THE IMPACT OF TEACHING MENTAL CALCULATION STRATEGIES TO PRIMARY PGCE STUDENTS

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Following a previous study involving five primary Post Graduate Certificate of Education (PGCE) students, which showed that there was short term impact resulting from an intervention (Davis, 2009), I revisited three of these ex-students to consider whether there had been any continued impact in the intervening two years. Using a case study approach I will show how these teachers, with very different experiences in school, have each built upon the skills, techniques and knowledge learned in the initial intervention sessions. I will also consider how this supports or contradicts the findings of other researchers studying the impact of Teacher Education.

Key words: Impact, Mental calculation, Primary, PGCE, Teacher.

INTRODUCTION

One of my strongest memories from primary school is that of completing a mental mathematics test every Friday afternoon, in preparation for the 11+ examination (selection for the local grammar school) during the final year. We were taught no strategies, other than learning multiplication tables by rote. Questions were fired at us and we had to calculate the answers ‘in our heads’ as the Dutch call this type of calculation (Thompson, 1999). For me, this merely meant picturing the formal written calculation and carrying out the formal method, working as quickly as possible, jotting down first the unit part of the answer, then the tens etc. It was not until many years later, as I trained to teach, that I realised that there was more to ‘mental calculations’ than this. The fact that I could choose from a range of strategies and use my knowledge of the number system to calculate much more efficiently was enlightening. Shortly after this, mental calculation became an important feature of the English primary mathematics curriculum when the National Numeracy Strategy was introduced (DfEE, 1999) and strategies were expected to be explicitly taught and regularly rehearsed and discussed. The recent ‘Williams Review’ (DCSF, 2008) has called for a refocusing on oral and mental mathematics in order to particularly benefit under-attaining groups of children.

Two years ago I conducted a study with five Initial Teacher Education (ITE) students (Davis, 2009) to identify what mental calculation strategies they possessed, how confident they were to teach mental strategies to children and whether my teaching of a range of strategies could increase their confidence of teaching this topic. This study involved an intervention which included teaching them a range of mental
calculation strategies, offering opportunities for the students to compare these to their own mental methods for different calculations (e.g. \(483 + 89; 58 - 34\)) across all four operations (+, -, \(\times\), \(\div\)). This taught session was audio recorded (and later transcribed) and questionnaires were completed before and after. Five weeks later, following the students’ final weeks of Teaching Experience, a further questionnaire and short intervention session (based again on activities involving discussion of calculation strategies) provided further data. The results showed that whilst these students knew only a limited range of strategies before my intervention, they became much more confident afterwards and for two of them there was a clear impact on their teaching in school. These students from my study have now successfully completed their first two years of teaching and three of them were willing to allow me to investigate whether there had been any longer term effect of my intervention.

LITERATURE REVIEW

I have considered the literature surrounding the impact of both ITE and Professional Development (PD) courses for teachers as both have the same aim: to develop the teaching skills of the participants and therefore to enhance the learning of their pupils.

A key aspect of successful professional development is the style or nature of the activities. Both Darling-Hammond (1999) and Elliott et al. (2009) found that discussion amongst participants is central to successful PD which is, of course, the basis of many leading theories of education, particularly that of social constructionism. A successful teacher of mathematics has to develop a deep and flexible understanding of subject knowledge and be able to make connections with other aspects of the subject (Darling-Hammond, 1999). Elliott et al., (2009) develop the idea further by specifying that it is Specialised Content Knowledge which has a strong impact on teaching skills. This literature seems to suggest that my intervention should have had a positive impact in the classroom.

However, Larose, Grenon, Morin and Hasni (2009) have discovered that practice observed by students in school often overrides the information given during the university part of ITE. Students have also been found to lose their enthusiasm for their own learning during their Newly Qualified Teacher (NQT) year and tend to focus on behaviour management rather than subject knowledge (Haggarty, Postlethwaite, Diment, Ellins, 2009). Students in their first year of teaching do not appear to gain from the type of PD experiences that Darling-Hammond and Elliott et al. advocate.

The other consideration for my research is whether mental calculation strategies should be taught at all. Thompson (1999; 2000) advocates the teaching of some frequently used strategies for addition and subtraction so that children can develop flexible methods of calculation. Murphy, however, found that explicitly teaching an addition strategy did not mean that the children used this when faced with
calculations that would benefit from its use (2004). Torbeyns, De Smedt, Stassens, Ghesquière and Verschaffel’s research supports these findings (2009). They found that there appears to be no difference in whether a particular subtraction strategy is used, whether or not children have been taught it. Threlfal goes a step further, by arguing that there is no need to teach particular strategies, but instead it is essential to develop a stronger understanding of the number system (2002). If we are to enable children to use flexibility in their approach to mental calculation I do not see these as mutually exclusive. Teaching some strategies may indeed support the understanding of the number system, and vice versa.

