The extent to which a primary maths teacher's success in the classroom is dependent on subject knowledge.

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This paper tracks 5 Primary PGCE Trainee Teachers through their Course: In particular it considers their Subject Knowledge (as measured through exam results and the PGCE mid- course Audit) and explores the extent of its significance in helping children to understand mathematical ideas and to make connections. It analyses the choices the trainees make prior to, and during, the 10 lessons observed. The Trainees reflections are heard in their post lesson discussions and in their focus group discussion at the end of the course. This is evaluated in terms of the balance between Subject Knowledge and Pedagogic Content Knowledge alongside Generic Teaching Pedagogic knowledge. Consideration is given to the need to create teachers who help children to make connections in maths when many trainees have not experienced such teaching themselves and are often fearful of trying to teach in such a way.

Keywords: GESK(Good Enough Subject Knowledge), Subject Knowledge (SK) , Pedagogic and Content Knowledge(PCK)

Introduction

The desire to clarify a blue print in terms of teacher subject and pedagogic content knowledge has led to an impressive collection of material. Shulman's (1986) PCK has been supported by, among others, Rowland and the Cambridge Team (2009): They made a significant attempt to define the blueprint for the Primary Maths Teacher. Askew (1997) referred to connectionist teaching that allowed more active involvement of children than most previous didactic, transmission- based approaches to learning. His references to the importance of good quality, ongoing, Professional Development for Classroom teachers seems to have been supported by the recommendations for deeper rooted subject knowledge proposed by Williams (2008.) These works are only part of a trail that has received many relevant additions from contributors to these informal conference papers.

Skemp (1976) was clearly identifying the need for interconnected teaching and learning. Whilst acknowledging the need for learnt knowledge, his distinction between "instrumental" and "relational" understanding seems at the heart of the trail so many of us have been following since then. The need to help develop trainee subject knowledge (often learnt through instrumental teaching) has challenged ITE Maths Trainers. The need to explore the degree to which students own learning affects their effectiveness led me to analyse a small group of trainees on the Primary PGCE Trainees to analyse the degree to which their knowledge assists them. I am indebted to Shulman (1987), whose discerning distinctions between subject, content and pedagogic knowledge I allude to in this paper.

Methodology

A questionnaire sent to PGCE Students in October 2009 allowed feedback from trainees regarding their hopes and fears about teaching maths. It revealed wide variations in trainee performance and considerable apprehension about explaining concepts to children when some of their own knowledge felt insecure. Many, however, responded positively to the modern curriculum (Strategy and Framework), particularly the emphasis on mental calculation. The pressure that mental calculation can bring worried some. Others wished they had been taught in such a way.

The five trainees selected were observed twice in 2010 (in February and again in June). Trends relating to Audit scores across the course were analysed. Finally all four of the five trainees who completed the course took part in a focus interview using an agenda I had prepared. I was present but didn't contribute to the session. The observations of the trainees do not themselves constitute meaningful evidence about how subject knowledge is used in significant way. However, by outlining a little of their teaching and the subsequent focus interview, the issues raised do merit analysis. The findings are evaluated and the conclusions are a contribution towards the relentless pursuit to one very large question. How do we develop effective primary maths teachers, when so many have been taught in a didactic way, that doesn't make it easy for them to stimulate, support and respond to children? These trainees default position often involves repeating their own experience and developing isolated understanding that follows only established rules.

Reflections on trainee observations

Teacher A (Maths GCSE – Grade C) didn't feel her teachers taught to allow understanding. She could see maths was more enjoyable when the purpose is clear. She feared she would be slow to make connections. She was keen to hear children's ideas but struggled to decide when to tell and when to scaffold when children were explaining. She appeared unaware of a lot of the difficulties the children experienced in their work and chose a child to talk in the plenary, based on his behaviour, not the content of his work.

Teacher B (A-Level Maths– Grade A). His questionnaire indicated that he wanted to be able to teach different abilities simultaneously; to get different levels of learning going within his classes. He wanted maths to be enjoyable. Both observations related to work he had prepared in the light of weaknesses he had noted in the children's previous lessons. His learning intention for the second observation was:

> To learn to solve word problems and establish secure written methods of calculation

As the title indicates, the content matter was vast. Although the children's voices were heard in response to being asked to verbalise some methods, Teacher B's voice was very much to the fore. He knew he was talking for too long to be effective:

> I have been talking for a long time and you've coped much better than I could have envisaged.

