An investigation into pupils' strategies for mental mathematics

Grahame Downey,
Mickley First School, Mickley, Stocksfield, Northumberland

> Aim

To raise pupils' attainment in mental calculations in mathematics through developing their ability to articulate the strategies they use

> Dimensions of this Case Study

Ten teachers and 204 pupils from four first schools took part in the study.

> Summary of Findings for this Case Study

- Extending the oral/mental start to the mathematics lesson produced benefits in the pupils' learning because it gave pupils the opportunity to reflect on and articulate their strategies.
- Thinking Skills approaches and the use of appropriate mathematical vocabulary assisted pupils in the articulation of strategies, helped the pupils to reflect on their learning and become better learners.
- Standardised mathematics test results showed significant improvement in pupil performance, but it is not possible to attribute this to the project alone.
- Teacher modelling of mental calculation strategies was important in increasing pupil understanding.
- Pupils were generally able to articulate the strategy they were using, although on occasions the knowledge or use of more precise vocabulary would have assisted their explanation.
- The partnership between the University of Newcastle and the four schools involved provided a model of effective In-service provision.

A research project funded by the Teacher Training Agency as part of the Teacher Research Grant Scheme 1999/2000

Introduction

Mental calculation strategies are central to the success of the National Numeracy Strategy (NNS). Teaching pupils to use these strategies of mental calculation is an established feature of the NNS framework. The ability of pupils to articulate the strategies they use is important in increasing their understanding. Thinking skills became an integral part of all subjects in the revised National Curriculum from September 2000.

This project investigated the impact of Thinking Skills approaches on the teaching of mental calculation strategies. Pupils were given extra opportunities to explain their strategies and to observe these strategies being modelled by the teacher and other children. The underlying premise of the project was that this would enable pupils to clarify their own thinking and to learn from others, potentially producing an increase in performance.

Context of this study

The University of Newcastle upon Tyne has developed an approach to Thinking Skills, which is based upon the infusion of key teaching and learning principles across the curriculum. In this project, Thinking Skills approaches involved encouraging the pupils to explain and reflect upon the strategies they used in mental mathematics. It builds on previous work in which the pupils were encouraged to develop questioning and reasoning skills in other areas of the curriculum.

Two hundred and four pupils from four First Schools, and their teachers, took part in the study. In each class the teachers increased the length of the oral/mental start to the mathematics lesson. The pupils were tested using NFER mathematics tests in September at the beginning, and in March at the end, of the project.

One school had an Ofsted inspection just after the project was completed and this evidence is also included.

The schools involved in the project held regular In-service training and support meetings, led by the lecturers from the University of Newcastle.

The intervention

In three lessons per week the teachers extended the length of the oral/mental start to the lesson by five minutes. The additional time was principally used to allow the children more time to articulate and discuss the strategy they used to solve a mental calculation. For example, when asked to calculate 23 + 23, a range of strategies was proposed:

"I know the answer . . .
double 23 is 46;
20 + 20 = 40, 3 + 3 = 6, 40 + 6 makes 46;
23 + 20 = 43, add 3 makes 46".

Pupils were encouraged to share ideas and to evaluate the effectiveness of the strategies used.

Teachers explicitly taught and modelled strategies and vocabulary from the National Numeracy framework. Teachers also assisted pupil learning by reinforcing effective strategies articulated by the pupils or showing how to proceed when pupils encountered difficulties.

Often the oral/mental part of the lesson gave information about the pupils' learning and development which influenced future teaching. This formative assessment process was extended by teachers carrying out individual interviews with the pupils in order to record how the pupils explained their mental calculation strategies. The calculations set were based on examples from the NNS framework. The explanations were recorded on formative assessment sheets, which were retained and shared by teachers at professional development meetings.

Half-termly support group meetings provided a forum for teachers to discuss issues related to teaching and learning. Input from University of Newcastle staff focused on teaching methods, progression in the numeracy framework, pupil learning, practical activities and the use of resources.

1.Gains in pupil performance

The test scores showed that overall pupils had made a significant improvement. Their standardised scores increased by an average of 6 points between tests. (The age-standardised score of a pupil making average progress would remain the same, irrespective of the time interval between tests.) It must be acknowledged that there are difficulties in using standardised tests in this way (due to factors such as uneven pupil gains month by month), – but the gain produced was larger than that normally expected.

