



**Evidence for
Excellence in
Education**

A close-up photograph of a wooden tray containing several colorful wooden number blocks. The blocks are arranged in a grid-like fashion. The top row shows a blue block (partially visible), a red block with the number '2', and a yellow block with the number '3'. The middle row shows a green block with the number '4', a white block with the number '5', and a purple block with the number '6'. The bottom row shows an orange block (partially visible), a blue block with the number '8', and a red block with the number '9'. The blocks have a natural wood grain texture and are painted in vibrant colors.

PISA in Practice: *Cognitive Activation* in Maths

How to use it in the classroom

Foreword

The OECD Programme for International Student Assessment – or PISA - is used by governments around the world to compare results of differing education policies and provides a wealth of information which informs educational policy.

Yet this evidence is not the sole preserve of policy makers. In-depth analysis of the PISA data can help inform practitioners and school leaders about factors relating to pupil achievement. Such analysis can, for example, provide robust, useful evidence about whether specific teaching practices are related to achievement, and whether that relationship is the same for all pupils, regardless of ability.

It is not enough, though, to simply identify where such relationships exist – it is important to reflect on how practitioners could introduce these into their lessons and embed them in ongoing classroom practice.

In this series, commissioned by the Department for Education (DfE), we showcase some findings from PISA which teachers can use in the classroom.

This report shines a spotlight on the teaching practice of Cognitive Activation, explores how this practice is related to achievement, and identifies short, medium and long-term strategies for using Cognitive Activation in the teaching of mathematics.

PISA 2012 in England was conducted by NFER on behalf of the Department for Education (DfE). The national report for England can be accessed at: <https://www.gov.uk/government/publications/programme-for-international-student-assessment-pisa-2012-national-report-for-england>; and the international reports at: <http://www.OECD.org/PISA>

Bethan Burge, Research Director

Published in June 2015

By the National Foundation for Educational Research,
The Mere, Upton Park, Slough, Berkshire SL1 2DQ
www.nfer.ac.uk

© 2015 National Foundation for Educational Research
Registered Charity No. 313392

ISBN 978-1-910008-36-2

How to cite this publication:

Burge, B., Lenkeit, J. and Sizmur, J. (2015).

PISA in Practice: Cognitive Activation in Maths. Slough: NFER.

Contents

Overview	2
Introduction: <i>Cognitive Activation</i>	4
How often do maths teachers use <i>Cognitive Activation</i> strategies in their lessons?	5
<i>Cognitive Activation</i> and pupil ability	7
<i>Cognitive Activation</i> and achievement	11
<i>Cognitive Activation</i> and family background	11
<i>Cognitive Activation</i> and pupil attitudes to learning maths	12
Summary	15
What can I do to increase the amount of <i>Cognitive Activation</i> in my lessons?	16
References	18

Overview

What is *Cognitive Activation*?

Cognitive Activation is, in essence, about teaching pupils strategies, such as summarising, questioning and predicting, which they can call upon when solving maths problems. Such strategies encourage pupils to think more deeply in order to find solutions and to focus on the method they use to reach the answer rather than simply focusing on the answer itself. Some of these strategies will require pupils to link new information to information they have already learned. Making connections between mathematical facts, procedures and ideas, will result in enhanced learning and a deeper understanding of the concepts.



Why is it an important teaching practice?

- *Cognitive Activation* is significantly associated with higher mathematics achievement.
- In England, pupils report that their maths teacher asks them to use *Cognitive Activation* strategies to solve problems more often than is the case internationally.
- There are significant differences in the frequency with which pupils of different abilities use *Cognitive Activation* strategies in their maths lessons.
- Pupils with low and medium socio-economic status (SES) profit most from higher levels of *Cognitive Activation* in their maths lessons.
- *Cognitive Activation* is positively related to a number of pupil characteristics that are linked to achievement (motivation, self-efficacy and self-concept).
- For pupils with low SES a higher level of *Cognitive Activation* in their maths lessons is accompanied by higher self-efficacy.
- For the majority of pupils, a higher level of *Cognitive Activation* in their maths lessons is accompanied by lower maths anxiety.

How can I make it part of my practice?

