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Date	March 2017
Key stages	KS2
School type	LA maintained, primary
Themes	Mathematics

Can Concrete-Pictorial-Abstract support pupils to securely reach age related expectations in 6 weeks?

St Paul's CE VA Primary School

Context

St Paul's CE VA Primary School is a village church school located in the Dacorum district of Hertfordshire. The school was rated as 'outstanding' by Ofsted in May 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 Hannah Willis, Year 1 Teacher, Maths Subject Leader and member of the Senior Leadership Team.***

As Jerome Bruner suggests, for deep conceptual understanding to take place, children need three types of representations of a new concept: enactive, iconic and symbolic. Reinforcement occurs when children go back and forth between all three representations (Bruner, 1966). This action research looks at the impact of concrete-pictorial-abstract (CPA) for children who are currently making limited progress.

Description of my approach

Starting point

I was aware that in the school where I teach, the use of manipulatives for supporting mathematical understanding lessens as the children move up through the school. I chose to focus on six children who seemed to be making slow progress in Year 3: two of the children were working below age related expectations (ARE), and four children were working broadly within ARE. I met with the teachers, to discuss how to implement a 'CPA rich' learning environment, so that it was inherent throughout their teaching. They responded well and carried out Jo Boaler's 'Week of Inspirational Maths' as well as more 'low-threshold, high ceiling' activities, so that the children could 'show what they can do, not what they can't,' McClure, L (2011).

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I started the research by discussing my objectives with the class teachers and also with the teaching assistants. I shared resources and websites which would promote the usage of CPA: Boaler's 'WIM', Singapore bar method, packs of Cuisenaire rods with a video clip of how to use them and the individual maths packs for each child. I then gave the whole class questionnaires about maths, focusing on what helps them learn, with a specific focus on the six research children.

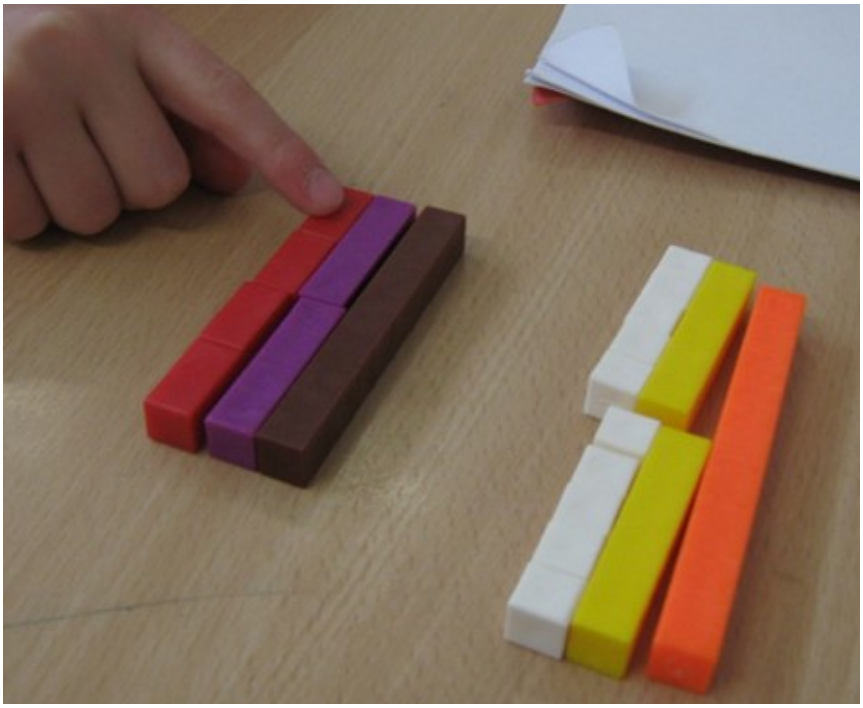
Materials and resources

I made up maths packs for the whole class, thus allowing every child the opportunity to succeed. The intention was to show that manipulatives are not just for the lower achievers, but can enhance mathematical thinking for all: "In time, higher attaining children become less reliant on visual representation. What is important to note, is that studies prove that those children who draw diagrams (compared to those who do not) enjoy significantly more success," (Weightman, 2016).

