

Exploring the introduction and teaching of algebra using Lesson Study

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Key Points

- Enabling young mathematicians to grasp algebraic concepts
 - A passion for Lesson Study: an effective medium for teacher learning
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Purpose

What were your reasons for doing this development work?

This case study is a small part of a two-year research and development project run by Camden, the MLP (Mathematics Leading Professional). I teach in an inner-city comprehensive secondary school, and welcomed the chance to develop my teaching and to think more deeply about effective methods of teaching and avoiding misconceptions. In this lesson study-based research I worked collaboratively with two teacher-researchers based in Year 4 in primary, Jo Davey and Paul Beeton of Primrose Hill Primary School. A main aim of the research project was to improve pupil progress and attainment in the harder to teach and harder to learn areas of the new (September 2013) mathematics National Curriculum, thus boosting attainment and progress in mathematics. The four areas under analysis were division, fractions, ratio and algebra. We decided to focus on algebra, a topic which hadn't been in the primary school curriculum (although some higher-attaining pupils would have been introduced to it) but was to be formally introduced in the new curriculum. We wanted to explore the question, "How can we best introduce algebra to lower-attaining students?"

Who were the identified target learners?

We selected three Y4 case study pupils that we would focus on, all with varying abilities and needs, so that we could think about how our teaching affected different pupils.

What specific curriculum area did you intend to have impact on?

Maths – algebra

How were you intending to improve pupil learning?

We decided that we wanted to improve the way that lower-attaining students learn algebra, focusing on pupil talk and the use of manipulatives. We also thought it would be important to make connections between different areas of mathematics. We selected three Y4 case study pupils that we would focus on, all with varying abilities and needs, so that we could think about how our teaching affected different pupils.

What were your success criteria?

Success criteria for each target pupil were devised for each lesson and progress reviewed in the post lesson discussions (see Lesson plans and Post-lesson discussion records, attached below.) The methods used to collect data were as follows:

- Video of pre-lesson discussions with teacher-researchers. Although notes would be taken throughout the interview, this would be used to double-check that there were no other significant surprises or suggestions after it had taken place.
- Lesson observations and notes. These observations would be undertaken by me and the other research teachers.
- Interviews with case study pupils. These would be transcribed so that the resulting qualitative data could illustrate any interesting observations.
- Photographs of children's work. The students themselves would not be photographed to preserve anonymity.
- Post-lesson discussion with teacher-researchers. As per the pre-lesson discussions, this would be videoed and notes would be taken.

Methodology

What did you do - what teaching approaches did you use?

We decided to focus on missing number problems and the meaning of the equals sign for the introductory lesson. We wanted the children to be able to solve equations with one unknown by really understanding that the equals sign meant "is equivalent to" instead of "find the answer", a common misconception. We also wanted to see what effect the use of manipulatives would have on the learning of the pupils, and to this end we decided to use the Numicon resource.

To emphasise the meaning of the equals sign, we used a balance scale with an equals sign in the middle to try and get the children to see that one side of an equation needed to be equivalent to the other side. The teacher started by taking one of the children's previous examples and used the scale to introduce the equals sign, taking a piece of card with an equals in it and putting it in the middle of the scales. Numicon pieces were then put in the boxes on each side of the scale and the children could see that the scale was balanced.

In the second lesson we wanted to explore 'equivalence' more. One of the problems the children encountered in the first lesson was that they saw a calculation with numbers on one side and immediately did the operation without considering the equivalence of the other side of the equation. We decided to use the equivalence of money to reinforce the meaning of the equals sign as a symbol of equivalence, rather than a symbol which means "calculate". After a

demonstration on the board, the children would have a cardboard “=” sign and be required to come up with different combinations of coins and notes which made the “money equations” true.

The third research lesson involved the introduction of the inverse and a ‘function machine’. A fuller description of the research lessons and their outcomes is in Research Lesson accounts, attached below.

What specific teaching resources did you use?

- Numicon www.numicon.com
- Mathematics function machine

What CPD experiences, materials, research and expertise have you drawn on?

The research group consisted of me (a secondary school teacher) and two primary school teachers who were based in the same year in the same primary school: Jo Davey and Paul Beeton. I worked collaboratively with these two teacher-researchers to trial teaching ideas and to document student learning in response to these trials. The research took place over a three week period following an initial planning session.