NEXT LESSON			
Relate your lesson to a real life scenario, for example: – What statistics do you come across in everyday life? Why is it important to understand how to interpret statistics used in the media?	Model key Cognitive Activation strategies and encourage pupils to use these techniques, for example: – Punctuate the discussion with questions like: ‘What if...?’; ‘Does everyone think that...?’; ‘Might there be an alternative way...?’	Listen – be prepared to adapt your lesson plan. Use the evidence of what you hear and see to ensure you are meeting learners where they are, differentiating their range of learning needs.	
NEXT TERM			
Encourage your pupils to identify how particular maths concepts can be applied in a range of situations and use their suggestions as a basis for planning subsequent lessons.	Encourage a culture of exploratory talk in your classroom. Ask pupils to consider a range of possible solutions to problems and identify, for themselves, what they need to learn.	Speak to your pupils about the Cognitive Activation strategies you are using in your lessons, are there any that they find particularly challenging and if so why?	Discuss with colleagues your observations of how the Cognitive Activation strategies you are using are working and any particular difficulties you have had.
NEXT YEAR			
Consider collaborative planning to develop and share a range of Cognitive Activation strategies to help ensure they are being used across different ability groups.	Hold regular update meetings so that colleagues can continue to share, inspire and maintain awareness of the importance of Cognitive Activation for enhancing learning.	Consider the development of interdisciplinary units where learning is linked to real life situations across subject areas.	



Introduction: Cognitive Activation

The three most basic dimensions of quality teaching have been described as:

- clear, well-structured classroom management
- supportive, student-oriented classroom climate
- *cognitive activation* with challenging content (Klieme *et al.*, 2009).

This report focuses on the third of these basic dimensions, *Cognitive Activation*, and explores the link between *Cognitive Activation* and maths achievement.

There has been much research on the relationship between the level of challenge pupils receive in their lessons and their achievement. In his extensive study of factors relating to student achievement, Hattie (2009) describes quality teachers as those who challenge their pupils. Specifically, instructional processes that teach pupils cognitive strategies and require

them to summarise, question, clarify and predict appear to be particularly important for learning. Further support for

this finding comes from OECD's international survey of teaching and learning (TALIS) which notes that

in order to foster cognitive activity teachers need to use deep and challenging content (Mayer, 2004; Brown, 1994). It appears that argumentation and non-routine problem solving in particular develop pupils' ability to make connections between mathematical facts, procedures, ideas and representations (Hiebert and Grouws, 2007; OECD, 2012).

In PISA, *Cognitive Activation* is identified as one of several practices that support the development of mathematical literacy (OECD, 2013). In PISA 2012, OECD sought to find out how often pupils were exposed to activities in their maths lessons that would be cognitively activating. This report uses data from PISA 2012 to explore the relationship between *Cognitive Activation* and achievement in England.

What is PISA?

The Programme for International Student Assessment (PISA) is the world's biggest international education survey, involving schools and pupils in over 60 countries.

It assesses the knowledge and skills of 15-year-olds in maths, science and reading and was developed jointly by member countries of the Organisation for Economic Co-operation and Development (OECD). Maths was the main subject in PISA 2012. In addition pupils and schools completed questionnaires to provide information about pupil background and attitudes, and aspects of school management and school climate respectively.

How often do maths teachers use *Cognitive Activation* strategies in their lessons?

As *Cognitive Activation* has been shown to support the development of mathematical literacy it is important to examine how often pupils in England use *Cognitive Activation* strategies to solve problems in their maths lessons and whether this varies across pupils of different abilities.

Pupils were asked, in the PISA *Student Questionnaire*, how often their maths teacher asks them to use a number of specific *Cognitive Activation* strategies to tackle maths problems in their lessons. This included asking pupils to reflect on problems, solve complex problems and apply knowledge to new contexts. They had to report whether the teacher used these strategies: ‘*never or rarely*’, ‘*sometimes*’, ‘*often*’ or ‘*always or almost always*’.

Cognitive Activation in PISA

The teacher...

- ...encourages us to reflect on problems.
- ...gives problems that require us to think for an extended time.
- ...asks us to use our own procedures for solving complex problems.
- ...presents problems with no immediately obvious method of solution.
- ...presents problems in different contexts.
- ...helps us to learn from mistakes we have made.
- ...asks us to explain how we have solved a problem.
- ...asks us to apply what we have learned to new contexts.
- ...gives problems with multiple solutions.

In England, pupils report that their maths teacher asks them to use *Cognitive Activation* strategies to solve problems more often than is seen on average internationally¹. For all of the strategies listed above, greater proportions of pupils in England reported that they occurred *often*, *almost always*, or *always* in their maths lessons (Wheater *et al.*, 2013). The strategy teachers used most often was asking pupils to explain how they had solved a problem, over 80 per cent of pupils reported that their teacher did this frequently. A high proportion of the pupils reported that their teacher gave them problems which required them to apply their learning to new contexts or presented problems in different contexts.

This suggests that teachers recognise the importance of having a more conceptual understanding rather than relying solely on surface knowledge or rote learning. However, less than half of pupils reported that teachers frequently asked them to decide on their own procedure for solving problems. This may reflect an issue identified by Hattie (2009) as ‘*knowledge telling*’, this refers to the observation that teachers spend a lot of lesson time telling pupils pieces of information. Therefore, although the data suggests that teachers frequently encourage their pupils to apply their understanding in new and different contexts, it is possible that for many pupils the understanding they are applying is something they have been told by the teacher rather than their own solution to a problem.

