do nothing" never percentage to increase for both year groups.
- the "ask the teacher for help" never percentage to decrease.

## Results after the intervention

The aims of our interventions were for students to feel more confident in lessons, enjoy their lessons more and to be able to cope better when they are stuck. For questions A, C and E the mean average should move closer to 0. By doing this students' anxiety within lessons should be reduced. This would be shown by the questions B, D, F's mean averages moving closer to 15.

**The "before and after" mean results for year 10**

| | November | June |
|---|---|---|
| A. I am confident in most lessons | 5.50 | 5.58 |
| B. My mind goes blank | 6.82 | 8.69 |
| C. Maths is something I enjoy | 8.04 | 7.65 |
| D. Maths makes me uncomfortable and nervous | 6.93 | 9.35 |
| E. I don't mind getting stuck in maths lesson | 6.50 | 7.15 |
| F. Maths makes me feel uneasy and confused | 6.39 | 8.77 |

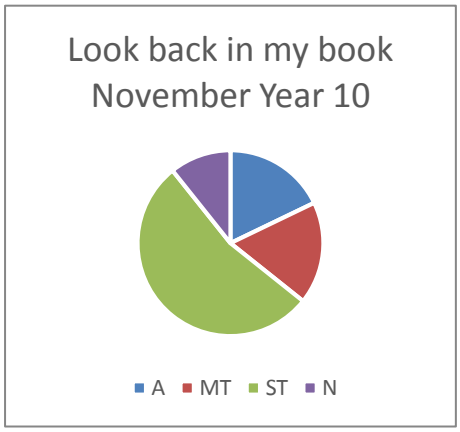
Year 10 students' confidence within lessons has stayed fairly similar with a slight decrease. 'Maths is something I enjoy' has improved moving closer towards always (0). Students "worry more about

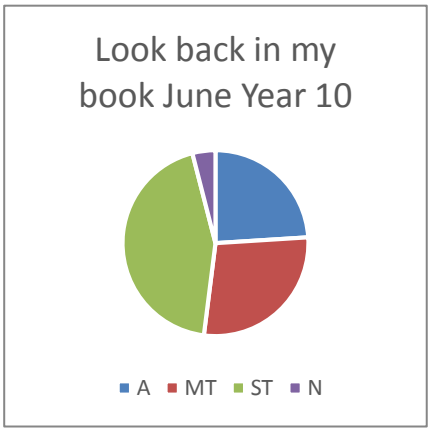
getting stuck" has unfortunately increased. However, their mind goes blank less frequently and Maths makes them feel less uncomfortable, nervous uneasy and confused than before.

**The "before and after" mean results for year 8**

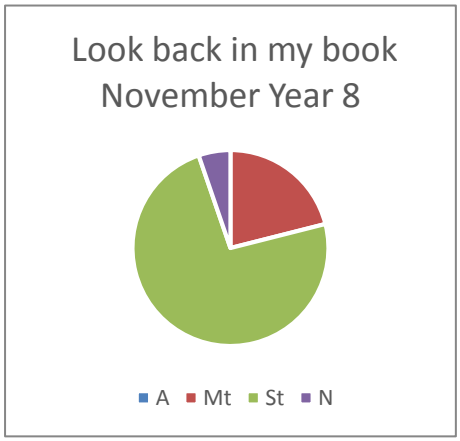
| | November | June |
|---|---|---|
| A. I am confident in most lessons | 5.89 | 2.8 |
| B. My mind goes blank | 9.21 | 9.05 |
| C. Maths is something I enjoy | 6.79 | 5.1 |
| D. Maths makes me uncomfortable and nervous | 9.32 | 9.15 |
| E. I don't mind getting stuck in maths lesson | 5.00 | 5.55 |
| F. Maths makes me feel uneasy and confused | 9.63 | 12.1 |

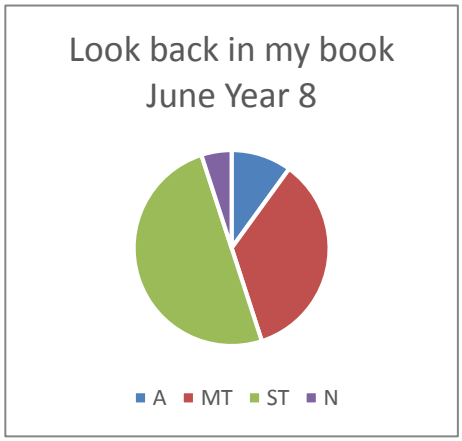
'I am confident in most lessons' has moved much closer to always (0). 'My mind goes blank' in lessons has remained roughly the same. 'Maths is something I enjoy' has also improved moving closer to always (0). However, 'Maths makes me feel uncomfortable and nervous' has remained the same and 'I don't mind getting stuck in the maths lesson' has remained the same. 'Maths makes me feel uneasy and confused' has moved closer to never (15). This is positive and I think I can say that the students' attitude to maths in the year 8 classes has improved.




As can be seen from the pie charts the year 10 are using their books more often when they are stuck the most of the time and always sections have both increased and the never has decreased.




The number of years 8s who never looked back in their books remained the same, however, some of the year 8s say they now do this all the time and the percentage who do it most of the time has increased.

Year 10 results

| | November Percentage | | | | June Percentage | | | |
|---|---|---|---|---|---|---|---|---|
| | A | MT | ST | N | A | MT | ST | N |
| Look back in my book | 18 | 18 | 54 | 11 | 24 | 28 | 44 | 4 |
| Discuss with the person next to me | 54 | 36 | 11 | 0 | 48 | 36 | 16 | 0 |
| Ask the teacher | 14 | 14 | 57 | 11 | 16 | 36 | 48 | 0 |
| Do nothing | 0 | 11 | 39 | 50 | 0 | 16 | 48 | 36 |
| Check Answers | 4 | 11 | 64 | 21 | 12 | 24 | 52 | 12 |

The percentage who always discuss with the person next to them always has decreased, which is what I wanted for the class. The percentage of students who always ask the teacher has increased. Although it is good that they are asking I had hoped that the students would ask less often, as they would be using the other methods. I am pleased that all students will now ask for help when they are stuck as before some students would never ask.

The percentage of students who say that they "do nothing" when they are stuck at least some of the time has increased which contradicts the other 5 options which have all improved. However this may indicate increased honesty in the response due to a better relationship. The percentage of students who always check their answers has increased by 8%. The number of students who most of the time check their answers has doubled. The number of students who never check their answers has halved. This is again what I had hoped for

Year 8 results

| | November Percentage | | | | June Percentage | | | |
|---|---|---|---|---|---|---|---|---|
| | A | MT | ST | N | A | MT | ST | N |
| Look back in my book | 0 | 21 | 74 | 5 | 10 | 35 | 50 | 5 |
| Discuss with the person next to me | 5 | 32 | 47 | 16 | 10 | 45 | 40 | 5 |
| Ask the teacher | 32 | 47 | 21 | 0 | 25 | 60 | 10 | 5 |
| Do nothing | 0 | 5 | 32 | 63 | 0 | 10 | 10 | 80 |
| Check Answers | 16 | 58 | 26 | 0 | 30 | 35 | 25 | 10 |

The percentage of year 8s who never discuss with the person next to them has fallen from 16% to 5% . The results show the year 8 now discuss the work more often when they are stuck which is what I had hoped. The percentage of students who always ask for help has decreased which is pleasing, however, some now never ask. The percentage of students who never or sometimes do nothing have both improved. The number of students who always check their answers has also improved by nearly double the amount. However, several students who sometimes checked their answers now never do.

## What we found out

This piece of research has raised in my mind

- my relationship with the students and how knowing them better has helped them respond to me more
- how I question students and how the way that students respond to this has changed our mind set.
- a positive mindset has moved things forward, making both the student and teachers approach the lesson more positively.

Change is not easy to achieve, and not easy to evidence, especially the changes that we wanted, which was to make the students more pro- active and resilient in their approach to mathematics. The questionnaires do show positive changes but it is hard to know how trustworthy the answers are. I suspect the Year 8 classes answered the questions in the way that they thought would please me most. If that is the case then they are getting the message about looking at their notes, discussing their work and not always asking the teacher straightaway, which is positive. They are also less likely to feel uneasy and confused so perhaps they are becoming more resilient.