METHODOLOGY

The main question I wished to answer was: Is there any evidence of long term impact of the teaching of mental calculation strategies to primary Post Graduate Certificate of Education (PGCE) students? These are students who train to teach on a one year programme having already completed an undergraduate degree in any discipline, so may not have received any mathematics teaching for at least five years.

In addition, there were also a number of subsidiary questions which would support me in answering the main question: Did the students teach any mental calculation strategies during their NQT year? Did the students only teach mental calculation strategies when it was already on their school’s planning? Is there any evidence that the children are using the strategies taught? Has the confidence of the students been affected by their teaching of mental strategies?

Each teacher held a particular interest for me and I wished to gain a ‘rich picture with ‘thick description’” (Thomas 2009, p.116) of them. Therefore the flexibility of a case study approach enabled me to study all three teachers in detail. I wished to develop a detailed ‘holistic understanding’ (Baxter & Jack 2008, p.554) of these new teachers’ experiences throughout their first years of teaching. I had no hypothesis at this stage of what the results of gathering this data would show, which also fits in with the idea of a case study approach.

As with any case study, there is no possibility of drawing any generalisations from this research. This does not mean, though, that I cannot use any information that I gather to improve my own practice. As Baxter and Jack report, a case study ‘can inform professional practice’ (2008, p.544). A particular strength of this research was to build upon the close collaboration and relationship that exists between me as the researcher and the teachers I was researching. In some methodologies this relationship might be seen as a disadvantage, and might be considered a barrier to the authenticity of the data collected. Using this case study approach, though, it can be seen as an advantage as this is the very reason that I am selecting this particular sample. I was very careful to ensure that the teachers understood I wanted to know what really happened, rather than them hoping not to offend me by telling me that my intervention had an impact on their teaching if it did not.
In order to gain as much information as possible for my ‘finished story’ (Thomas 2009, p.115) and to corroborate the evidence I collected, I used a range of data collection tools. Using a variety of data sources ensured that I was not exploring ‘through one lens, but rather a variety of lenses’ (Baxter & Jack 2008, p.544) and this is where the case study approach enabled me to build up a particular picture of the teachers which might not have been possible with other methodologies.

I began my study by designing questionnaires. The questions were ‘precise and non-leading, that neither assume nor presume’ (Castle 2010, p.67) and were a combination of closed questions and open questions to allow for comments about their teaching of mental calculations during their first years of teaching (Cohen, Manion & Morrison, 2000). I included some questions about confidence and competence in teaching mental mathematics strategies from the original questionnaires, completed by this group of students nearly two years ago, in order that I could make comparisons. For this reason I used a five-point Likert scale, as that was used in the original study.

In order to establish whether Haggarty et al.’s (2009) findings regarding a strong focus on behaviour management overriding other aspects of teaching were true for my sample, I also included a section where they ordered a range of five statements about areas they felt they developed most during their first year of teaching. These statements included both behaviour management and subject knowledge. Finally, the questionnaires included three open ended questions about the impact of the PGCE year as a whole on their development in their first year of teaching.

Following an initial analysis of the questionnaires I conducted semi-structured interviews with each teacher, which were recorded and transcribed. In particular, this method of data collection enabled me to prompt the teachers to reflect on any impact during their NQT year of my mental calculation strategy intervention and provided an opportunity for them to consider whether any teaching of strategies had any impact on the mental maths skills of the children. Planning and assessment records to support these opinions were collected where available.

CASE STUDIES

Ellie

‘Ellie’ was a mature student who taught across the primary age group in one school as a regular ‘supply’ teacher for a year, before spending two terms in a Year 5/6 class. She has recently returned to the first school to resume regular supply cover, again covering Years 1-6 (ages 5-11).

The data shows that Ellie has taught a range of mental mathematics strategies to children across this age group. In particular, teaching doubling and halving with all age groups was clearly very important to her, as this was mentioned for the first time less than ninety seconds into the interview. Although she initially taught this strategy
to Key Stage 1 children (ages 5-7) Ellie also teaches it regularly to 9 to 11 year olds, focusing on how this can support a range of other calculations; for example calculating percentages, equivalent fractions or simply using it to divide by 4 easily.

Ellie also teaches rounding and approximating to Year 3 and 4 pupils, to support their mental mathematics, and using Interactive Teaching Programmes (ITPs) (DfE, 2010) and physical resources, such as bead strings, to support the children in understanding and visualising the number system.