¹This refers to the OECD average. This is the mean of the data values for all OECD countries for which data are available or can be estimated. The OECD average can be used to see how a country compares on a given indicator with a typical OECD country (OECD, 2005).

Table 1: Frequency of Cognitive Activation strategies in maths lessons

Thinking about the mathematics teacher who taught your last mathematics lesson, how often does he or she do each of the following?

	<i>often, almost always or always</i>			
	All pupils	Low ability	Medium ability	High ability
The teacher asks questions that make us reflect on the problem.	69%	68%	66%	73%
The teacher gives us problems that require us to think for an extended time.	72%	62%	72%	78%
The teacher asks us to decide on our own procedures for solving complex problems.	46%	45%	44%	50%
The teacher presents problems which have no immediately obvious method for finding the answer.	59%	43%	58%	66%
The teacher presents problems in different contexts so that students know whether they have understood the concepts.	67%	60%	68%	72%
The teacher helps us to learn from mistakes we have made.	78%	77%	78%	79%
The teacher asks us to explain how we have solved a problem.	83%	76%	83%	86%
The teacher presents problems that require students to apply what they have learned to new contexts.	73%	62%	74%	81%
The teacher gives us problems that can be solved in several different ways.	66%	65%	67%	65%



Cognitive Activation and pupil ability

PISA defines ability in terms of proficiency levels. The proficiency levels describe the types of skills pupils are likely to demonstrate and the tasks that they are able to complete (OECD, 2014). Test questions that focus on simple tasks, involving familiar contexts where all relevant information is present, are categorised at lower levels. Questions that are more demanding, that require pupils to develop and work with models for complex situations, identifying constraints and specifying assumptions, are categorised at higher levels. Pupils described as being at a particular level not only demonstrate the knowledge and skills associated with that level but also the proficiencies required at lower levels.

Based on these proficiency levels, we categorised pupils as **low ability**, **medium ability** and **high ability**. In England, 17 per cent of pupils are categorised as low ability, 42 per cent as medium ability and 41 per cent as high ability.

As shown in Table 1, there are some differences across the ability groups in terms of the frequency with which they report their teachers using a number of *Cognitive Activation* strategies. On average, high ability pupils report being given cognitively activating tasks in their maths lessons significantly more often than the medium and low ability pupils. The low ability pupils report undertaking cognitively activating tasks least often.

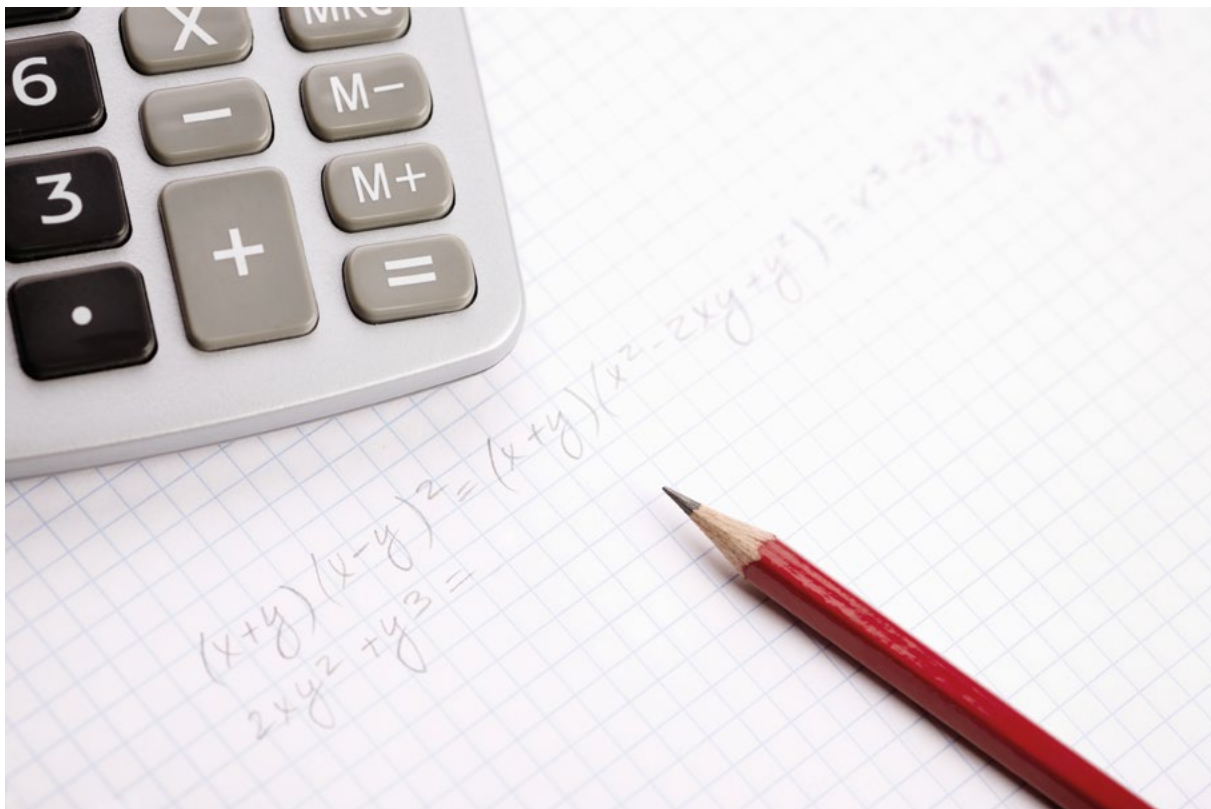
- Low ability pupils report that their teacher gives them problems that require them to think for an extended time; asks them to apply what they learned; presents problems in different contexts and asks the pupils for explanations significantly less often than the medium or high ability pupils.
- High ability pupils report that their teacher encourages them to reflect on problems and presents them with problems that have no obvious solution significantly more often than the low and medium ability pupils. These latter groups report being given these types of problems with similar frequency.

