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Date	March 2017
Key stages	KS1
School type	LA maintained, primary
Themes	Mathematics

Can the effective use questioning develop growth mindsets and deeper mathematical thinking?

Yewtree Primary School

Context

Yewtree Primary school is a two form entry school located in the Dacorum district of Hertfordshire. The school was rated as 'good' by Ofsted in 2014.

The focus

On Friday 18th September 2015, the Herts for Learning maths team hosted a national conference with Jo Boaler, Professor of Mathematics at Stanford University, as the key note speaker. Many Hertfordshire teachers attended the conference to find out more about developing mathematical mindsets and were inspired to continue improving opportunities in mathematics for their pupils through an action research project. The purpose of the project was to explore some of the themes covered by Jo Boaler and research different ways of developing mathematical mindsets. *This case study has been written by Tia Robinson, Maths Leader at Yewtree Primary School.*

My professional development over the last four years has led me to believe that the teaching of maths within schools can often paint a distorted view of the subject and as a result this can lead to a dislike for, or even fear of mathematics (Boaler, 2009, Westwood, 2008). I personally believe that the teaching of maths should equip all pupils with the skills that they need later in life, including independent thought and the ability to solve problems. Such teaching should include regular use of open-ended questions to aid cognitive achievement, whilst encouraging and extending children's mathematical thinking (DCSF, 2009, Fraivillig et al, 1999).

I considered whether the types of questions asked were predominately closed, thus resulting in the children feeling like a correct answer had to be given and lack confidence, this led me to reflect upon Skemp's theory on instrumental understanding (1976). I wanted my research to consider enhancing the children's growth mindsets by using low threshold high ceiling activities and effectively using key questions such as: 'What's the same? What's different?' and 'What do you notice?' Consequently, leading staff and pupils to become more aware of Mathematical Thinking by increasing awareness of the mathematical powers of conjecturing and convincing (Mason et al, 2005). As a result of the increase of effective questions, I hoped that all children would participate and contribute in lessons confidently with an increased relational understanding (Skemp, 1976) exposed through articulation and increased confidence.

Description of my approach

I decided from the beginning that I would firstly work with my Key Stage (KS1) to establish the direction in which I would take my project, with the view in mind that that I would continue implementing and support my findings further into KS2 next year. Bell (2005) suggests that triangulation is vital to ensure reliability and validity of the data. I first established a baseline of the current use of questioning and its effectiveness through the data collection methods. These would then inform my decisions about the direction of the research project with questioning through planned CPD for staff; the data collection methods would be repeated again towards the end of the research project to evaluate impact.

Planning scrutinies enabled me to see where opportunities were to expose pupil's understanding. However, I recognised that just because questions may or may not be planned, does not mean they did or did not take place. I decided that would use classroom observations also with a lesson study type approach to provide a professional learning model to improve the classroom teaching and learning in a collaborative approach, in order to get more than one perspective of what was happening. Finally, in order to look at how individuals are able to respond to specific questions, I completed a sample of questions with a group of six pupils from across Year One. These questions aimed to use specific types of questions such as 'What's the same? What's different?' and 'What do you notice?'. In addition to these forms of data collection, I would be working with the other Year 2 class daily and both Year 1 classes weekly as part of an ongoing support (all ethical rights were considered at this time).

I compared specific lesson study observations in Year 1, observing how the focus children responded, along with others. I was astounded by the amount of closed questions asked. Throughout the lesson observation, I continuously referred to the lesson plan provided by the teacher. I found that there were types of open-ended questions on the plan, but none of them were asked and the teacher did not refer to her plan once. I had to take into account the nerves of the teacher. I found the questions asked were testing the children's knowledge but not their understanding, which Thompson (2003) concludes is a common feature in classrooms. When a child was given the question "How many ways can you make 10p?" , they responded with a variety of different calculations, however, there was no 'deeper' thinking required. This directed me to supporting the teacher in using a smaller amount of questions but making them purposeful and effective, I wanted to draw the teacher's attention to which mathematical skill they are promoting and what they want to find out. The observations showed that the children had little exposure to the deeper mathematical thinking required in order to answer these types of questions. Mason (2005) promotes the use of probing children with questions as it can reveal what they are attending to and the responses given revealed the children were attending 'only superficially'.

For further triangulation, I selected three children from each Year 1 class with whom I would focus on by analysing their responses to questions posed to them. All children were an equal mix of ability and gender. The children were given a series of deeper mathematical thinking questions, specifically focusing on 'What's the same?' 'What's different?' 'What do you notice?', and 'Convince me', based on the mathematical power of convincing (Mason et al, 2005) which underpinned my research. Overall, the baseline assessment questions carried out, suggested there was a lack of generic strategies used or known in order to convince or mathematically prove an answer, other than working practically. This was particularly evident when asked: 'convince me that 2p + 3p + 8p + 7p = 20p'. The child relied on counting cubes, rather than using their knowledge of number bonds to 10 it was clear that the children needed visual representations.

Impact and recommendations

Through weekly planning sessions for the Year 1 staff, in the form of mentoring and / or coaching, alongside delivering planned CPD sessions to the whole staff, I was able to link pedagogic strategies that had been modelled to the staff and ensure they were effectively embedded within the KS1 classes. After successfully implementing a series of lessons which focused on eliciting the children's understanding, in-line with the theory of constructivism in the form of accommodation (Piaget, 1964), one of the class teachers had found success in the delivery of a different approach to constructing knowledge. Cognitive conflict (Haylock and Thangata, 2007) was used effectively here to demonstrate to the children how 12 + 8 could not have been 110 and why their previous answers were incorrect, building on their existing knowledge, and also supported their deeper understanding of place value and the use of zero as a place holder.