His high audit and exam grades are reflected in his confident outlining of mathematical algorithms (and awareness of Framework and Strategy methods). This is suggestive of good Subject and Content Knowledge. However his lessons were not successful in terms of learning. Children lost focus; the sheer baulk of issues being thrown at them was too daunting. He couldn't cue in to the comments of the children

to bring the lessons to life. His timings were inappropriate to the children's needs. His Foundation knowledge (Rowland 2009) was sound. However, a limited capacity to transform the lesson was not supported by appropriately manageable connections for the children. Rowland's fourth quality, Contingency, was also absent.

It appeared that the ability to respond to children's comments was marginalised by two things. Firstly, his own agenda seemed to take priority. Thus, the children's comments in some ways were seen by him as slowing his delivery. Secondly, he seemed to feel burdened by the gulf between what he knew and all the things he could detect that the children didn't. He couldn't provide manageable learning experiences in a way that addressed misconceptions to help the children learn.

One might argue he may move from a "transmission" based approach to a "connectionist" (Askew 1997, 31) one. His own reflections suggest this moment is not imminent.

Teacher C (Maths A Level with Statistics- Grade A). She remembers very little dialogue from her own schooling. She feels enthused by the modern emphasis on mental calculation. She feels lots of different, connected experiences may help children to make connections. She was seeking to use open ended questions to develop children's understanding rather than just teaching to achieve the right answer.

Such a willingness to hear Year 1 children's voices and allow them to make connections came through in her teaching in a number of ways. The style of a number of her questions was very open

> What do you know about money? (Lesson 1).
>
> How might any of this equipment help us in our work? (Lesson 2).

She invested a lot of time hearing children's different responses. In her summer lesson in number work she had located every conceivable resource the school possessed (some of which the class teacher had never seen before). She was in the middle of allowing the children to access all of it over a 3 day period. She was aware of what came to pass, namely that the children needed time simply to explore the equipment for a period of time on their own terms. She allowed this to happen before refocusing children on the task.

She already possessed, in part at least, Ma's (1999) notion of "embedded knowledge"- an awareness of what children need to know and questions and experiences that might help them get there. She also had one other notable quality. Even on the first observation she revealed that this research observation "liberated her". She trusted the process. I wasn't there to judge but as an interested (and maybe knowledgeable) observer. She wanted to experiment, to try things out and to engage in dialogue. This again conjures up images of Ma (1999) defining the ongoing interest in debating mathematical issues , present in so many Chinese teachers but comparatively few American or British ones. She mentioned the constraints of school policy, the need to avoid embarrassment when being observed formally, as constraints. Indeed, it would take a confident trainee to digress too far. Overall I felt Teacher C was confident. Her knowledge and experimentation would, I felt, bare fruit soon.

Teacher D (B Grade- Maths GCSE) Her mid course audit placed her as the weakest of the five. However, in terms of generating engaging lessons and facilitating learning to develop relational understanding I felt she was much higher. What did she do to make me feel that real connections were being made by the children?

She researched thoroughly. She had made herself enough of an authority on the content knowledge of the areas being taught. She allowed enough time to be spent clarifying understanding and addressing misconceptions.

The pace of her lessons meant children were stimulated, receptive and engaged through clarity and appropriateness of task. Her knowledge had limits. She had been unaware of all the connections possible in the task for her most able children and yet, even in her first teaching practice had been smart enough to buy herself two minutes to explain the task after she had sent the rest from the carpet to work.

By the summer her work in a challenging year 2 class also bore fruit. The main lesson developed children's understanding of arrays. They had tackled word and number problems after her modelling. Yet Teacher D wanted to allow further connections to be made through a different plenary experience. Her Plenary focused on a solution to a problem that needed to be explained so that the children could become used to starting at different points in a problem. She had excellent pedagogic teaching skills as well as excellent awareness of factors affecting achievement in maths. This differs from SK.

Teacher E (GCSE Grade D Maths) She developed a negative attitude to mathematics at school, and low self esteem. Despite improvement she fears what she doesn't know

A weak first observation in Year 1, (Data Handling Block Graphs) revealed a lack of confidence in behaviour management and planning as well as a lack of understanding as to how to set up experiences where learning by discovering was possible.