Ability level	What pupils can typically do
High ability	<ul style="list-style-type: none"> conceptualise, generalise and utilise information based on their investigations and modelling of complex problem situations link different information sources and representations and flexibly translate among them advanced mathematical thinking and reasoning possess a mastery of symbolic and formal mathematical operations and relationships, and develop new approaches and strategies for attacking novel situations reflect on their actions, and formulate and precisely communicate their actions and reflections
	<ul style="list-style-type: none"> develop and work with models for complex situations, identifying constraints and specifying assumptions select, compare, and evaluate appropriate problem-solving strategies for dealing with complex problems work strategically using broad, well-developed thinking and reasoning skills begin to reflect on their work and formulate and communicate their interpretations and reasoning
	<ul style="list-style-type: none"> work effectively with explicit models for complex concrete situations select and integrate different representations, including symbolic, linking them directly to aspects of real-world situations utilise their limited range of skills and reason with some insight construct and communicate explanations and arguments
Medium ability	<ul style="list-style-type: none"> execute clearly described procedures, including those that require sequential decisions articulate interpretations that are sufficiently sound to be a base for building a simple model interpret and use representations based on different information sources and reason directly from them handle percentages, fractions and decimal numbers and work with proportional relationships interpret and recognise situations in contexts that require no more than direct inference extract relevant information from a single source employ basic algorithms, formulae, procedures, or conventions to solve problem
Low ability	<ul style="list-style-type: none"> answer questions involving familiar contexts where all relevant information is present identify information and to carry out routine procedures according to direct instructions in explicit situations perform actions that are almost always obvious and follow immediately from the given stimuli

Source: Adapted from OECD (2014), p.61

The biggest differences are seen between the high and low ability pupils. This finding suggests that teachers may not feel that lower ability pupils have a sufficient level of basic mathematical knowledge to approach more cognitively demanding tasks. The most notable difference is seen for the following strategy: *The teacher presents problems which have no immediately obvious method for finding the answer*. Twenty per cent more high ability pupils reported that their teacher used this strategy frequently in maths lessons. It is possible that teachers may not believe lower ability pupils are able to cope with the cognitive demand of solving a problem in this way or these pupils may not have access to a variety of solution methods and therefore this could become a de-motivating activity. A sizable difference is also seen for the strategies that involve pupils applying their knowledge and understanding in new or different contexts. This may be a result of the fact that teachers of lower ability pupils have to spend more time ensuring that pupils have understood the 'basics' and may not have time to spend working in different contexts before they need to move on to the next topic.

There was no difference between the ability groups in terms of how often they report that their teacher helps them learn from their mistakes. This suggests that teachers may feel that pupils of all abilities can be helped to learn from their mistakes. As Hattie (2009) points out it is not just low ability pupils that make errors, pupils of all abilities do not always succeed the first time and therefore for all pupils there will be opportunities to learn from mistakes. Understanding the mistakes we make is a critical step in understanding what we need to do to improve and become successful.





Cognitive Activation and achievement

Cognitive Activation is significantly related to higher maths achievement across all pupils. This means that pupils who are more frequently given tasks which require them to summarise, question, clarify and predict, in their maths lessons have higher mean maths scores in PISA. However, as we have seen in the previous section, higher ability pupils report that their teachers use *Cognitive Activation* strategies more frequently than less able pupils. Therefore it is difficult to say whether the use of these strategies results in higher achievement or whether higher achievement is the result of higher ability pupils using these strategies more frequently in their lessons.