## 3. Using resilience to raise Attainment - Anne Cooper and Jacquie Heartly, Hazeley Academy

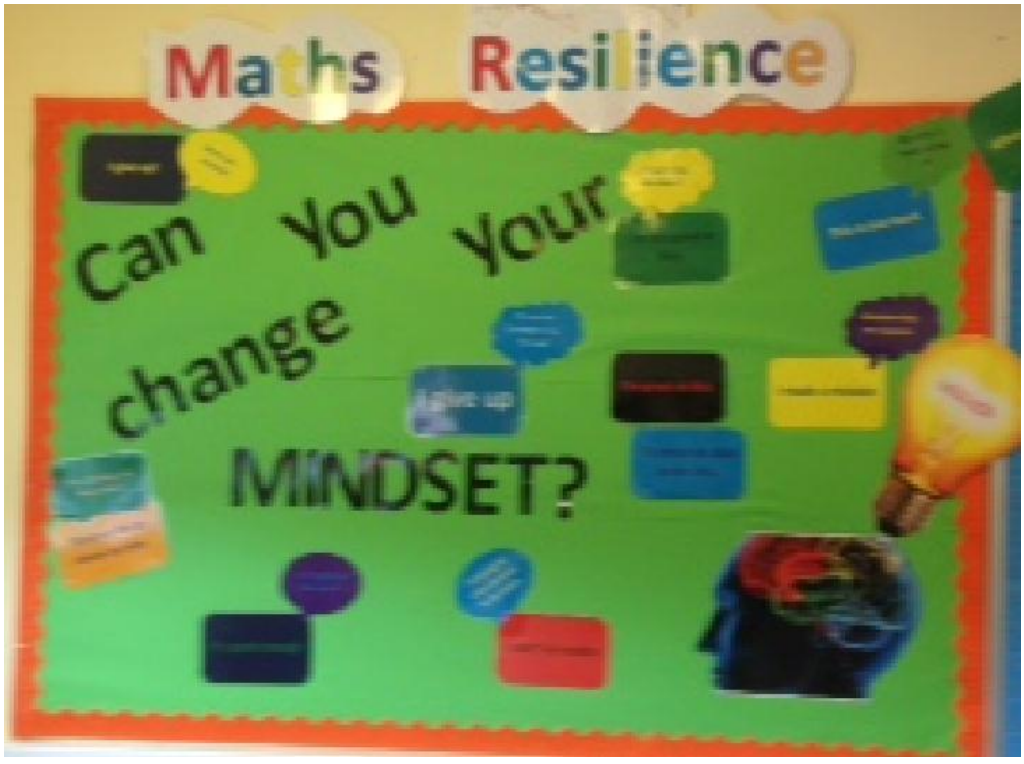
### Aim

We felt that our Year 11 girls could improve their Mathematical resilience. It seemed to us that many were underachieving because of a lack of confidence in mathematics. The girls seemed reluctant to even attempt to answer questions in class or on an assessment and this appeared to be because they thought they would get it wrong. They also lacked basic skills which acted as a barrier to improving their self-belief and their ability to answer questions in a variety of topic areas. The class we focused on also contained some loud boys who dominated the lessons and ridiculed the girls when they got something wrong.

### Action

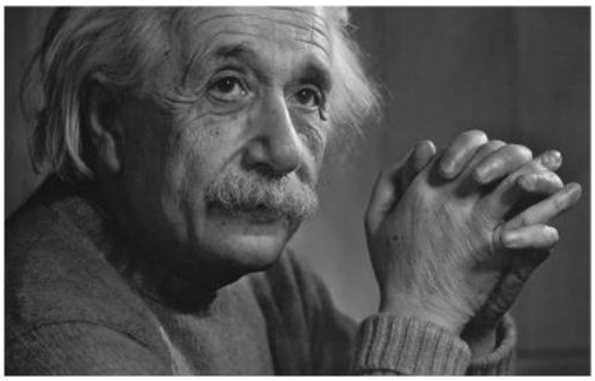
#### Changing mindsets

We wanted to improve the mindset of the students in the classroom from a fixed mindset to a growth mindset, as we felt that this was a severe barrier to their progress. Amongst several other ideas, we created a board in the classroom which made the 'can do' attitude visible in all lessons. We were careful to talk in a growth mindset way in lessons and to refer to the poster if a student said "I can't do it!"




We also put up lots of posters, see an example below, in the Mathematics corridor with quotes by famous people showing how having a growth mindset would improve the students life chances and opportunities

It's not that I'm so smart; I just stay with problems longer.



Albert Einstein

## Improve basic skills and ability to talk about mathematics

We decided to focus on improving the basic mathematical skills of the class as we felt that this was an important first step in improving their mathematical resilience. We also helped them to improve their mathematical resilience by working on their mathematics vocabulary. This would mean that they could express their ideas and begin to talk about their mathematics learning and any problems they encountered. As the students became more mathematically resilient we hoped that they would gain a voice in the classroom and feel able to engage in classroom discussions.

We worked on their mathematical skills by focussing on repetition of basic mathematical concepts and skills, firstly on a weekly basis but then more frequently prior to their GCSE examinations. We used the "skills checks" from Mathsbox for Foundation GCSE. These "checks" practice the same skills each time but they get progressively harder, see the example below. By returning to the same skills and concepts regularly we hoped that the class would gradually develop the confidence that they "know this". They would start to feel more successful with mathematics and perhaps become more

Name : FB1.1

| | | | |
|---|---|---|---|
| **Question 1** List the factors of 28 | **Question 2** List the factors of 73 | **Question 3** Write in figures : two thousand, seven hundred and three units | **Question 4** Write in figures : twenty three thousand, two tens and six units |
| **Question 5** Work out 392 + 156 = | **Question 6** Work out 512 + 77 = | **Question 7** Work out 880 - 329 = | **Question 8** Work out 215 - 59 = |
| **Question 9** Work out 54 × 8 = | **Question 10** Work out 65 × 8 = | **Question 11** Work out 789 × 10 = | **Question 12** Work out 228 × 100 = |
| **Question 13** Simplify 5b - 2b + 8b | **Question 14** Simplify 6x + 3x - 6x | **Question 15** Solve x × 12 = 108 | **Question 16** Solve x ÷ 10 = 8 |
| **Question 17** Calculate the mean 2, 6, 6, 5, 6 | **Question 18** Find the median 13, 8, 21, 6, 21 | **Question 19** Calculate the perimeter of a square with side length 5 cm | **Question 20** Calculate the perimeter of a rectangle with height 11 cm and length 3 cm |

(Mathsbox, http://www.mathsbox.org.uk/index1.php)

willing to challenge themselves to try and attempt harder or more complex problems.

## What we found out

Over a 14-week assessment period, all the students in the class improved their basic mathematical skills. The time that it took to complete the "skills checks" in lessons reduced substantially from 30 minutes to just 10 minutes as the students became more confident.

As their "skills checks" scores improved, there was also a noticeable improvement in the students' willingness to discuss in class, share ideas and offer solutions. It appeared that they felt increasingly confident in their own ability to work with mathematical ideas. This was also the case when they did practice GCSE papers. Previously they would leave questions blank when they felt that they did not know the answer but, by the end, the students would make a start with the questions and therefore gain part marks for working out, even if they didn't get the final answer.

As they gained in confidence and resilience, the girls began to feel able to challenge the boys in the lessons and the boys became more inclined to listen, as they knew that the girls had more to offer.

| Student | test 1 | test 2 | test 3 | test 4 | test 5 | test 6 | test 7 | test 8 | test 9 | test 10 | test 11 | test 12 | test 13 | test 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| female 1 | 10 | 11 | 13 | 17 | 16 | 19 | 19 | 19 | 20 | 19 | 20 | 20 | 20 | 20 |
| male 1 | 11 | 12 | 12 | 18 | 19 | 18 | 18 | 18 | 18 | 17 | 18 | 19 | 17 | 19 |
| male 2 | 9 | 13 | 13 | 16 | 13 | 18 | 15 | 15 | 18 | 17 | 19 | 19 | 19 | 18 |
| female 2 | 11 | 13 | 15 | 20 | 20 | 20 | 19 | 19 | 20 | 18 | 20 | 19 | 19 | 20 |
| male 3 | 7 | 9 | 10 | 7 | 13 | 15 | 15 | 17 | 20 | 18 | 17 | 15 | 20 | 20 |
| male 4 | 4 | 7 | 10 | 12 | 17 | 7 | 13 | 11 | 20 | 17 | 18 | 18 | 14 | 18 |
| female 3 | 5 | 8 | 11 | 19 | 18 | 18 | 17 | 17 | 19 | 18 | 20 | 19 | 16 | 18 |
| male 5 | 8 | 12 | 13 | 9 | 10 | 8 | 14 | 18 | 19 | 16 | 18 | 18 | 17 | 20 |
| male 6 | 5 | 7 | 10 | 11 | 12 | 13 | 14 | 10 | 14 | 16 | 15 | 17 | 18 | 19 |
| female 4 | 4 | 5 | 7 | 15 | 9 | 15 | 12 | 12 | 18 | 17 | 17 | 12 | 14 | 17 |
| female 5 | 5 | 5 | 10 | 17 | 16 | 17 | 16 | 15 | 16 | 18 | 19 | 18 | 17 | 16 |
| female 6 | 6 | 8 | 14 | 16 | 16 | 10 | 13 | 15 | 18 | 19 | 17 | 19 | 19 | 20 |
| male 7 | 7 | 13 | 14 | 15 | 16 | 16 | 15 | 18 | 19 | 18 | 20 | 19 | 19 | 19 |

## What should others take from this?

Ideas about growth mindset helped our students to be more prepared to both try to get started with a mathematics problem and to begin not to mind if they made a mistake. When we talked about growth mindsets and referred to the poster, this helped the students to feel they could make progress and therefore they were willing to "have a go" at improving their basic skills.

The "skills checks" used regularly meant that they constantly reviewed their basic skills and we could help them where they needed to improve. Using something like the "skills checks" on Mathsbox only takes 10 minutes out of a lesson once the students are used to doing the "checks", but has a significant impact on students' progress and confidence.

Gradually this repetition by reviewing basic skills has a positive impact on students' Mathematical resilience. The students improved both their basic skills and their confidence in being able to work with mathematical ideas, which has had many positive repercussions in terms of their general attitude towards the subject and their ability to access it and hopefully their examination results.

# 4. Resilience within a primary school - Headlands Primary - Siân Francis and Catherine Fryers

## Aim

The aim of our project was to develop children's mathematical resilience within a primary school setting. To underpin our research, we began by looking at the role concrete resources play in developing children's mathematical resilience in the context of problem solving. To give depth and breadth to our research, we selected a focus group of children from Key Stage 1 and Key Stage 2, to ascertain if there were any trends emerging as the children progressed through primary school.