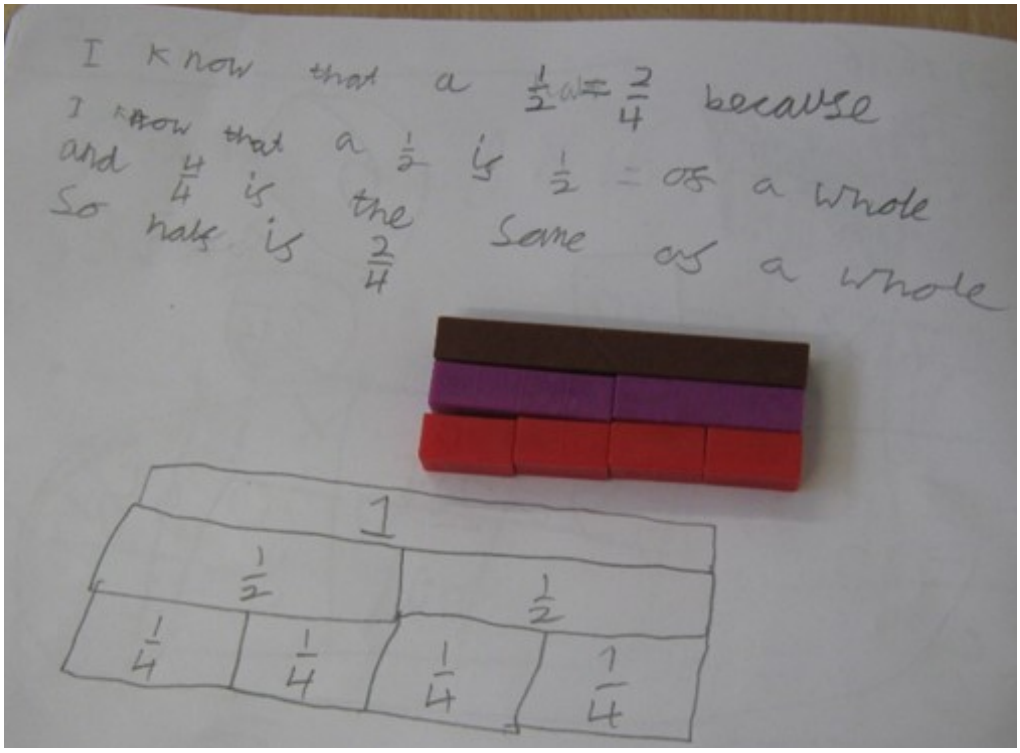
The learners' responses:

Let us refer to the six focus children as child **A, B, C, D, E** and **F**.

- Six weeks after starting the research, each of my focus children completed the same questionnaire as previously. The responses gave insight into how CPA had impacted their learning. Out of the six, three made significant progress, one moving from working towards to broadly, and two moving from broadly to secure. It was interesting to note the mind-sets of children **D, E** and **F** who did not achieve so significantly.
- Child **D** explained in his follow up questionnaire that he was getting so good at maths that he rarely needed to use his Maths pack anymore.
- As formally observed by the TA, children **E** and **F** did not use their maths packs unless reminded by an adult, and even then they did not use it effectively.
- Based on the responses of children **D, E** and **F**, I felt it vital for the adults within the class to frequently model how to use manipulatives. This would support those children who did not seem to understand how to use it them effectively.
- I interviewed each of the six children about their feedback. It was apparent from this that a 'CPA rich' learning environment had had an impact. The three children who made progress, (children **A**, **B** and **C**) were the only ones out of the six who spontaneously said that their 'How can I draw it?' card had helped them.
- Child **B**: "When I draw it, it helps me explain my answers better." (see photos below).
- Regular use of Cuisenaire rods had given child **A** a better understanding of division. Her supporting adult reported that she had exclaimed in her 'light bulb' moment: 'I didn't used to get it, but now I do!' This same child's confidence had grown significantly so that she was now spontaneously joining in whole class maths discussions; previously she had needed encouragement to voice her reasoning.
- Child **C**: "I like the 'How can I draw it?' card. Say I knew 50+10 =60, the card helps me explain it; so I also know that 500+100=600."
- Child **C** also modelled to me how he had used Cuisenaire to understand equivalent fractions (see photos below.



Using Cuisenaire rods, child **C** demonstrates how he knows that both 2/4 and 5/10 are equivalent to 1/2.



Child **B** explained that her reasoning card had helped her to think about how she could draw out equivalent fractions. She then used Cuisenaire rods to confirm her answer.