Cognitive Activation and family background

This section explores the link between *Cognitive Activation* and maths achievement in PISA 2012 for pupils from different family backgrounds. PISA asks pupils a range of questions about their family background. This information is used to create a measure of economic, social and cultural status (ESCS index). For this report we sorted pupils three groups (**low**, **medium** and **high** ESCS) based on their responses to the questions.

As noted above, all pupils benefit from *Cognitive Activation* strategies in their maths lessons, however, it appears that **low** and **medium** ESCS pupils profit most from higher levels of *Cognitive Activation*. This is particularly important as we know from previous analysis of the England PISA 2012 data that pupils with lower ESCS scores have, on average, lower maths achievement (Wheater *et al.*, 2013).

As noted in the previous section it is lower ability pupils who report that their teachers use *Cognitive Activation* strategies less frequently in their maths lessons. Given that the evidence suggests it is exactly these pupils who will benefit most from undertaking these strategies, teachers working with lower ability pupils should encourage them to summarise, question, clarify and predict in order to solve even basic mathematical problems.

PISA index of economic, social and cultural status (ESCS)

ESCS is a measure that combines a variety of family background characteristics (OECD, 2014). It is based on pupils' responses to questions about their parents' background and education, and possessions in their homes. The measure captures different elements of social background such as economic deprivation and the value a family attributes to education and educational resources.



***Cognitive Activation* and pupil attitudes to learning maths**

PISA explores a wide range of pupil characteristics including family environment, learning and thinking strategies, attitudes to school and learning, behaviour, motivation and beliefs. Here we are focusing specifically on pupil attitudes to learning maths (measured in PISA by motivation to learn maths and pupils' beliefs in their own maths skills). There is a wealth of research evidence to show that aspects of motivation, self-efficacy and self-concept are more strongly correlated with achievement than other personality variables (Hattie, 2009).

Pupil attitudes are likely to be shaped by what happens in the classroom and therefore it is important to explore whether there is a relationship between *Cognitive Activation* and motivation, self-efficacy and self-concept. In addition, given that we have found that *Cognitive Activation* is linked to maths achievement, it is important to establish whether it has a negative relationship with these pupil attitudes, as this may influence a teacher's decision to use *Cognitive Activation* strategies in their maths lessons. Table 2 and Table 3 show the direction and strength of the relationship between *Cognitive Activation* and motivation and beliefs for all pupils and each ESCS group.

Motivation to learn maths

‘Motivation and engagement can be regarded as the driving forces behind learning.’ (OECD, 2013)

In PISA, motivation to learn maths is measured in terms of *intrinsic motivation* (based on a pupil’s interest and enjoyment) and *instrumental motivation* (where learning maths is seen as a useful activity). The OECD found that pupils who reported lower levels of interest in and enjoyment of maths tended to have lower maths scores than pupils who are more intrinsically motivated. The same was true of instrumental motivation, with pupils who reported that learning maths would help them in the future generally having higher maths achievement.

Pupils in England did not report a particularly high level of intrinsic motivation to learn mathematics. However, they showed a greater level of instrumental motivation. For example, nine out of 10 pupils in England said that learning maths is worthwhile because it will improve career chances, compared with eight out of 10 on average internationally. This suggests that although pupils in England do not find maths particularly interesting or enjoyable they recognise that it is useful for their future (Wheater *et al.*, 2013).

Table 2 Cognitive Activation and pupil attitudes to learning maths

	All pupils	Low ESCS pupils	Medium ESCS pupils	High ESCS pupils
Intrinsic motivation to learn maths	+	+	+	+
Instrumental motivation to learn maths	+	+	+	+

Shaded cells: statistically significant associations

Light blue cells indicate small associations; darker blue cells indicate medium associations

Table 2 shows that *Cognitive Activation* is positively related to both *intrinsic* and *instrumental motivation*. In general these relationships are the same for pupils regardless of their socio-economic status. This suggests that there is a link between how often pupils are asked to use *Cognitive Activation* strategies to solve maths problems and their level of motivation to learn maths. However, it is not possible to say for certain how this relationship works. We do not know whether it is because pupils are motivated to learn maths that their teachers use *Cognitive Activation* strategies more often or whether the opposite is true. That is, do classrooms where teachers use *Cognitive Activation* strategies more frequently foster beliefs that maths is more enjoyable and interesting and enable pupils to see importance of learning maths for their careers?