When team teaching with a Year 2 teacher it was clear that the teacher had prompted a discussion, rather than offering her own knowledge and reasoning: *'Child C is disagreeing with you Child D, what do you think?'*
In addition, teachers were becoming more aware of the power of 'convince me' as a way of engaging children in purposeful discussions and were beginning to see its potential for its use throughout the subject. They were now starting 3 / 5 lessons with "What do you notice?". I could see through lesson observations that the middle and lower attaining children were confidently participating. The teacher was keen to accept all suggestions from this question whether it was maths related or not, to ensure all children were accessing the task. This was a strategy we developed in order to support children with low threshold high ceiling activities.

Through working with individual children throughout the research project, I was also able to capture their confidence in questioning and how responsive they were to a more constructivist approach, requiring them to have a deeper understanding, brought about by higher -level thinking. This teaching revealed that the child, when prompted through questioning, and by drawing attention to, was able to create their own new learning and understanding. In this case, I needed to expose the child to the fact that an array could be used not just within groups of two and I had achieved this by merely posing a question to them to produce cognitive conflict (Haylock and Thangata, 2007): *"You have shown me you can make an array for 2 x 3, what happens if I flip it around? Now what do you notice? Child E's eyes lit up "It is the same!"*

As the research project came to an end, data collection methods were repeated from the start, as well as taking evaluative staff views across the whole school to identify any potential changes in attitudes, beliefs and practice and to measure the impact. The feedback demonstrated the impact of the research project and CPD, and was testament that staff had recognised the need for and understood the pedagogy behind effective questioning in learning to support mindsets. There was a strong sense of learning on behalf of the staff about reducing teacher talk in order to allow a more rich dialogue between pupils, engaging them in learning conversations and articulating their thinking. In order to triangulate the evidence, I then looked at teaching and learning within my focus cohorts to determine whether the teachers' pedagogy had translated into practice. I spent time analysing and reflecting upon the focus teachers' questioning in lesson observations towards the end of the research project. Both of the teachers were now considering the types of questions they were using and for what effect.

It was clear in planning scrutinies that a greater amount of higher–level questions were now being used with an emphasis on the key questions. These questions were effectively planned to expose learning, which confirmed the change in practice and pedagogy staff had undergone. Another example was in the starter of one lesson observed. Number sentences were given to children involving identical numbers but re-arranged with inverse operations in order to deliberately draw attention to the fact the same numbers were being used, but in a different order and operation. The teacher was now not using as many questions, but she had used the ones she had planned for and they were purposeful and they scaffolded all children to enable them to feel confident.

Finally, I began to look at the individual questions I carried out with individual children as part of my focused study. I repeated the same questions that had been carried out previously, noting responses and approaches, comparing to the baseline data. Overall, there had been an improvement in how children responded to the high-level questions, with an increased ability to articulate and reason mathematically using the skills and knowledge they had gained over the previous terms. An example of this was when Child E was asked to convince me as to why 13 could not be sorted into two groups. She was now able to articulate clearly her reasons why not. Previously, Child E could not articulate that she had one cube left over and why this was important in her explaining, instead she tried to put it into one of the groups. However, now she was fluent in the type of mathematical response she needed to provide in order to justify her response. She then went onto say, "…so this means it will be the same for another odd number". This was evidence that the use of high-level questions such as 'convince me' could prompt higher-level thinking, and in this case, the ability to start generalising. This was indicative on the whole for all of the focus children.

Recommendation for others:

- Work from what the children already know and understand. Support them to refine their own methods rather than impose your own methods on them.
- Support children's confidence with low threshold high ceiling activities.
- Support all children in feeling successful by introducing tasks with "What do you notice?"
- Encourage a dialogue rich classroom. If they child can understand how to solve a problem then can they teach it to someone else?
- Make resources readily available and allow children to select resources for themselves. Don't view resources exclusively as a way of supporting low achieving students.

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Reading and website references	Bell, J. (2005) *Doing your research project: A guide for first-time researchers in education, health and social science.* 4th edn. Berkshire: Open University Press. Boaler,J. (2009) *The Elephant in the Classroom.* London. Souviner Press. DCSF (Department for Children, Schools and Families). (2009) *Independent review of the primary curriculum: final report (Rose Review).* Nottingham: Department for Children, Schools and Families. Fraivillig, J., Murphy, L., Fuson, K. (1999) 'Advancing children's mathematical thinking in everyday mathematics classrooms'. *Journal for Research in Mathematics Education. 30* (2). pp. 148-170. Haylock, D. & Thangata, F (2007) *Key Concepts in Teaching Primary Mathemetics.* London. Sage. Available online at: https://www.dawsonera.com/readonline/9781849202459 Mason, J. Graham, A. & Johnston – Wilder, S. (2005) *Developing thinking in Algebra.* London. Paul Chapman Publishing Skemp, R (1976) 'Relational Understanding and Instrumental Understanding.' *100 Years Mathematics Teacher Journal* [Online] Available at: http://eledu.net/rrcusrn_data/Skemp%20article.pdf School website: http://www.yewtree.herts.sch.uk/

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