## Action

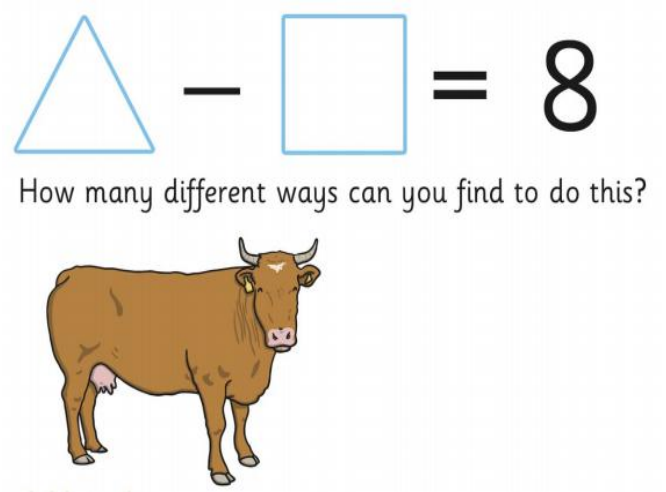
Firstly, we sourced problem solving activities, and decided to use two focus cgroups. Only one of the groups was given appropriate concrete resources to use when solving the activity, the other did not. We posed the following key questions to structure our research:

- ✓ How long does each group sustain their concentration and engagement?
- ✓ Which group asks for help first?
- ✓ Which group states they have completed the activity first? The group working with or without resources?
- ✓ Which individual children work well together?
- ✓ What strategies do the children without concrete resources use to solve problems?

## Key Stage 1 - Observations

**Activity 1 -** This is the open ended subtraction problem given to a small focus group of Key Stage 1 children.

Some children were given concrete resources including Numicon and multi-link cubes, the other children were not given access to any concrete resources.



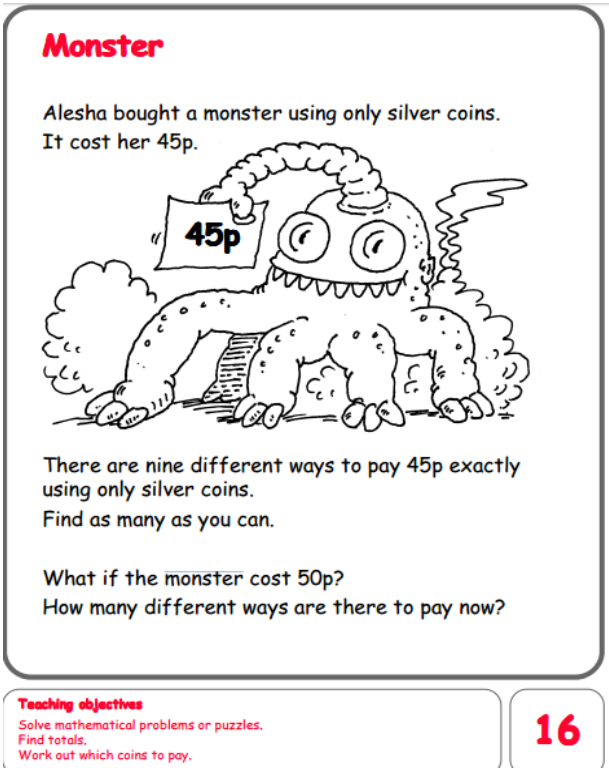

The key outcomes from the activity observed were as follows:

- ✓ Children with access to concrete resources generally discussed the activity more with each other compared to the children who did not have access to concrete resources.
- ✓ Children without concrete resources were offered these resources towards the end of the activity but said they didn't need them. They were happy to continue with the activity as they were.

- ✓ The first child to say they had finished was a child with access to concrete resources, 22 minutes into the activity.
- ✓ Nobody asked for help but some questions were asked including, can you do numbers above 10? Can I use a number line?
- ✓ Children without access to concrete resources used their prior knowledge of systematic problem solving previously carried out within mathematics lessons.
- ✓ Children used the large classroom number line to support their calculations.

**Activity 2 -** This was the second problem solving activity given to the Key Stage 1 focus group.

This was a closed addition problem involving money. Some children had coins available to support them, whilst other children did not.

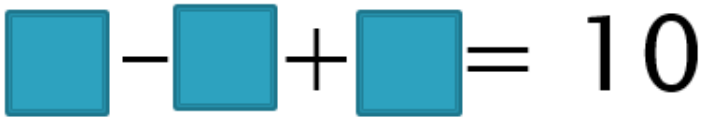



The key outcomes from the activity observed were as follows:

- ✓ During the activity, the children did not ask for help. Two children without coins verbalised that 'it was difficult'. When asked, they said they wanted to use the coins which they were then given to support them.
- ✓ The first child to say they had finished had no concrete resources. When the child was told that there were other ways to make 45p, the child was happy to continue using coins.
- ✓ All children moved to the table with coins when struggling.
- ✓ The availability of concrete resources improved the children's resilience and they were happy to persevere with the activity.
- ✓ Children without access to concrete resources used their knowledge of coins and multiples of 5 and 10. Some errors were made with coin values.

## Key Stage 2 - Observations

**Activity 1 -** This was the open ended subtraction and addition problem given to the focus group of Key Stage 2 children. Some children had access to concrete resources including Numicon and counters, whilst others did not.

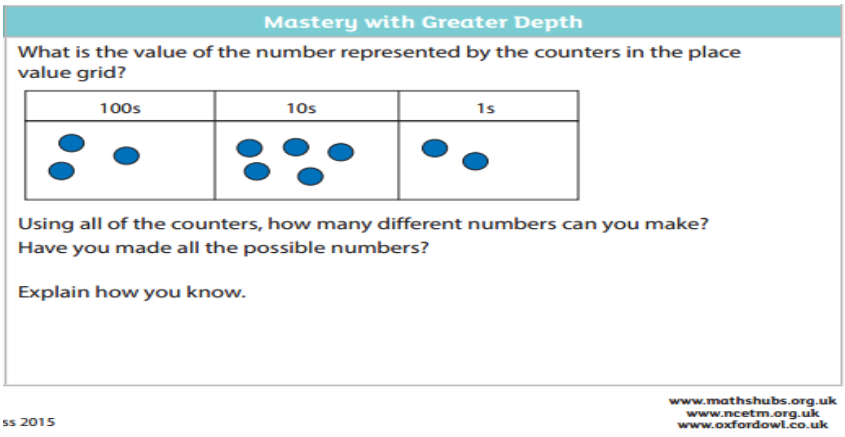


The key outcomes from the activity observed were as follows:

- ✓ Children seemed to be reluctant to use concrete resources. They said they felt they were for children who 'struggle'.
- ✓ Children with access to concrete resources demonstrated less mathematical resilience, disengaging with the activity much earlier. When the children were offered resources to manipulate, they said they didn't want to use them as it would involve getting into another routine and they were not struggling.
- ✓ Children using concrete resources were the first to ask for help.
- ✓ When children were asked about their perceptions of using concrete resources, one child commented, 'we do not need resources. If we use them, it will be getting into another routine. We are not struggling.'

These research activities revealed that mathematical resilience was demonstrated by children within both the Key Stage 1 and Key Stage 2 focus groups. We discovered which children collaborated well together when engaging in problem solving. It was evident that children in the Key Stage 1 focus group demonstrated greater enthusiasm towards activities and reflected that they were proud of themselves.

**Activity 2 -** A place value activity was selected from NCETM (Teaching for Mastery: Questions, tasks and activities to support assessment Year 3). All children had access to counters as resources



The children were asked the following questions:

- ✓ Can you make a number smaller than 100?
- ✓ Can you make a number including zero?
- ✓ Can you share your strategies for finding all possibilities?
- ✓ How many possibilities have you found?
- ✓ How helpful were the counters (concrete resources) in helping you find all possibilities?

The key outcomes from the activity observed were as follows:

- ✓ Children were more positive in their perceptions of the helpfulness of the concrete resources for this problem. One child said, 'It was helpful because you can move counters to make new numbers'. Another child said 'it helps me remember the number. If I imagined the number e.g. 5 in the hundreds, 3 in the tens, 4 in the units, I would forget it.'
- ✓ Another outcome was that children could see the benefit of using these concrete resources as it supported visual representations. All the children completed the challenge and persevered throughout the lesson.
- ✓ The final outcome was that children found it challenging to explain their thinking.

## Changes made during the project

After meeting again with our research group in March 2016, and listening to the other groups' research foci, we proceeded to introduce the Learning Zones to Key Stage 1 and Key Stage 2 after hearing the positive impact they had had in other schools.

At Headlands, a whole school approach was being developed around Assessment for Learning (AfL). The Learning Zones were introduced to teachers across the school to trial with their children alongside other Shirley Clarke AfL strategies including 'My Wonderful Mistake' and 'Walkabout'. We shared our positive experiences of using the Learning Zones and described how this strategy gave children a common language to use when reflecting on their learning. This has started to support both teachers and children in building a culture of resilience.

## What we found out

From carrying out our research, we have discovered that mathematical resilience can be based on a child's personality or mood and their mind set. The use of concrete resources doesn't always guarantee that children will persevere when solving a problem but their resilience can be improved through the use of positive verbal encouragement.

Children in Key Stage 2 children were often reluctant to use concrete resources as they had a fixed mind set which focused on concrete resources being used by children who are 'struggling'. Conversely, children in Key Stage 1 were happy to use concrete resources to scaffold their learning and deepen their conceptual understanding.

The Learning Zones had a positive impact on children's mathematical talk and capacity to reflect on their own learning. It provided children with a simple but effective language to verbalise their learning journey. The Learning Zones gave children the confidence to admit that they didn't understand a concept or to share that they were not being sufficiently challenged in their learning. The Learning Zones are also visually supportive to younger children who can relate to the different colours associated with each zone.

## What can other schools take from this?

After reflecting on our research, the following ways forward may be beneficial to other schools:

- ✓ Concrete resources need to be used throughout school where appropriate, as part of a Concrete, Pictorial, Abstract approach. Where their use is a normal part of classroom practice the students may not develop the idea that using resources means they are finding the mathematics particularly difficult.
- ✓ Providing children with an AfL tool such as the Learning Zones, which uses a common language, will support children's discussion about their learning journey, enabling them to become reflective learners.
- ✓ The Learning Zones also help children to understand the importance of setting high expectations for their own learning ensuring they are sufficiently challenged in every lesson i.e. not working within the 'comfort zone' for long periods.
- ✓ The Learning Zones support children in understanding why some activities may take more time and deeper thinking to complete.