Self-belief in maths skills

‘Mathematics self-beliefs have an impact on learning and performance: cognitive, motivational, affective and decision-making.’ (OECD, 2013)

Several aspects of self-belief were explored in PISA 2012, *mathematics self-efficacy* (the extent to which pupils believe in their own ability to handle tasks and overcome difficulties), *mathematics self-concept* (pupils’ beliefs in their own mathematics abilities) and *mathematics anxiety* (thoughts and feeling about the self in relation to mathematics) (OECD, 2013). The OECD found that on a country level maths self-efficacy, maths self-concept and maths anxiety are strongly related to maths achievement.

In England, pupils showed generally positive self-beliefs and low anxiety about maths. Pupils in England reported greater belief in their abilities in maths than was the case internationally. For example, nearly three-quarters of pupils in England reported that they *get good marks in mathematics* compared with less than two-thirds internationally. This greater belief in ability is reflected in the level of anxiety reported, where pupils in England reported less anxiety about maths lessons and tasks than pupils internationally (Wheater *et al.*, 2013).

Table 3 Cognitive Activation and self-belief

	All pupils	Low ESCS pupils	Medium ESCS pupils	High ESCS pupils
Maths self-efficacy	+	+	+	+
Maths self-concept	+	+	+	+
Maths anxiety	-	-	-	-

Shaded cells: statistically significant associations

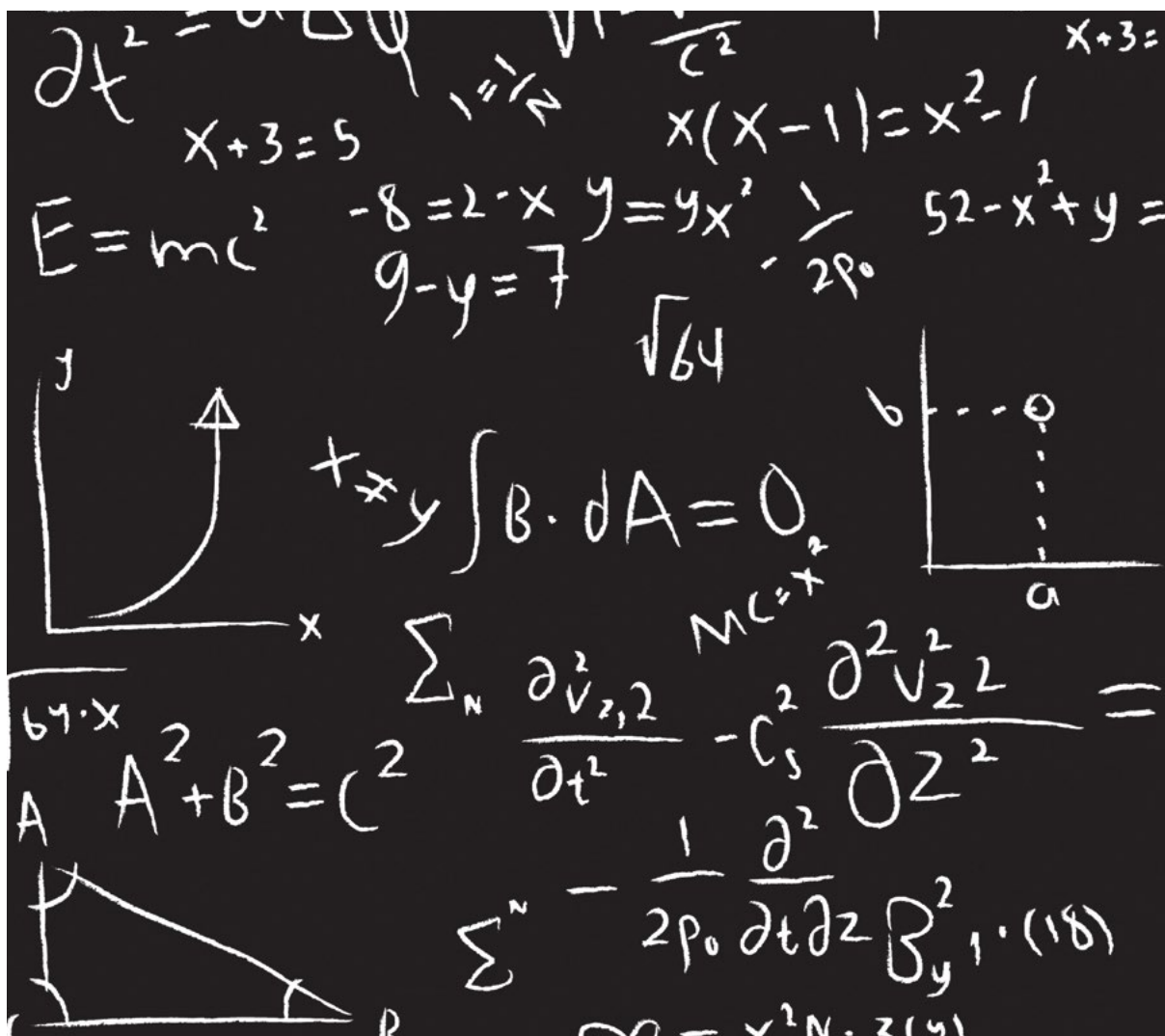
Light blue cells indicate small associations; darker blue cells indicate medium associations