By June she was composed, organised and had made clear strides forward in her behaviour management strategies. She modelled visual representations of methods outlined by year 5 children, solving addition problems.

Progress

Such teacher progress in terms of, particularly, generic teaching strategies used, is not uncommon on the PGCE course. In addition, managing learning experiences for the children in terms of pitch, style and content are areas where a lot of students make pleasing progress. Teacher E mirrors this. By the Final Teaching Experience the majority of students were making connections, learning from doing (and through making mistakes). Trainee teachers learn to understand what learning is rather than providing activities. They may have started to assess what children do and don't know.

Focus interview – July 2010

The agenda relate to trainees experiences of teaching maths, what had helped or hindered and what they thought was important. Several notable points emerged from the trainees discussion.

They spoke of a growing understanding of children's physical and intellectual needs mentioning visual and concrete support and basis for learning. In addition to active learning they also spoke of the need to develop thinking through questioning children; allowing children to discuss work and to articulate their thoughts. On a practical note they identified the need to find time to research, prepare and plan both the lesson and its' intended goals. They also discussed the impact of differing attitudes among the class teachers whose classes they had been in. It was felt school

policies, ethos and class teacher insecurities had meant different levels of encouragement and expectation had been present in the 4 different school classrooms.

Finally they identified the ability to respond to the unexpected comment or discovery, from a child, as a skill to strive for; both to help children make links but also to allow them to become actively involved in their learning. This has clear links with "Contingency"(Rowland 2009). Teacher E saw this as a long term goal to aim for. She would sometimes divert the conversation if children were commenting in ways she, personally, found difficult to evaluate or link to her planned lesson.

Points emerging from research

Pulling together the threads from this research, trainee mathematical knowledge, and received teaching style, impacted on teaching. Those who learnt instrumentally had to adapt more.

Not all trainees have weak subject knowledge (witness Teachers B and C). In addition their general, pedagogic teaching skills often develop quite quickly in the second part of their PGCE (witness Teachers D and E).

However, it appears to take Trainees with more "instrumental" (Skemp 1976) understanding longer to prepare for lessons and to create meaningful learning situations where children can learn to make connections. Even among teachers with good subject knowledge, if it is not accompanied by reflective teaching skills that embrace child development then some of the impact may be lost.

At this point I am left with the idea that very effective and reflective teaching skills could be more effective than, say, good or very good subject knowledge if the teacher has what I am terming Good Enough Subject Knowledge (GESK) to scaffold their own development from: the willingness and confidence to advance less developed understanding through research, discussion with children and clearly through their own general professional development, highlighted by Askew (1997).

However quality professional development in maths is not an easy area to access. The newly qualified teacher also has many demanding transitional challenges to make. Insecure subject knowledge is often addressed through safe maths teaching, which targets transmitted teaching, and often develops instrumental understanding.

Supporting trainee teachers

The emphasis (in maths teacher training) to develop awareness of efficient mental calculation and models and images, that can scaffold the transition from concrete to abstract thinking, is often helpful to less confident trainees. It models and clarifies the areas they will seek to support children in. Time is invested in focusing trainees on the area of assessing children's responses and linking mistakes to misconceptions that can be addressed and overcome.

A wider range of maths lessons available on video would also help. Analysis of good teaching that engages, clarifies understanding and facilitates active thinking would model effective teaching and provide a basis for effective group planning and discussion, including the use of misconceptions. This would support the Post Williams (2008) MAST Math Teaching Programmes that are currently supporting existing teachers to possess deeper mathematical understanding to support colleagues in schools.

Relevance of research

Thus, this research aims to support previous attempts to define the attributes and style of effective maths teaching. Instrumental (Skemp 1976) teaching and learning still dominates most primary classrooms. The coining of the term GESK is relevant for two reasons. Without defining the extent of subject knowledge needed it acknowledges its' relevance to other content and pedagogic skills. It also gives hope to a significant percentage of anxious trainees who are all too aware of their insecure and underdeveloped knowledge. This knowledge is, in the main, understood in an instrumental way. Trainees can see their own mathematical understanding as a work in progress: This means that the possession of "Good Enough" understanding can be either a goal that they can work towards (as quickly as possible in some cases) or it can be a starting point from which to deepen their understanding further.

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