# 5. Using the Growth Zone Model to improve pupil resilience in maths - Dot Marlow and Suzie Bower, Ponsbourne St Mary's Primary School

We were interested in looking at how we could improve pupil resilience in maths. We are the Head and Deputy of a small village church primary school, with 94 children in mixed age classes and the whole staff has for many years been working to enable our children to learn efficiently and effectively. Our children mainly attain well on Key Stage Tests and have a good attitude to learning. As a school we feel we are quite far on in the journey with fostering growth mindset in our pupils and staff. The use of talk partners, lollipop sticks for formative assessment, growth mindset characters and use of verbal feedback rather than physical rewards are all well-established throughout the school as a result of engaging in a project based on the work of Shirley Clarke.

## Aim

One of our teachers advocated pupil choice in learning and working from children's chosen interests several years ago which resulted in choice being given for any follow up activity in maths and the children not being grouped according to attainment. A further teacher introduced "The 6Rs" as developed by Guy Claxton as part of an M.Ed project. We encourage all children to develop meta-cognition and since learning is life's most important skill, we want them:

- to take responsibility for their learning
- to become resilient, resourceful and reflective
- to develop the skills of reasoning
- and have respect for themselves and others.

## Action

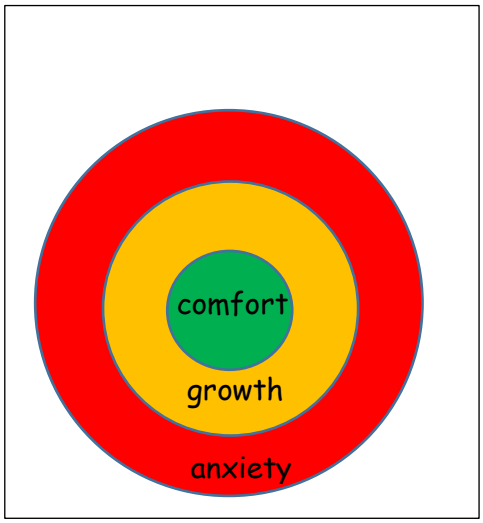
| **Resilience** – being ready, willing and able to lock onto learning – knowing how to work through difficulties when the pressure mounts or the going gets tough. Resilience is made up of: | | | |
|---|---|---|---|
| **Absorption**<br>Being able to lose yourself in learning – becoming absorbed in what you are doing; rapt and attentive; in a state of 'flow'. | **Managing Distractions**<br>Recognising and reducing distractions; knowing when to walk away and refresh yourself; creating your own best environment for learning. | **Noticing**<br>Perceiving subtle nuances, patterns and details in experience. | **Perseverance**<br>Keeping going in the face of difficulties; channelling the energy of frustration productively; knowing what a slow and uncertain process learning often is. |

The Developing Pupils Resilience project has enabled us to look at how we can develop resilience further. Our first step was to further define resilience, using a Guy Claxton model and we broke it down into a number of areas.

Figure 1 The attributes of resilience, Claxton 2006.

As teachers, we discussed in staff meetings how we could teach, promote and assess each of these areas. Previously, 'The Pit' had been a model in school, this idea was used to illustrate an area where

children grappled with new learning and used the 6Rs to 'find the light'. The idea was to help them learn an acceptance that learning is not always immediately easy and that that is okay.




Despite all this good practice, we still felt that we had a small number of children who were quick to become disheartened and found it difficult to persevere. We also observed a small number who were quite passive in their learning and were happy to be "spoon-fed", which meant that they found problem solving very challenging. When shown the Growth Zone Model (Johnston-Wilder & Lee, 2013), we saw an opportunity for giving children the language and awareness of how their emotions were affecting their learning.

This model seemed more positive than 'The Pit', as we had always felt that being in a pit could be a frightening experience, whereas the idea of growth sounded more child-friendly and less intimidating.

**Figure 2 the Growth Zone Model**

We decided to run a project in Year 5 & 6, where we used Nrich (Nrich.maths.org) open ended investigations as a vehicle to introduce the model and promote resilience. We planned a sequence of lessons in which children would be free to choose a level of challenge in which it would be essential for them to show resilience. We deliberately chose activities which were easily accessed by all, but had the potential to challenge higher attaining children. We identified success criteria which were linked to resilience as well as pure maths objectives.

| **L.O. to persevere a an investigation** | | |
|---|---|---|
| **Success criteria:** | **Pupil** | **Teacher** |
| Decide what you will investigate | | |
| Create appropriate squares from the squared paper provided | | |
| I can choose an appropriate level of challenge to put me in my growth zone | | |
| I can explain my reasoning to others | | |

**Halving**

These images show squares split in half:

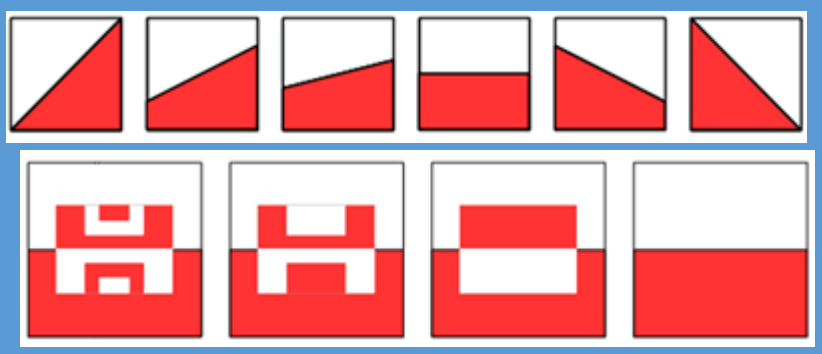


Figure 3 Halving from NRich website (NRich.maths.org)

We asked:

How might you check that each was correct?

Can you think of more ways to split a square into two halves?

## Using the Growth Zone Model

We introduced or reinforced the growth zone model at the beginning of each session. We discussed with the children what each zone would feel like. They seemed to understand the various zones and made the following comments:

<table>
<tr>
<td>

- **Anxiety Zone**
  - feeling friends can do it
  - embarrassment at not being quick
  - not understanding how to get started with a question
  - needing to work out what to do
  - feelings - frustrated and worried.

</td>
<td>

- **Comfort zone**
  - pages of ticks
  - straightforward calculations
  - easy questions
  - when partner helps so much they are doing it for them.

</td>
</tr>
<tr>
<td colspan="2">

- **Growth zone**
  - you sort of know
  - you make mistakes
  - when you are learning something new
  - when you are learning something not to easy or too hard
  - might not be completely new
  - need to keep on being resilient
  - want to learn something
  - being determined.
  - “I would go for the growth zone because I’m always learning a new thing.”

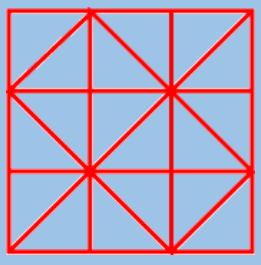
</td>
</tr>
</table>

The children were encouraged to think about which zone they were in during mini-plenaries in the lesson. Through discussion, they were able to articulate what would challenge them more or less and how they could begin to control for themselves which zone they were working in. Their awareness of their own learning was definitely increasing and children were starting to comment voluntarily about their zone in maths and in other areas of the curriculum. Following a number of lessons, children began to identify when it was good to be in their comfort zone, such as ‘when I am doing a test’, ‘when doing my times tables’, ‘when practicising stuff I have already learnt’. Certain children who following the first activity had quickly moved to their anxiety zone, had now learnt to recognise the cause of their panic and strategies which would help them to approach a task more confidently.

**More Fractions**

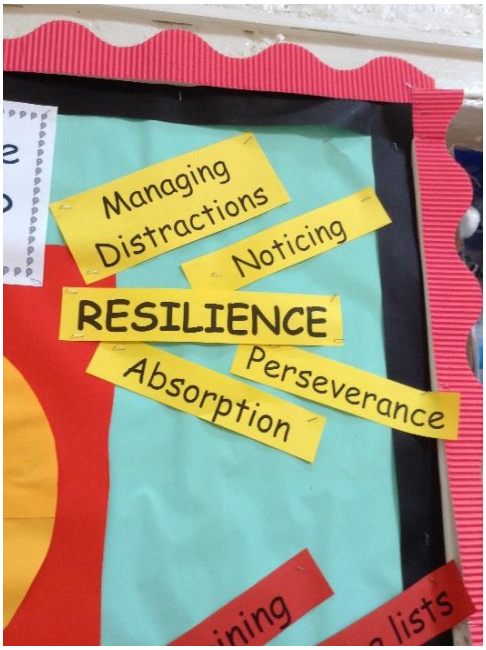
Use the lines on this figure to show how the pattern of triangles can be used to divide the square into two halves, three thirds, six sixths and nine ninths.

More lines are needed to divide it into four quarters.



| | | |
|---|---|---|
| | | |
| | **Pupil** | **Teacher** |
| | | |
| | | |
| | | |
| I can explain my reasoning to others | | |

Figure 4 More Fractions from NRich (NRich.maths.org)


## Developing resilience in learning

Alongside this work, we were looking at each area of resilience in turn, thinking about how children could manage to grow in these areas.

For example when thinking about managing distractions, children were encouraged to self-assess how distracted or focused they had been following incidents which could detract from their learning, such as when a visitor comes into the room. Using their fingers, they scored themselves – 5 meant that they had not noticed the distraction, 3 that they had managed to refocus quickly and 1 being that they had instigated the disturbance! This work also raised children's awareness of resilience.