Although *Cognitive Activation* is related to all three aspects of maths self-belief, the relationship is strongest for self-efficacy (as shown in Table 3). In general the relationships are weaker than those seen for intrinsic and instrumental motivation. However, the findings still suggest that there is a link between how often pupils are asked to use *Cognitive Activation* strategies to solve maths problems and their level of self-belief in their maths skills. Again, it is not possible to say for certain how this relationship works. We do not know whether it is because pupils are less anxious about maths that their teachers use *Cognitive Activation* strategies more often or whether the opposite is true. That is, in classrooms where teachers use *Cognitive Activation* strategies more frequently, pupils are less anxious about maths.

The strength of the relationship between *Cognitive Activation* and self-efficacy and *Cognitive Activation* and maths anxiety is different for pupils in the low ESCS group.

The relationship between *Cognitive Activation* and self-efficacy is stronger for pupils in the lowest ESCS group. For this group of pupils, a higher level of *Cognitive Activation* in their maths lessons is accompanied by higher self-efficacy. Therefore it appears that the use of *Cognitive Activation* strategies in maths lessons may be particularly beneficial for this group. We know from the PISA data that pupils in the lower ESCS groups are, on average, the lower ability pupils and as identified in this report lower ability pupils are likely to use *Cognitive Activation* strategies less frequently. However, given the potential benefit to these particular pupils it is even more important that teachers try to use these strategies more frequently in their maths lessons.

There is no relationship between the use of *Cognitive Activation* strategies and maths anxiety for pupils in the low ESCS group compared with medium and high ESCS groups. This means that a higher level of *Cognitive Activation* in their maths lessons is not accompanied by lower maths anxiety. As anxiety has been found to be a barrier to learning (Hattie, 2009), it is important that teachers consider using other teaching methods to help reduce maths anxiety for this particular group of pupils.



Summary

Cognitive Activation appears to be an important teaching strategy that is positively associated with maths achievement across all groups of pupils (regardless of ability or socio-economic status).

This provides further evidence that teaching practices which challenge pupils to think and reflect upon given mathematical problems and give them the opportunity to choose their own procedures when faced with problems that have no obvious solution will foster pupils' critical thinking about mathematics and have the potential to improve attainment. To provide pupils with these opportunities, teachers will need to develop mathematical problems that can be solved in different ways and may require different solutions in different contexts. This kind of freedom in the learning process also requires a classroom climate where the discussion of different solutions is encouraged and in which pupils are asked to explain and defend their approaches and supports pupils to learn from their mistakes.

Cognitive Activation is only one of several practices that support the development of mathematical literacy (OECD, 2013). It is reasonable to assume that it will be most effective within a set of teaching practices that teachers use in order to meet the specific needs of their class (Vieluf *et al.*, 2012). This school effectiveness research suggests that *Cognitive Activation* is most effective at enhancing pupil learning in combination with clear, well-structured classroom management and a supportive, pupil-oriented classroom climate.



What can I do to increase the amount of *Cognitive Activation* in my lessons?

Here are some short-term, medium-term and long-term strategies.

What could I do in my next lesson?

- Depending on your particular lesson focus or objective, try to relate the maths context to a real life scenario, for example:
 - How would a mathematician tile my bathroom?
 - Is there enough food for everyone in the world? How could you work it out?
 - What statistics do you come across in everyday life? Why is it important to understand how to interpret statistics used in the media?
- Start to model key *Cognitive Activation* strategies and encourage pupils to use these strategies as they solve problems individually and in small groups, for example:
 - Punctuate the class discussion with questions like: ‘What if...?’, ‘Does everyone think that...?’, ‘Might there be an alternative way...?’
 - Prompt pupils to provide more information to explain how they have arrived at a particular solution to a problem: ‘Why did you choose that method...?’, ‘Did you try any alternatives...?’
 - Demonstrate thinking vocabulary: ‘I think...’, ‘because...’, ‘What do we do next?’, ‘How do I check...?’
- Encourage and support collaborative work and talk for learning – provide opportunities for groups to share ideas.
- Listen – be prepared to adapt your lesson plan. Use the evidence of what you hear and see to ensure you are meeting learners where they are, differentiating their range of learning needs.

What could I do next term?