Ellie is very keen to encourage children to discuss their mental methods whenever appropriate and this was a topic she frequently returned to during the interview. She believes this is a direct result of my intervention sessions. Her passion for this crucial element of teaching mental strategies can be seen in the following extract:

Ellie: I often, I do, I do ask them about methods a lot now because I remember sitting with you and we all had so many different methods and it might be that there’s children in that classroom that just have not worked out a really easy method but by swapping methods, sort of do it this way, have you got a different way so you’ve counted on, you’ve rounded, and y’know, added bits on and taken bits off........

Later in the interview Ellie returned to this topic when she reflected on the fact that until her PGCE course she generally had just one way of tackling any set mathematical problem. The structure of the intervention enabled her to realise that there were other ways of approaching mental calculation and this realisation has altered her own way of teaching, ensuring she teaches a range of methods. She says she has ‘a better awareness, which is probably why I now ask the children, ‘how did you do that?’ and I think oh yeah, ’cause *** (names one of the students) did it differently to the way I did it.’

In contrast to Haggarty et al. (2009), who found that Newly Qualified Teachers (NQTs) did not develop subject knowledge but focused merely on classroom and behaviour management, Ellie had made a conscious effort to continue to develop her subject knowledge throughout her first two years of teaching, attending three mathematics courses in this time. Indeed, improving subject knowledge in core subjects was the area she had most developed in her NQT year.

Whilst Larose et al. (2009) found that practice in school overrode the practice learned during the university part of ITE, it is clear that Ellie had reflected on all of her university based mathematics sessions, including my intervention sessions. Her maths file, containing notes from all the taught sessions, has been in constant use throughout the intervening two years. As she says, ‘I know that I have dipped in and out of that file a lot, for resources and, and for bits and pieces ...... no doubt about it.’

Ellie agrees with the findings of Murphy (2004) and Torbeys et al. (2009), that learning a range of strategies does not necessarily mean that children will use them. However, she also believes that revisiting and rehearsing constantly is a crucial part
of children’s learning and she found herself going, ‘over it and over it and over it’. She has found that if children are exposed to these strategies regularly, and are encouraged to talk about them regularly, they do begin to select an appropriate strategy more independently.

**Donna**

‘Donna’ completed her NQT year in a year 1 class (ages 5-6) and has spent the subsequent year teaching Foundation Stage, Year 1 and Year 2 (ages 4-7) children in the same school, where she is now employed to cover other teachers’ classes during their time for other commitments. This has meant that Donna has been in the unusual position of teaching some of the children this year who she taught throughout last year, which has given her the opportunity to see how the children have developed their skills and to judge the longer term impact of her teaching.

Donna has taught and practised a range of strategies to support mental calculation, the first that she mentioned (after only 53 seconds) being doubling and halving. Like Ellie, she was able to explain why she believes this to be an important skill, and she began this with Year 1 children by using counters and other resources to support their learning. As she says, ‘in Key Stage 1 its probably one of the first .... non-counting operations .... you do mentally’. Some of these very young children were already able to recall doubles up to 20 by the age of 6 and this year she has seen how they are able to use these skills to support other aspects of mental mathematics. Many others were still learning one to one correspondence, though, and basic counting skills, so by no means were all children able to calculate mentally even in Year 2.

It is interesting to note that Donna encourages the development of mathematical skills across many other areas of the curriculum, and sees this as an important part of their learning. Indeed, this approach is advocated by many leading educationalists, and forms one of the main recommendations of the recent ‘Cambridge Primary Review’ (Alexander, 2010). Donna particularly focuses on these skills in Physical Education (PE) lessons:

**Donna:** But in PE and in games we used a lot of .. things like counting in twos to score, rather than always counting one point, y’know for getting one thing back in a race or something. Counting in different numbers or thinking about .. playing games with beanbags. How many more beanbags do you need to make 10? ---- and having teams racing against each other.... and I found PE was a really good way of, .. kind of incorporating maths...

It was clear from interviewing Donna that she was working in a team who were all keen to encourage children to develop mental skills, combined with a strong level of independence of thought. This made me wonder whether my two intervention sessions had had any impact on her teaching, or whether, as suggested by Larose et
al. (2009), practice observed by students (and presumably NQTs) in school overrides the information given during the university part of teacher training. Donna acknowledged that she has learned a lot from these new colleagues, and, for that matter, she has always used doubling to support her mathematics since her own school days, but she makes it very clear that despite the two sessions lasting less than two hours in total, they have had a significant impact on her teaching:

   Donna: DEFINITELY, definitely ...... probably even more so this year because I’ve been working more with year 2....trying to get the children to explain to me the different strategies and then explain why they would choose a particular one and why it was better, and picking out the features. It really stuck with me that when we were talking, how useful that was, so I’ve done that quite a lot with the children in the class. Definitely.

   Tutor: And was that something you might have picked up anyway on your TE placement?

   Donna: I might have done but I think that really rammed it home, that..., how important it was for the children to find out for themselves which ones work for them and which ones are..are more efficient than, than others, erm and that unless you get them to think about what they’re doing and why they’re doing it they might not, you know, I think I was just more overt with it than maybe I would have been anyway.