It became apparent during the close scrutiny of the lessons and when listening to children's responses from questions such as, 'What can you do if you are in your anxiety zone?', that some children were over-reliant on their talk partners and could offer no different solutions to moving out of the anxiety zone other than that they would ask their talk partner or teacher. We recognised that although there are huge benefits to using talk partners, this was one disadvantage and needed to be addressed.

In the following lesson, children were given several scenarios to discuss.

**The Scenarios**

Rick is finding his long multiplication really hard. He can't remember the method the teacher taught on Monday. He copies his partner's answer. He gets it right and gives himself a big tick.

Sally is sitting next to Tom. She knows Tom is copying her, but she feels quite proud that he thinks she knows what she is doing. They both get a page of ticks. All good!

Tariq has forgotten how to do long division and is stuck half way down his calculation. He turns to his partner for help. His partner asks him to explain what he has done so far. He gives him a suggestion as to what he could do next.

Sally and Jo are working on an open ended problem, with multiple solutions. Sally quickly finds a solution, but Jo thinks she might be wrong. As Jo thinks Sally is better than her at maths, she says nothing.

Bill and James are talk partners. Bill knows his shape facts and names really well. James is not so sure, but he feels silly if he is doing 'easier' work than Bill. He does the same but gets it wrong.

Holly's talk partner is getting on with their spicy challenge work but Holly is stuck. She goes to ask the teacher for help.

Sam is struggling to find an equivalent fraction for 15/45. His talk partner reminds him how to find an equivalent fraction for ½, then ¼.

These situations resulted in good discussion on how to help someone and what was not very helpful. New ground rules for good talk partner work were laid down. The children decided to, for example, ask each other what they had found out so far and what they could try next, rather than telling their partner what to do next. This higher level discussion benefited all children as it forced them to articulate their thinking and learning.

## What our school has gained from this project

The learning from this project has enabled children to make better choices of their appropriate level of challenge in all maths lessons and we have seen less children continuing with an activity which is easily within their comfort zone. Instead, they have found ways to make the task more difficult for themselves and to choose to move themselves into their growth zone. We have also noticed that children have become less influenced by the choice of activity taken by their talk partner. Getting everything right is no longer seen as a positive achievement by the pupils. They are keen to tell us when they were in their growth zone and what they have learnt in lessons. At first glance, there may appear to be less work in children's books but on closer inspection, the level of learning is much deeper. Assessments have also shown that the children who were previously less resilient in their maths learning now have a better grasp of concepts.

There has been significant interest from other teachers in the school who have enjoyed hearing about the success of this project and we plan to roll out the Growth Zone Model to all classes throughout next year. We have been so pleased with the difference the training on talk partners has made, that we are going to look at how we can build on this, for example with prompt cards. We feel that the project has had a significant positive impact on the resilience of our older children and look forward to reaping the benefits in other year groups in the future.

# 6. Improving engagement through Mathemtical Resilience - Roger Williams, Stephenson Trust

## Aim

A year 11 student had such low mathematical self-esteem he was in danger of giving up on maths and disengaging entirely.

The student in question is a pupil in a mixed SEMH secondary school and is statemented (now called an Education and Health Care Plan) for behavioural issues having been excluded from primary school at a young age. His comprehension of mathematical concepts is very poor and he has been in the habit of giving up on work in a very explosive fashion. A pseudonym is used throughout to protect his identity.

> *The work had been explained to the students and they were engaged with the task which was a short worksheet. John called me over for some help with his work so I approached him and asked which question he was having trouble with. He held out the sheet and shouted, "that f*****g one" as he pointed in the general direction of the sheet. When I enquired as to which one he replied, " you should know, your the f*****g teacher!" This was a fairly typical response and often led either to him storming out of the room and slamming the door or flipping over a table. I would remain calm and have a conversation with him later once he had cooled down. Later he would be very apologetic and we would even laugh about how furious he had been. We would joke about him 'throwing his toys out of the pram'.*

My concern was that, not only would he learn very little, but he was very likely to repeat this behaviour in his GCSE exams and fail. Providing differentiated work proved to be problematic because he would notice if anything he was doing was easier than that given to the others and would object to "retard work [sic]". It became obvious that his behaviour was not simply a strategy to avoid work but that he was genuinely frustrated and angry that he could not understand what was being explained to him. Having tried many strategies to bring about a change in behaviour I felt it was time to explore a different approach.

## Action

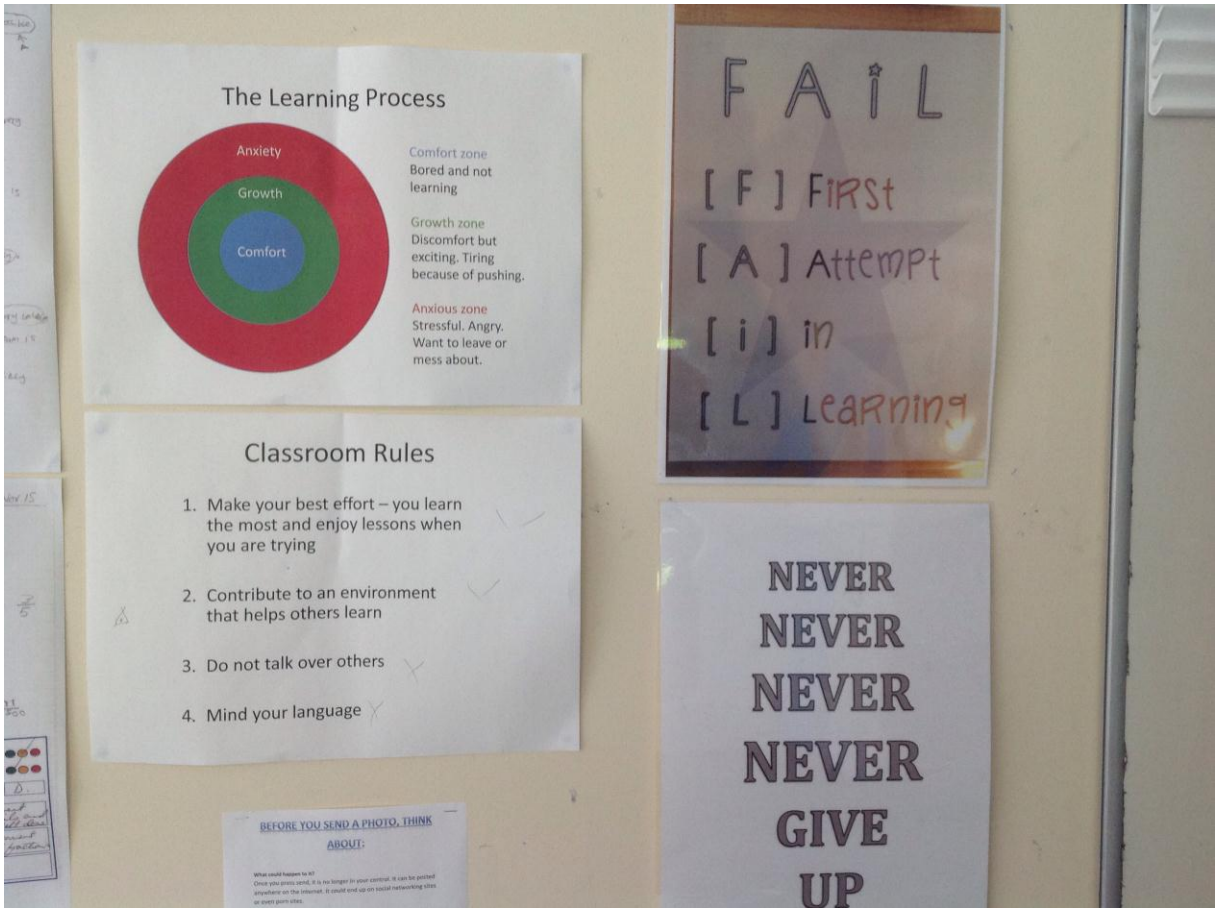
Having signed up to participate in research into mathematical resilience, I was introduced to the concept of the Growth Zone (Lee and Johnston-Wilder, 2016) and Language for Learning Maths (Lee 2006) both of which showed promise for this particular case.

My plan from December 2015 was:

- Present the concept of the Growth Zone to the whole school in assembly
- Talk through it with John
- Refer him to the poster about growth zone displayed in the classroom so he can identify with the different zones
- Discuss 'language for learning' with him with an aim to develop better communication rather than explosions
- Work on practising better communication in lessons

## Results - what did I find out and what happened?

The idea of the Growth Zone was presented to the school in assembly and a poster was placed in my classroom so students could refer to it and so that I could use to it to illustrate the learning process when teaching. It enabled me to say that if students were in the blue comfort zone then the work they were doing was too easy and they should try the harder tasks and when they start to make some mistakes and need help they were in the correct zone. This was helpful because many of them react badly to failure and I felt they needed to understand that it is part of the learning process.




Being able to help the students understand what might be happening when they felt like throwing a chair or leaving the room was also useful and provided an image that they could identify with. In fact, on a number of occasions, students would laugh and shout out, "Sir, I'm in the red zone!"

In January 2016 I talked through the poster with John and it gave him the opportunity to tell me that he had always felt like the "dumb one" since primary school. He felt that everyone else was above him. I asked him if he ever had any help at home with his education or if anyone ever read with him when he was growing up and he said, "No, I never got any of that." He agreed that he reacts very badly when he finds things difficult and was very apologetic about his explosion before Christmas. I explained to him that my goal was to help him verbalise his difficulty with the work by simply and calmly saying "I don't understand this" and pointing very clearly to exactly what he had trouble with. He would then have to try to explain in his words what it was that he didn't understand but, if I didn't grasp what he was saying straight away, then he should try to remain calm and help me to understand by having another go at explaining it. We agreed that in all this it was important for him to try to stay calm and he seemed happy about working in this way because he said he wanted to learn.