- Seek out and explore 'real life' applications of the mathematical concepts you are teaching.
- Speak to your pupils to identify the *Cognitive Activation* strategies that they find the most difficult to use and explore why they find these particularly challenging. Focus on these strategies during the term. Consider whether there are strategies that are more difficult for particular groups of pupils.
- Encourage a culture of exploratory talk in your classroom where the goal is not to produce a right or wrong answer – but where pupils consider a range of possible solutions to problems and identify, for themselves, what they need to learn.
- Encourage your pupils to identify how learning on a particular topic can be applied in a range of situations and use their suggestions as a basis for planning subsequent lessons.
- Record observations of where you see effective learning taking place as pupils begin to become familiar with *Cognitive Activation* strategies (with a view to sharing/discussing later with peers).
- Discuss with colleagues your observations of how the *Cognitive Activation* strategies you are using with your class are working and any particular difficulties you have had.

What could my maths department do next year?

- Consider collaborative planning to develop and share a range of *Cognitive Activation* strategies. This will help to ensure they are being used across different ability groups.
- All maths teachers could gather evidence of which strategies enhance learning in their class and share this evidence within and across departments, identifying if there are any strategies that work well for specific groups of pupils or for particular topics.
- Ensure regular short updates (perhaps at staff meetings) so that colleagues can continue to share, inspire and maintain awareness of the importance of *Cognitive Activation* for enhancing learning. Use this forum to find success, discuss difficulties and establish what makes it good practice.
- Share techniques and strategies on a whole-school level to help develop the use of effective *Cognitive Activation* techniques across departments.
- Consider the development of interdisciplinary units where learning is linked to real life situations across subject areas. For example, linking maths and geography through a project to plan the layout of a town to minimise the distances people travel to visit key community locations.

NFER provides evidence for excellence through its independence and insights, the breadth of its work, its connections and a focus on outcomes.

References

- Blaumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., Klusmann, U., Krauss, S., Neubrand, M. and Tsai, Y. (2010). 'Teachers' mathematical knowledge, cognitive activation in the classroom and student progress', *American Educational Research Journal*, **47**, 1, 133-80.
- Brown, A.L. (1994). 'The advancement of learning', *Educational Researcher*, **23**, 8, 4-2.
- Hiebert, J. and Grouws, D.A. (2007). 'The effects of classroom mathematics teaching on students' learning.' In: Lester, F.K.K. (Ed) *Second Handbook of Research on Mathematics Teaching and Learning*. Greenwich, CT: Information Age Publishing.
- Mayer, R. (2004). 'Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction', *American Psychologist*, **59**, 1, 14-10.
- Klieme, E., Pauli, C. and Reusser, K. (2009). 'The Pythagoras Study: investigating effects of teaching and learning in Swiss and German classrooms.' In: Janik, T. and Seidel, T. (Eds) *The Power of Video Studies in Investigating Teaching and Learning in the Classroom*. Munster: Waxmann Verlag.
- OECD (2005). *PISA 2003 Data Analysis Manual: SPSS® Users*. Paris: OECD Publishing [online]. Available: <http://www.oecd.org/education/school/programme-for-international-student-assessment-pisa/35004299.pdf> [19 February, 2015].
- OECD (2013). *PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy*. Paris: OECD Publishing [online]. Available: http://www.oecd-ilibrary.org/education/pisa-2012-assessment-and-analytical-framework_9789264190511-en [19 February 2015].
- OECD (2014). *PISA 2012 Results: What Students Know and Can Do - Student Performance in Mathematics, Reading and Science (Volume 1)*. Paris: OECD Publishing [online]. Available: http://www.oecd-ilibrary.org/education/pisa-2012-results-what-students-know-and-can-do-volume-i-revised-edition-february-2014_9789264208780-en [19 February, 2015].
- Vieluf, S., Kaplan, D., Klieme, E. and Bayer, S. (2012). *Teaching Practices and Pedagogical Innovation: Evidence from TALIS*. Paris: OECD Publishing [online]. Available: http://www.oecd-ilibrary.org/education/teaching-practices-and-pedagogical-innovations_9789264123540-en [19 February, 2015].
- Wheater, R., Ager, R., Burge, B. and Sizmur, J. (2014). *Achievement of 15-Year-Olds in England: PISA 2012 National Report (OECD Programme for International Student Assessment)* London: DfE [online]. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/299658/programme-for-international-student-assessment-pisa-2012-national-report-for-england.pdf [19 February, 2015].

NFER ref. PQUK

ISBN 978-1-910008-36-2

© 2015 National Foundation for Educational Research

National Foundation for Educational Research

The Mere, Upton Park,
Slough, Berks SL1 2DQ

T: 01753 574123

F: 01753 691632

E: enquiries@nfer.ac.uk

www.nfer.ac.uk