Also, since the project was concurrent with the introduction of the National Numeracy Strategy it is not possible to attribute gains solely to the project or to the training and teaching linked to the National Numeracy Framework. Teachers involved in the study felt that encouraging pupils to articulate their strategies had contributed to the pupils' success.

The project had the highest impact on pupils who had had the lowest standardised scores at the beginning of the project – these pupils made the greatest progress. Teachers felt this was because they had been able to provide more focused teaching for these children due to the information provided by the tests and from the opportunities to identify their strengths and weaknesses as the pupils articulated their strategies.

The performance of different groups of pupils was compared, for example, boys and girls, different year groups or autumn and summer birthdays. No significant differences were found in the test scores for these groups. This shows that the intervention was equally effective for all identified groups of pupils.

2. Pupils were able to articulate their strategies

One major benefit of the project was that teachers spent some time with individual pupils discussing mental calculation strategies and recording the pupils' responses. The pupils were clearly able to describe how they had carried out a calculation, even from reception class.

For example:

Year 2

Teacher: 6 + 5
Pupil: 11
5 + 5 + 1 more.
(Strategy - using near doubles.)

Year 4

Teacher: 560 + 575
Pupil: Double 500 is 1,000
Split 75 into 40 + 35
Add 60 and 40, is 100.
Then add 35 is 135.
1,000 and 135 is 1,135.
(Strategy - doubles, partitioning.)

The above examples show that these pupils were able to articulate their thinking processes and quite often they were also able to identify the strategy they had used, such as near doubles. Pupils' identification of strategies was more effective when the teacher modelled effective strategies and made the explicit use of mathematical vocabulary a priority.

In articulating their strategies, pupils were developing their 'metacognitive' skills; the skills necessary to help them to learn about and to control their own learning processes. Pupils use metacognitive language when they discuss and reflect upon their own learning, identifying what and how they have learned, - an important lifelong learning skill.

The pupils were able to use metacognitive language – identifying the type of strategy they had used rather than simply saying what they had done.

Younger pupils (in Reception and Year 1) showed the greatest frequency of using metacognitive language, often indicating that they had "counted on", "counted back" or "counted in tens".

The greater use of metacognitive language by younger pupils may reflect the level of modelling and guidance given to these pupils by the teachers, including the use of appropriate language to use when describing the strategy, giving explicitly shared meanings in the learning process. This is part of the teaching process for young children, making the learning process explicit.

Use of metacognitive language in older pupils was less frequent. This finding suggests that there may be a need for teachers of older children to spend more time modelling strategies and reinforcing the correct use of vocabulary. Teachers of older children may assume a greater shared understanding than exists and spend less time making things explicit than their colleagues in Early Years. It may also indicate that some older pupils have difficulties with mathematical vocabulary, and relating abstract concepts to technical terms. They may need time for discussion to reinforce this link. The identification of strategies and terminology within the National Numeracy Strategy Framework gives the basis for a shared vocabulary.

Pupil confidence in mathematics was reported to be higher and teachers attributed this to the project and the opportunity to spend more time on the oral/mental part of the lesson.

3.Teaching improved when the children articulated their strategies

The teachers involved in the project reported greater confidence in their teaching of mental calculation. They indicated three factors contributing to this:

a). increase in knowledge about strategies and progression in mental mathematics;

b). explicit linking of progression to suggestions for practical activities in the classroom; and

c). insight into pupil strategies provided by pupil interviews.

In the regular support group meetings the teachers indicated the value of having information available about their pupils from tests and classroom observations. They were able to use this formative assessment information to inform their planning and make their teaching more effective. This formative assessment was quite highly structured using NFER test analysis and listening to target pupils talk about the strategy they were using. The information built up a more complete picture of each child's learning in mathematics, identifying secure knowledge and misconceptions. This was carried out most efficiently in individual pupil interviews. However, other opportunities presented themselves, for example in the class or group situation, and in the oral mental part of the mathematics lesson, when common needs, such as strategies and vocabulary, could be identified at a more general level. The extra time allowed for discussion of strategies in the mathematics lesson assisted with this process. As teachers became more familiar with the progression and strategies in the National Numeracy Framework, diagnostic information was used to identify next steps for learning.