Donna indicated that she had received no professional development in mathematics since completing her PGCE, and I wondered if this might support Haggarty et al.’s view (2009), that behaviour management becomes the main focus for NQTs, with a lack of enthusiasm for development of their own subject knowledge. From the initial questionnaire it was clear that Donna felt that behaviour management was the skill she developed most in her NQT year, but further discussion during the interview revealed that this was because she had two children displaying such challenging behaviour that both the children and Donna received regular specialist support from the local authority throughout the year. This did not mean that Donna had a lack of enthusiasm for developing her own subject knowledge; in fact, she attended three courses and an NQT conference, all of which heavily focused on subject knowledge, albeit not mathematical subject knowledge. Donna would really appreciate the opportunity to receive further training in mathematics, and made it clear that it was not through choice that the courses she attended had different foci.

From her responses in the questionnaire it is clear that Donna is very confident about her own knowledge of mental calculation strategies and she has increased her confidence in her own ability to teach these strategies to children since she was a PGCE student. This was supported by her discussion of the impact of her teaching on
the children, which was particularly evident when working with one group of children for both years of her teaching career.

Belinda

‘Belinda’ has spent her first two years in a Foundation Stage class (ages 4-5), although the PGCE course she completed was a Key Stage 1 and Key Stage 2 course (ages 5-11). Children are divided by achievement into maths groups and she teaches the higher achievers.

Once again, teaching doubles was one of the first strategies mentioned by Belinda (less than two minutes into the interview); although despite mentioning this strategy at various points during the interview it is interesting to note that she did not mention the corresponding halves at all. However, the children learn doubles up to 20, using resources such as counters, pencil marks or fingers to initially support this, before they develop as ‘known facts’.

Belinda has learned an enormous amount from her colleagues, and readily admits that most of her mathematics teaching is based on their advice and experience rather than on her learning from her PGCE course, which, in contrast to Donna and Ellie, supports the findings of Larose et al (2009). She has not looked at her mathematics file since the day she left the course. Having said this, she still believes that the two intervention sessions have had some impact on her first years of teaching. In particular, these sessions made her realise that ‘everybody visualises things differently and they see things very differently and they have to use different ways to work it out’. She thinks this, combined with her colleagues’ advice, ensures that she offers children a range of choices throughout their mathematical learning, despite this not being a strategy included in the published scheme that the school generally work from.

When considering developing subject knowledge compared to developing behaviour management skills, Belinda has attended a number of courses during her first two years of teaching and these have all been based on subject knowledge. Bearing in mind that she is teaching in an age phase for which she was not trained, this is probably unsurprising. The courses have taught her knowledge of the Foundation Stage Curriculum and ways to assess children of this age. Behaviour management is something which Belinda feels she has made least progress in as it has not been a problem for her.

CONCLUSION

Considering the main aim of my research, to establish whether or not there is any long term impact of the teaching of mental calculation strategies to PGCE students, there clearly was for all three of these teachers. In particular, all had a strong belief that an ability to quickly mentally double and halve numbers is crucial to mental calculation. I would certainly agree with this and this was a message given
throughout my intervention sessions. It can clearly support multiplication and division by four or eight, but it can also support multiplication by 5 (multiply by ten and halve); division by 5 (double then divide by 10); multiplication by 20 (double and multiply by 10); division by 20 (divide by 10 and halve) and can similarly support multiplication by 50, 25 and so forth. Percentages can also be worked out mentally using the knowledge of doubles and halves; for example to find 25% of a number just halve and halve again; to find 15% just find 10%, halve it and add the two numbers together. Similarly, equivalent fractions can be found by doubling or halving both numerator and denominator.

Whilst this has been a very small scale study and I therefore cannot possibly draw any general conclusions from my data, I have succeeded in answering all of my subsidiary questions. All three teachers taught mental calculation strategies; they taught these even when it was not on the school’s planning; they all believed that not only could the children use the strategies, but some children could also select from a range of strategies, even at the age of five. Confidence was a different issue altogether, as only one student had increased her level of confidence in teaching these strategies, and this seems to be entirely down to the individual experiences of the students.

So why might these teachers have been different to those researched by Larose et al (2009) and Haggarty et al. (2009)? Why have they built on the teaching they received on their PGCE course and why have they continued to develop their own subject knowledge? As suggested by Elliott et al. (2009), I am convinced that this is as a result of the type of teaching they received. If suitable consideration is given to the content and delivery of ITE taught sessions, a small amount of input can have long term impact on their teaching. For maximum impact, the subject knowledge related to mental calculation needs to be taught in an environment where students, teachers or children can discuss their methods freely with one another.

REFERENCES