During the initial planning session we developed the group protocol. This was as follows: All members of the Lesson Study group would be equal in our capacity as learners. This meant that there would be no single Teacher-Researcher in charge and that all suggestions within the planning session would be treated with positivity. Group members would listen to each other and themselves and build on the discussion. We would share the aims of the study with the pupils involved and we would share the outcomes with our colleagues and pupils in a way that would benefit the teaching and learning of others. The other two teachers in our research “triad” had been informed of the aims and research protocols via a number of conferences and meetings. However, further to this I asked them to sign a short statement to show that they had given their informed voluntary consent for their data to be used in this report, and to assure them that they could withdraw their consent any time. This protocol was as suggested in The Lesson Study Handbook (Dudley, 2013). The research drawn on is referenced in the ‘References’ attachment below.

Outcomes and Impact

What has been the impact on pupil learning?

Algebra is a recent addition to the Primary Curriculum, and in fact is only mentioned as an independent topic in the Year 6 programme of study (DoE, 2014). However, it is clear from the research literature, and from what I have observed in this research, that a strong arithmetical

foundation and the gradual introduction of letters to represent an unknown variable is key in building up pupils' confidence in this traditionally tricky area of mathematics. The way the topic of algebra was broken up step by step during this research meant that the children went on a learning journey with resources and situations relative to them (eg. the idea of money, and breaking codes). There was originally a reluctance from the primary school teachers to introduce algebra as there was a fear it would be too difficult and irrelevant, but through discussion and collaborative planning the children had an experience which empowered them and gave them confidence in their mathematical abilities. Using fun contexts such as "Inspector Number", code-breaker and other fun "hooks" helped with the children's engagement and making links. We found that children learn if it's fun, clear and if there are opportunities for practice and success. We found that having a strong arithmetical foundation is vital before moving on to letters. There is currently no algebra in the curriculum for year 4 and yet in this lesson study we tackled some of the main issues in teaching it. It isn't inaccessible to this age of children with properly scaffolded and differentiated lessons.

A misconception which appeared again and again was seeing the equals sign to mean "the answer is". In most cases the children had to "unlearn" this instinct which has been developed, and through carefully planned activities the children had great success with seeing the equals sign as meaning equivalence. These lower-attaining children were managing to solve equations which they would not normally be introduced to for at least another three years. We learned from this that the meaning of the equals sign needs to be embedded from early years, and also parents need to be informed as it is possible that many are using "equals-means-answer" with their children from a young age. This needs to be investigated further.

We found that the children had different strengths and weaknesses in different areas of mathematics. Constant assessment was very important, and using the medium of Lesson Study meant that children's successes and difficulties were captured. We were very surprised at what the children were capable of given the right environment and appropriate scaffolding. It was also a surprise just how capable the top end of the group was and the importance of pace and extension work. Very differentiated questions meant that they experienced success and praise and they had trust in their teachers. They wanted to show that they had their own thoughts about mathematics. A technique which worked well was using mathematical vocabulary along with another, more common, word. For example, during the lesson on Function Machines the teacher initially used the word "opposite", then gradually introduced the word "inverse" alongside this, and then phased out the word "opposite". This helped with the children's technical language and at the end of the research lesson only Case Pupil 1 and a couple of similarly levelled students were unable to use the word "inverse". Another technique which came out of this Lesson Study was keeping resources visible within the learning environment for a number of weeks. This perhaps had an impact on retention of learning and, even though the research lessons were a week apart, the children had little difficulty in picking up where they'd left off.

Evidence of impact on pupil learning

See Research lesson accounts, below.

What has been the impact on teaching?

This Lesson Study, and others before it, has influenced my practice in a number of ways. I've realised the importance of briefing the other adults in the room thoroughly and TAs need to be briefed so they know the common misconceptions. Perhaps most importantly I've seen the constant need to be open to seeing that children are fluid in their ability in different areas of mathematics and that constant assessment is key. Extension material (enriched maths) always needs to be available for higher-attaining students and this group in particular can always surprise me with just how capable they are. Lesson Study as a medium for teacher learning is something I've developed a passion for and I intend to become part of the process of effecting this CPD in other London schools in the future.

Evidence of impact on teaching

See Research lesson accounts, below.

What has been the impact on school organisation and leadership?

Not applicable in this case study

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What is the crucial thing that made the difference?

Close observation of target learners and conversations with them about their learning; structured post-lesson discussion with fellow teacher-researchers.

What would your next steps be?

I intend to become part of the process of effecting this CPD in other London schools in the future.

Sharing Practice

If another individual or school was attempting to replicate this work, where should they start?

Start by investigating lesson study as a research methodology and find colleagues willing to research with you.

What would be the essential elements to include?

See The lesson study website <http://lessonstudy.co.uk/the-lesson-study-process/>
[Lesson Study handbook](#)