Shortly after this I taught a lesson on the area and perimeter of rectangles where students were asked to write the perimeter under the shapes and the area inside. John was very quick off the mark and wrote the perimeter correctly under the shapes and seemed very proud of himself that he had done it quickly and correctly compared to the rest of the class of four students. When he realised that he needed to work out the area as well and that he was, in fact, behind the others he remained surprisingly calm and told me that he didn't know how to work the area out and politely asked me to explain it to him. From that point on in the lesson he coped well and at the end of the lesson I pointed out to him that he had worked well and had done well not to get angry he said, "thank you Sir" and left the classroom smiling.

At this point I was pleased with the victory that he had experienced but I anticipated that there would be setbacks as we worked towards his GCSE's in the summer. My plan was to keep reminding him of the language that he should use and that he should remain calm as we had discussed in the hope that it would become a habit. It seemed sensible to me to keep the language simple for him so that he could easily remember what to say when he was beginning to get angry. He shared with me that he often had trouble understanding what I was saying to him and it became increasingly clear that his troubled time in mainstream primary school meant that he missed out on much of the mathematical language that is typically used as a matter of course in secondary education. For example:

*How many times does 2 go into 10?*

*What is 15 divided by 3?*

These are straightforward questions for most secondary students but the language didn't mean anything to him and he was be too ashamed to admit it in the classroom. He was happy to discuss this with me and seemed pleased that he understood his struggles a little better.

John's concern about how he appeared to his peers and also the progress he had made with his reactions was illustrated later in January:

> *In a maths lesson one day we were working on a topic when John asked me if I could unlock the toilet door for him (which was just outside the classroom). I left the classroom with him and he said that he didn't need to use the toilet but this just wanted to ask me how to do the work without the others hearing. This was a victory for him and I commended him for not getting angry but finding a solution that worked for him.*

As I reflected on the work I was doing with John problems with understanding mathematical language began to become evident with other students in the school. I discussed it with another mathematics teacher and she agreed that it was an issue, particularly as many of our students have great difficulties with literacy. Additional material will be added to the school numeracy policy in order to alert other teachers to this issue so that they think about it and help the students understand mathematical vocabulary and expressions.

Leading up to the GCSE examinations John started to become increasingly stressed about his exams and regressed in his calm use of language and the strategies that he had been working on. This was disappointing, but for a serial exam avoider it was not surprising and, though agitated, he did not stop attending lessons and he did not stop learning. The real victory came in May and June when he completed his entry level mathematics qualification and sat his GCSE Foundation mathematics examinations without exploding, quitting or 'no-showing'.

## What can others take from this?

Many students have difficulty with mathematics, sometimes it is that like John they have not understood the basics, sometimes it is because of the language that is used that they have not had the opportunity to understand. Admitting that they need help is not always as hard as it is for John but many students cover up their difficulties by appearing not to care or by disruption.

The ideas in the growth zone poster can help, by showing that everyone feels anxious at times when trying to learn mathematics and if you always stay in your comfort zone you will never learn anything more. It also provides simple language for the students to tell their teachers that they need help.

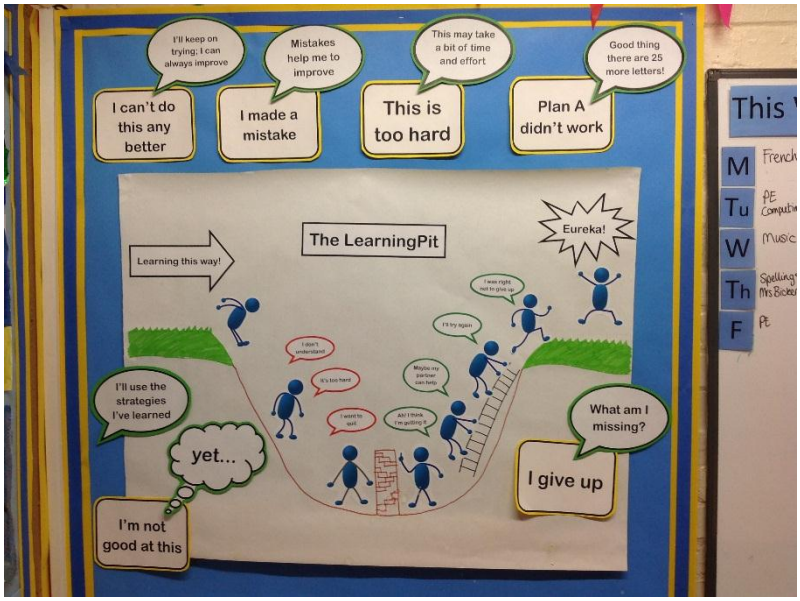
With John I found that having the language to express what he was feeling and just what he was stuck with was a big issue. When John alerted me to this I found that this was true for many students. I now take much more care with the way that I use language in mathematics, and I tell my students to alert me if I forget to explain what a word or expression means. Becoming more resilient means taking this kind of responsibility for your own learning.

## 7. Developing Maths Resilience through a 'Growth Mindset' approach - Christine Upton and Katherine Cole - Turnfurlong Junior School

### Aim

The main aim of the project was to develop our children's resilience in mathematics across the 12 classes in our school. It was becoming evident that many of our cohort were struggling in the application of certain areas of maths, which was a concern particularly with the high expectations introduced via the new national curriculum. Following lengthy discussions, we felt it was necessary to change the children's perception of themselves as learners through developing their resilience to the different challenges presented by the subject. As a school with many high-achieving children, we felt that it was paramount that the issue be addressed before their transition to secondary school.

### Action




As part of performance management targets, four year leaders which included 2 members of the senior leadership team were asked to take part in the 'Great Learners Project' where Carol Dweck's 'Growth Mindset' was the underlying principle of the discussions. Here, it was decided that we should create a 'learning pit' in each of the classrooms as a stimulus to aid the children in their day-to-day learning. Initially, it was just the year leaders who trialed the new concept.

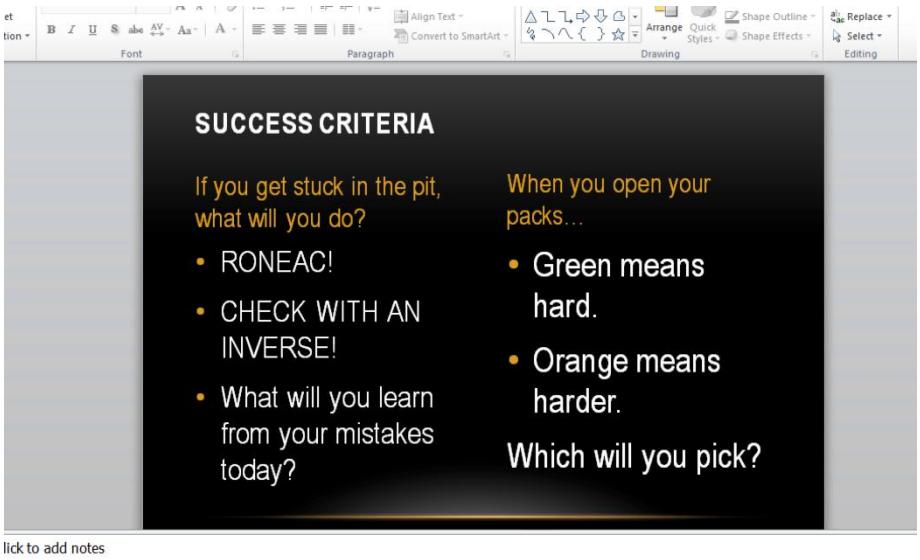
The children within each of the classes were very receptive to the new style of teaching and learning. Within each lesson, the children were allowed to differentiate their level of challenge for themselves. Most of the children knew what level of challenge they should attempt but there were a few who needed some guidance as to the most appropriate level of challenge to start with.

The children were actively encouraged to not just challenge themselves, but to challenge us as their teachers. If they felt the work was too easy and they were flying over the Pit in their 'hot air balloon' then they needed to prove to us that the work offered was not challenging enough and demand a harder task. This was quite an eye opener for the children and adults alike. At first, the children would say that it was too easy when in fact, they hadn't quite understood the task and their work was too hard! However, once the concept had been embedded into the way the children worked in the classroom, the children felt quite at ease to come to us and inform us that they had understood the task and they wanted something harder. A year ago, this would not have happened and it has certainly kept the teachers on their toes to ensure the pitch is appropriate and a challenge is there at

all times. From the children's point of view, it has also ensured that there is a healthy dialogue between them and the teachers and they feel their voice is heard and that they have some control in their learning.

After a few weeks, it became apparent that many other members of our teams were interested in the project as they were beginning to see the impact that this new approach to working had on the classes. Many teachers started to allow their children to self-differentiate and were surprised and thrilled with the results. A staff meeting was held to fully explain the concept of growth mindset. On the whole, it was received in a positive manner although there were some concerns raised regarding how the children would be able to differentiate for themselves. Weekly year group meetings followed and the challenge of how to plan for self-differentiation was discussed. It was decided to use 'tough, tougher and toughest' as levels of differentiation for most lessons and the children could choose where they wanted to start. It was made clear to the teachers and children alike that they could change their level of challenge depending on their success at the task so far.

Our school is a three-form entry school and has, over the years, had a culture of differentiating not just by classes but also by table. The new concept of Growth Mindset eradicated the need to differentiate by table to encourage challenge for all. This shift in culture was probably the biggest issue for our teachers who were concerned with how to support the children in accessing the curriculum and also how to challenge those that were already attaining at high levels. During a staff training session to roll the concept out to the whole school, this became the sticking point amongst many colleagues and is still not quite embedded in all classes within the school.