4.OFSTED evidence

One of the schools involved in the project was inspected by Ofsted shortly after completing the project. The inspectors reported positively about the impact of Thinking Skills approaches on attainment in Mathematics.

Ofsted reported that the introduction of thinking skills was having an impact on learning and had improved the pupils' achievements in mental mathematics. They praised the teaching in oral/mental mathematics and commented on the speed, agility and enthusiasm demonstrated by the pupils.

5.Conclusions

Teachers' Learning

1. The support of lecturers from the University of Newcastle was central to the success of the project. It helped provide a focus and support for the group, maintaining the momentum of the project. In-Service training sessions delivered by the University staff on teaching mathematics provided the teachers with opportunities for:

   - discussion of the framework for mathematics;
   - consideration of effective teaching approaches; and
   - discussion of their work and to share experiences and ideas.

The training provided an additional source of ideas to support the development of pupil strategies. Teachers were able to reflect upon their own learning. An analytical approach was taken to the National Numeracy Strategy framework which assisted in the selection and targeting of the most appropriate strategies for pupil learning in each year group. The project helped teachers to understand and apply elements of the framework.

Provision of accessible information from the testing allowed early identification of problems in pupils' performance and enabled better planning to overcome these difficulties.

2. The in-depth assessment of a sample of pupils in each class gave rise to detailed knowledge about how the children used the strategies. This enabled next steps in teaching to be identified which applied to the individual child. To an extent they were also taken as being indicative of the sort of strengths and weaknesses that might be expected from similar children within the class. Again, this assisted the planning and the teaching of appropriate strategies.
3. The Thinking Skills approaches used here made the application of the National Numeracy framework more effective by improving the pupils' articulation and understanding of strategies. It gave teachers a way to promote and model pupil strategies and advance their use of metacognitive language.

Pupils' Learning

1. Pupils were generally able to articulate the strategy they were using, although on occasions more precise vocabulary would have assisted the explanation.
2. Pupils' access to understanding of the strategies was helped by their own articulation o f the strategies and by hearing them articulated by the teacher and other pupils.
3. The teachers felt that teacher modelling of the strategies played a vital role.

6. Some implications for practice

1. The partnership with a higher education institution gave us access to new thinking and quality In-Service provision. This proved effective as a way of introducing initiatives and supporting effective staff development for groups of teachers and schools.
2. Extending the oral / mental phase of the mathematics lesson gave the pupils time to think about and articulate their strategy, helping their understanding and giving feedback to the teacher about their knowledge. This was done on a regular basis. The effectiveness of the main teaching activity in the mathematics lesson was maintained by pace, integration and in some cases extending the teaching time.
3. Pupils benefited when taught to select the most appropriate strategy for a calculation from the range available, i.e. a strategy which produced the correct answer quickly and reliably.
4. Pupils benefited when taught appropriate vocabulary to help them explain the strategies they used.
5. The role of the teacher in modelling strategies and language was important and is an area for further development.
6. Articulating the strategies and hearing them articulated was a benefit to all the pupils.

Further reading

Askew, M. (1999) *"It ain't (just) what you do: effective teachers of numeracy"* in **Thompson, I**. (1999a) Issues in teaching numeracy in primary schools, Buckingham: Open University Press

McGuiness, C. (1999) *"From Thinking Skills to Thinking Classrooms: a review and evaluation of approaches for developing pupils' thinking"* London: **DFEE** Research Report RR115

Reynolds, D. and **Muijs, D**. (1998) *"Numeracy matters: contemporary policy issues in the teaching of mathematics"* in **Thompson, I**. (Ed.,) (1999a) Issues in teaching numeracy in primary schools, Buckingham: Open University Press

Reynolds, D. and **Muijs, D**. (1999b) *"The effective teaching of mathematics: a review of research."* School Leadership and Management; Abingdon; August 1999

Thompson, I. (1997a) *"Teaching and learning early number"* Buckingham: Open University Press

Thompson, I. (1999a) *"Issues in teaching numeracy in primary schools"* Buckingham: Open University Press

Contact

Grahame Downey,

Mickley First School, Mickley, Stocksfield, Northumberland, NE43 7BGwww.teach-tta.gov.uk

Publication number TPU0657/06-01

Further copies of this summary are available from TTA publications 0845 606 0323