Widening the approach

I chose to work with two job share teachers from Year 3 because of their open mindedness and desire to do what was needed to help their low achievers make progress. I knew that if there was an impact, these teachers would share it and, as a result, the other staff would be more likely to embrace the idea of CPA.

Furthermore, I decided that Year 3would be a good focus year group - historically it seemed that the use of CPA lessened by the end of Year 2.

I have since arranged for two maths tutors from Hertfordshire University to come in and teach individual sessions with Reception pupils, Year 2, Year 3 and Year 5, to model to the teachers how to use Cuisenaire effectively in lessons. The aim is to clarify to all staff that the CPA approach is not a fad, but a foundational necessity upon which we will build our abstract application. As Robinson (2015) explains, "It is important for teachers to explain *how* symbols can provide a shorter and efficient way to represent numerical operations."

As my research progressed, I became increasingly aware of the intrinsic link between the use of CPA and reasoning. Resulting from the responses of children **A, B** and **C** - they explained their answers to me using both drawings and manipulatives. I realised the value of CPA for developing reasoning skills similar to that found by leading teacher, Tia Robinson. She found that the children, (including her high achievers) were more confident with developing their mathematical thinking through conjecture and convincing whilst being able to move tangible objects. As a result, I have asked that maths packs be set up for all children in all year groups, with slight differentiation for older year groups.

Impact and recommendations

Changed mindsets

Out of the six children, the three who made progress were **A**, **B** and **C**. The three who had not were **D**, **E** and **F**. Based on the pupil voice feedback, **C** had previously said that challenges made him feel worried. His follow up feedback said: "I feel excited and scared together."

A, who had previously not had the confidence to voice her ideas in maths lessons, now confidently joins in. From observations, she has become more animated and engaged. She was also starting to be much more vocal in her group investigations, whereas previously she had let others lead. Her response in her follow up feedback was: "It's fun! Mrs D makes it fun!'"

In **B**'s follow up feedback, she stated that 'my maths pack helps me a lot, especially my card which says 'how can I draw it?' She also commented that she now feels 'more confident' when she has a challenge.
Interestingly, **D**, **E** and **F** rarely used maths packs, and from observations **D** and **E** were less engaged during carpet time; both **D** and **E** said that they preferred to work alone. **D** stated: 'I don't need to use equipment, because I'm getting really good at maths.' Based on the teacher's assessments, it was interesting to note that the two children with fixed mind-sets made little or no progress. As Dweck (2012) points out, her students with fixed mind-sets showed a decline and an immediate drop in grades.

What made the impact?

I would attribute the changes to an altered whole class approach, stemming from the Year 3 teachers. They embraced the CPA learning culture, and sought to make it an inherent part of their teaching. Using Bruner's enactive, iconic and symbolic model, and switching between the three within the maths lessons played a vital role; it was particularly beneficial to those children who embraced that model.

What could be altered next time?

Regular modelling of how to use the resources within the maths packs would be necessary. This was clear from the two children who did not understand how to use their packs effectively. Equally, I believe that there needs to be a whole school belief that CPA is not for low achievers, but is a foundational necessity for all children. Indeed, as a colleague highlighted, it is often the high achievers in her class who struggle to represent abstract maths in any other way than by the use of symbols. Therefore, having CPA maths packs for each child at every maths lesson would impress upon the children that it is for all. In addition to this, I believe that a longer time period for research would be necessary to gain a clearer picture of the possible impact.

Contact	**Hannah Willis, Year 1 Teacher & Maths Subject Leader**
Reading and website references	**Dweck, C. (2012). *Mindset—How you can fulfil your potential*. 1st ed. London: Robinson** **Weightman, R. (2016) *From Strong Foundations-Our Conceptual Approach to Teaching Number*, Putteridge Primary School** **Robinson, T. (2015) HFL, Maths autumn newsletter: Moving between concrete – pictorial – abstract.** ***Websites:*** **Jerome Bruner's Theory of Development: Discovery Learning & Representation - Video & Lesson Transcript | Study.com. [online] Available at: http://study.com/academy/lesson/jerome-bruners-theory-of-development-discovery-learning-representation.html** **NRICH: http://nrich.maths** **Youcubed: https://www.youcubed.org/week-of-inspirational-math/** **School website: http://stpauls909.herts.sch.uk/**

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