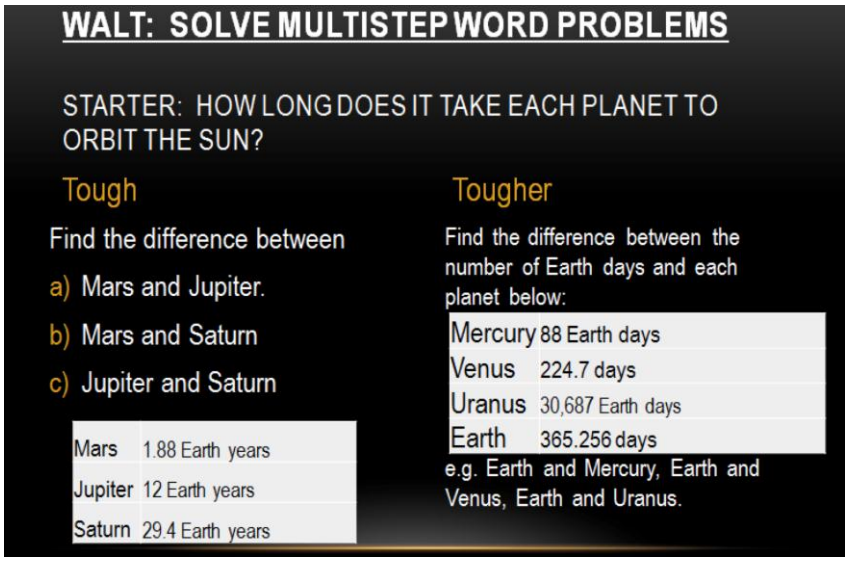

One colleague decided to search the idea of Growth mindset on Twitter and Pinterest for different ideas that would be suitable for our school. One idea, which we really liked, was to celebrate mistakes in maths. The very nature of the maths – seen as being either right or wrong - puts many children, especially girls off the subject. However, we found that allowing the children time to share and reflect on their mistakes allowed them to come to the conclusion that mistakes are a part of life and we all learn from them. Moreover, looking at mistakes supported the idea of self-challenge. The children quickly came to the conclusion that making lots of mistakes meant that the challenge wasn't appropriate and that making none at all meant that it was too easy.

After a surprisingly short time, there was a real buzz in the school and the growth mindset concept wasn't just evident in maths but across all areas of the curriculum. Weekly assemblies were held to discuss resilience using stimuli such as Star Wars, Pixar animations and the muppets! All these were used to encourage the children to start to understand that it's good to struggle with our learning and not always be in our comfort zone.

## What changed?

From discussions with children and colleagues, we found a huge shift in the perceptions the children had of themselves. Children talked about their mathematical learning in a completely positive manner, which was a contrast from the beginning of the year. This was noticeable particularly in the lower and middle attaining groups, who had viewed maths as 'too difficult'. Teachers found that this group of children were now pushing their learning further than they had ever done and that they would persevere in a task instead of giving up. This was evident in open-ended investigations as well as the normal maths exercises.

When it came to self-differentiation teachers were surprised at how many of the children chose more challenging tasks than what they would normally have assigned to them. What surprised them more was that the children succeeded in the tasks. Some children needed guidance with choosing activities, but often, the children were capable of choosing tasks that matched their understanding of the concepts so far. This was a type of differentiation that some teachers hadn't tackled before.




In addition, the teachers commented that they themselves had changed their perception of the children and were surprised at what the children had achieved. This was from just a simple switch in mindset and the introduction of the learning pit. It was noted that one child, who would always get very upset with making mistakes, now embraced the 'Great Mistake' philosophy. This meant that they celebrated the errors in their learning in the lesson and were keen to explain what they had learnt as a result of their mistakes. This has also resulted, in some cases, in teachers having to pitch their maths lessons higher. The work they had planned for SEN/low attaining children was discarded in favour of the more challenging activities. Expectations have risen, from the teachers and children.

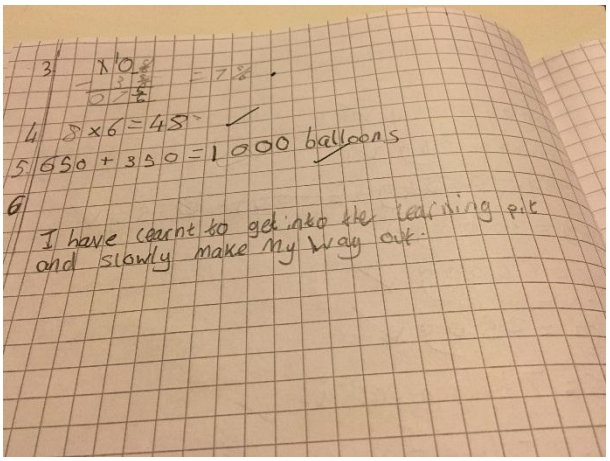
The children that struggled the most with the change were the classical high achievers. They were shocked that other children were now doing similar work to them (and succeeding) and were noticeably hesitant about challenging themselves out of their comfort zone. We have slowly been addressing this in maths, but it has taken time. With constant reflection on mistakes, we feel that this will remove the fear of failure, as it becomes habit to analyse their learning.

We feel that this is a step in the right direction for removing the 'glass ceiling' that often occurs in lessons /classes. It has freed the children and the teachers from restrictions placed on them by ability groupings. Classes are more dynamic with the mixed ability seating and the children are empowered in lessons. It also caters for individual learning in a trusting and meaningful manner.

## What have we found out?

We started this project in three classes and then it was rolled out to many other classes in school. From looking at the children's progress using our assessment system, we noticed an effect that could

be to do with this emphasis on resilience. In one year group, 2 out of 3 teachers used this style to test the effectiveness of the growth mind set philosophy. The classes taught by the two teachers using Growth Mindset showed an average of 7 points progress over one term, compared to the other class, which only showefd 2.52 points progress. The latter was also the high achieving set. During discussions with these teachers, it was felt that the growth mind set philosophy would have made a difference.




When observing lessons, Growth Mindset was evident across much of the school and it was noted that it inspired and engaged children in a way that hadn't been seen before the project. For example in one lesson, the teacher set a very challenging task for all the children. They were completely stumped, but when the teacher produced some 'clue cards' with pictures of ladders on the envelopes (linked to being in the learning pit). They linked their lack of understanding to being 'in the pit' and were immediately engaged and ready to learn. We also noticed that children have become much more reflective about their learning, even commenting on the 'pit' in their maths books. Their enjoyment of maths has increased and they will always ask for challenge when they need to.

## What should others take from what you did?

In summary, we think that the project has been a success and we hope to promote this to all classes within the school. From our experience, we think that starting small works best and that working through the many different ideas available needs careful consideration. Introduce them in stages, talking them through with the children on a regular basis. Also, it is important to use the language of challenge frequently in class and when marking the books. We found assemblies particularly useful in this approach. So far we have yet to include the parents in our new approach, but this is something we wish to address in the next academic year.

Without a doubt, this approach to teaching and learning has been successful. Many colleagues have raved about the children's progress and the children feel that they have ownership of their learning. It has raised the standards of teaching in school, leading to better quality lessons. The pitch of the maths lessons has been raised to a standard, which reflects the new curriculum. This is especially apparent in the younger years of the school.

## 8. Supporting children in improving their resilience in maths. - Rob Crilly and Sarah Hornsby and 60 Year 5 children

### Aim

The aim of our project is to improve Year 5 children's resilience in maths. Both of the teachers involved in the project are Year 5 teachers, one is Deputy Head (and part of a job share) and the other is maths lead. The school is in a small village and is largely populated from the village. Year 5 has 60 children. In each class there is 1 SEN child, the others are a range of abilities from 'working towards standard' to 'exceeding standard' with the majority being at Year 5 standard in Term 6. We teach 5 maths lessons over 4 days – a whole morning on Mondays and then one hour on Wednesday, Thursday and Friday. We do not set for maths, but we do have an extra teacher who takes groups for intervention, dependant on need.

By the end of Term 1, having taught the children for a number of weeks, we had both noticed that certain children lacked the ability to sustain resilience in maths when they felt the learning was too challenging for them. As teachers, we were certain that these children were capable of the level of learning challenges we were setting and we were somewhat disappointed at their lack of staying power. The children seemed to find it all too easy to give up, despite us attempting to give them strategies to cope with being stuck. We also found that children were fixated on getting the 'right' answer and we wanted to foster an approach where the journey was as important as the end.

### What we did

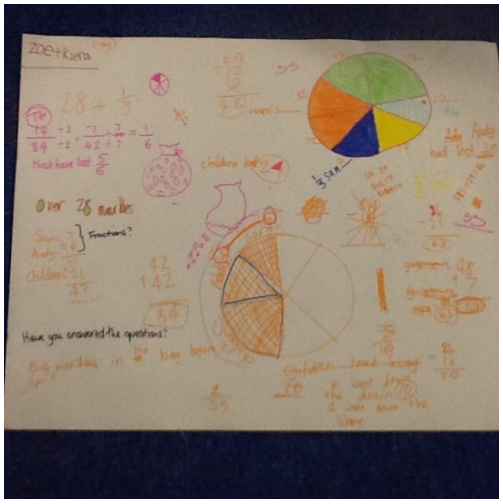
We decided to start with our own classes, the intention being that if we had favourable outcomes, we would involve the whole school at a later date. During the first meeting, the idea of a Growth Mindset was introduced and we found this very interesting and thought it was something we could use in our classrooms. Having done some research for ourselves, we introduced Growth Mindset at school, using a questionnaire with the children. Interestingly, some of the children were able to see what the questionnaire was asking and were giving the answers they thought they should give, rather than honest answers. After discussion about this, these children admitted that they wanted to be classed as Growth Mindset because we had given the impression that it was a good thing, they then changed their answers to give a truer picture. With hindsight, we would do the questionnaire before we introduced Growth Mindset in the future.

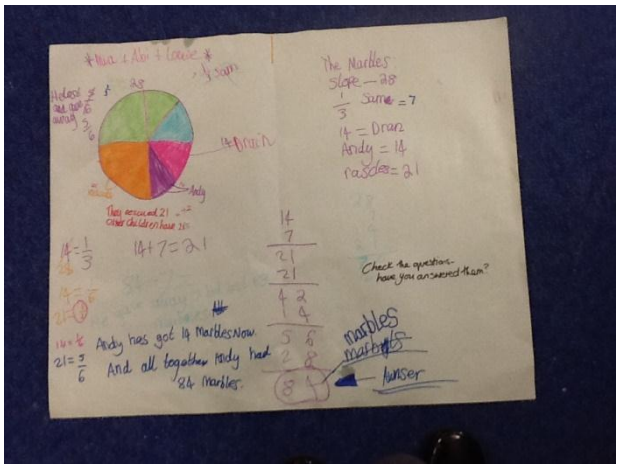
The questionnaire showed that many of the children believed that intelligence is fixed; that you are either good at something or you are not. After discussion, we found that this belief comes, in part, from how their learning is organised and supported. From an early age, children are grouped according to their ability or attainment. In some cases, they are set and only ever learn with the same children. This gives them the impression that they are bound by their group, that they can't get out of it, no matter how hard they work.

### Growing a growth mindset

The easiest way to begin to address this issue was to stop sitting children in attainment groups. The children are now organised into mixed attainment groups and, once the lesson is started, the children are allowed (within reason) to choose their own working style; some children like to work in a small group, others with a partner and some prefer to work alone. There is also the offer of a teacher focus group which is largely opt-in. Initially, lots of children chose the security of the opt-in teacher focus group. Now, they have to be able to explain exactly why they feel the need to be there – not just, " I don't get it". They often find that explaining what they don't understand helps them

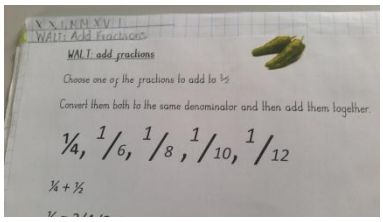
make sense of it and it was made clear that not knowing their 7 times table, doesn't mean they need teacher support.

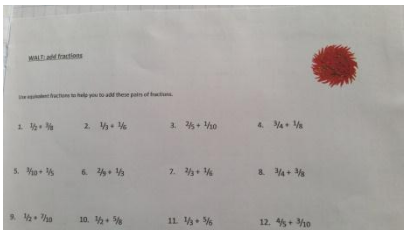



***The children have begun to choose who they work with and 'dip' in and out of the teacher focus group when they feel they need support.***

The second thing we put into place was to give the children ownership of the level of challenge they chose. We decided to use chilli peppers to indicate the level of challenge – mild, spicy or extreme. This is something that needed careful monitoring at first because some children chose the easy option to stay in their comfort zone and some over challenged themselves because they thought it made them better at maths. Now the children are good at reading the challenges and carefully considering the level that is right for them. They are beginning to realise that just because they were working on spicy yesterday, doesn't mean they should be the same or higher today. Although the challenges are slightly differentiated, they still fall within the Year 5 curriculum.




***The tasks are labelled with stickers to indicate the level of challenge – here are mild and spicy.***

## Planning for challenge

We have also changed the way we plan maths lessons. As a school we are following a Mastery Curriculum for maths and have found that we are only teaching Year 5 objectives – not dipping into the previous or next years' objectives as we used to. We are now planning and teaching the same content to the whole class and differentiation is more about the support the children choose to receive and less about the level and range of activities offered. We have also found that we are less likely to put a ceiling on their learning, based on their attainment.

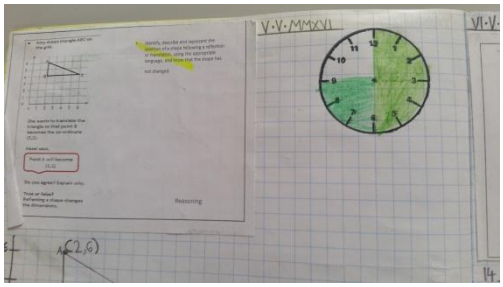
On our planning, we also highlight key questions and think of ways to phrase them openly to encourage discussion. We use phrases such as "What might happen if...?" and "How can *we* find

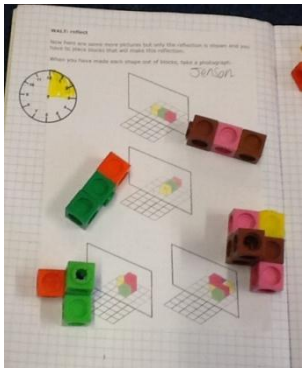
out..?" We feel it is important to use "we" rather than "you" to engender a more collaborative classroom where we, as teachers, are part of that collaboration; to give the children the belief that we are finding out with them, that we are in this together. The rationale being that they feel safe trying new challenges if we are trying them too, and that how we got to the answer would be more important than the answer itself.

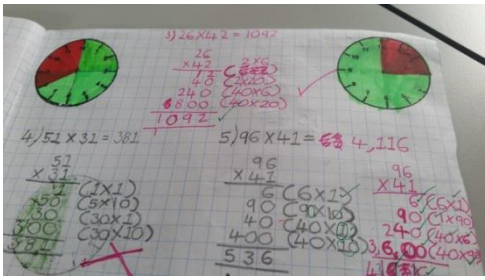
We very quickly noticed a change in the atmosphere of our maths lessons. Because the children are now sitting in mixed attainment groups, there seems to be more animated discussion all around the room, rather that it being focussed on one or two tables. When the discussion involves the whole class, the contributions come from all around the room, rather than one or two tables and we have found that children who wouldn't historically choose to be involved are now putting their hands up and joining in. One hypothesis for this is that they feel more confident now because other children on their table are answering questions, which didn't happen before.

## Giving the children a voice

As we continued with the project, we found we wanted to find out what the children felt about their learning. We were having discussions with children on a regular basis, but we wanted to get an idea of how they felt while they were working and whether there feelings changed as they worked through a problem or challenge. We decided to try a clock face. We now have clock face stamps that the children colour in over 10 or 15 minute intervals during the maths lesson. They use the Growth Mindset colours – yellow is comfort zone (I am finding this easy) green is growth zone (I am learning, my brain is growing) red is danger zone (this is too much of a challenge).







***The children fill the clock faces in as the lesson progresses.***

The children are encouraged to think about their learning and not just colour the clock face in green because they think that is what we want to see. Having filled it in, they then consider their challenge and ask themselves, "Do I need to change?"

This has been a really useful strategy. As teachers, we can see at a glance what the children feel about their learning and we can question them based on what we see. For example, if a child has coloured the clock red, but appears to have completed the task, we can talk to them about why they used red and how we can help them to feel better about their learning. Likewise, if they have coloured it yellow, but appear to have struggled, we can address their misconceptions or encourage them to join the teacher focus group in the next lesson.

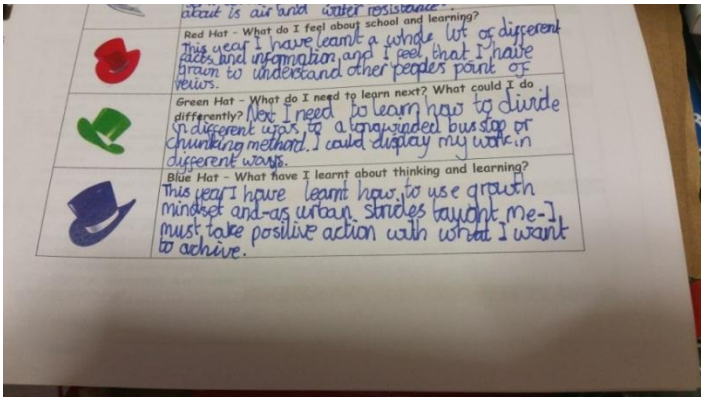
## Involving the whole school

In term 4, we delivered some staff training in Growth Mindset and discussed what we had been doing and what we had found. We gave the staff the same questionnaire as we gave the children and found a mix of mindsets amongst them. All of the teachers were engaged by our ideas and

findings and we intend to roll it out whole school in the new academic year. One of my main concerns, as maths lead, is that there are still members of staff who set for maths. This is something that I would like to discourage as I believe that it encourages a ceiling on the learning and is detrimental to a Growth Mindset. As stated earlier, setting gives children the belief that they are only capable of working within that group.

## What we found out

In Term 5, I carried out a questionnaire with the Year 5 children to see how they felt about their maths learning. 6 children form each class were chosen, across a range of maths attainment levels. All of the children said that they feel positive about maths learning in Year 5. They said they prefer not sitting in 'groups' and enjoy learning with other people and being able to discuss their maths with someone else. Most of the respondents said that they use Growth Mindset to help them with their maths; they believe that if they try hard enough they can achieve and that they can find help in lots of different ways. Some of the children also mentioned the changes in their lessons and attitude to learning on their school reports.




As we approach the end of the year - and the end of the project - we have found that the children's relationship with their maths learning has changed. On the whole, the children are more positive, the atmosphere in the classrooms is more positive, more vibrant. During maths lessons, the conversations being had in the classes are supportive. The children are making conjectures and proving their theories. They refer to previous learning and use a myriad of strategies to support each other from resources, to previous learning, to other peers, to adults. They think carefully about the challenges they attempt and know how to recognise when they need to lower or raise the challenge. But they also understand that lowering a challenge doesn't necessarily mean changing it – it could mean seeking support with it – either from another child or from an adult.

***Working together and using resources.***

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