TEACHERS = INTERPRETATIONS OF EFFECTIVE WHOLE CLASS INTERACTIVE TEACHING

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Abstract: With the increasing interest in improving standards of numeracy, eight mathematics teachers from four Welsh secondary schools formed a teacher inquiry group to research the effectiveness of introducing whole class interactive teaching strategies into their own practice. Possible teaching approaches and activities were developed and agreed during group meetings. These were trialled by the teachers during their normal mathematics lessons. Lesson observations, interviews with teachers, and discussions at the group meetings, however, indicated that the implementation of the approaches varied significantly across teachers. This paper analyses the differing interpretations and related teaching styles and discusses their impact on the quality of the classroom discourse. The determining features discerned within the classroom dialogue included the extent to which pupils were encouraged to reflect on their mathematical knowledge, and the ways in which teachers were able to scaffold pupils' learning.

Concern over the standards of mathematics in schools in England and Wales, in particular what the media describes as pupils' inability to do "basic numeracy", has led to the introduction of a National Numeracy Strategy (NNS) within a framework for teaching mathematics, (DfEE, 1999; 2000). Introduced into English primary schools (pupils aged 5-11) in 1999, it has since been extended into the secondary phase.

The definition of numeracy proposed for primary schools by the NNS refers to a broadly based practical skill which includes "confidence and competence with numbers and measures... a repertoire of computational skills and an inclination and ability to solve number problems in a variety of contexts" (DfEE,1999 p4). This is extended in the secondary document to include other aspects of mathematics, especially algebra. This echoes earlier definitions (e.g. Crowther, 1959; Cockcroft, 1982; Mathematical Association, 1992) which argue that numeracy requires not merely a secure knowledge of numerical facts and processes but also the capability and disposition to construct personal approaches to the solution of problems which are appropriate to the context and are based on knowledge of individual strengths and weaknesses. To be numerate is to be able to mathematize situations, using techniques and processes which are confidently known, to generate a secure answer. Numeracy, therefore, is taken here to involve an interaction between mathematical facts, mathematical processes, metacognitive self-knowledge, and affective aspects of mind including self-confidence and enjoyment of number work.

The NNS details what mathematical content should be taught and recommends that lessons should be structured into three parts: a mental and oral session; the main teaching activity; and a plenary to end the lesson. Although examples are provided of what these phases are intended to involve, they are open to a variety of interpretations. For example, the main teaching activity is required to include "direct teaching and interactive oral work with the whole class and groups; and an emphasis on mental calculation" (DfEE, 2000 p10). This emphasis on direct whole class interactive teaching is one of the strongest and probably one of the most radical recommendations in the Strategy. Yet it is possible, as the Strategy acknowledges, to interpret this in a variety of ways so that some teachers may assume that they are already teaching in the recommended style. The intended meaning of the phrase is elaborated as:

> High quality direct teaching is oral, interactive and lively. It is not achieved by adopting a simplistic formula of "drill and practice" and lecturing the class, or by expecting pupils to teach themselves from books. It is a two-way process in which pupils are expected to play an active part by answering questions, contributing points to discussions, and explaining and demonstrating their methods to the class.
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> (DfEE, 1999 p.11)

Whilst many lessons may already exhibit some of these features, it is the quality of the classroom processes which is at issue here. Research provides clear indications as to those factors which lead to effective teaching and learning of mathematics. These include the use of higher order questioning; the setting of challenging tasks which require pupils to think; requiring pupils to explain and discuss their own mathematical ideas; and collaborative problem solving (Askew et al, 1997; Brown et al,1998; Jones, Tanner and Treadaway, 2000). Our previous research into the effective teaching of mathematical thinking indicated the importance of dynamic scaffolding and reflective discourse where pupils were expected to articulate and discuss their own methods and conjectures within a supportive classroom culture (Tanner & Jones, 1999).

Learning to think mathematically is more than just learning to use mathematical and numerical techniques although acquiring fluency with these tools is clearly an element. Mathematical thinkers have a way of making sense of information - a way of perceiving, analysing and representing their world, and a willingness to engage in the practices of mathematical communities. Although mathematical “sense making” may derive from constructivism, developing a mathematical viewpoint is more akin to enculturation into a community. These two viewpoints need not be mutually exclusive and it is argued here that teacher and pupils interactively generate the culture of the classroom through negotation and communication (Bauersfeld, 1994). Within this perspective, pupils learn by participating in a “culture of mathematising” which is characterised by subjective, personal reconstruction of knowledge through the negotiation of meaning in social interaction (Bauersfeld, 1988). Articulation within this context provides an opportunity for pupils to test their understandings for viability against corporate meaning, it also contributes to the generation of corporate meaning by providing a further opportunity for construal to other members of the class. Whilst listening to pupils describe their methods, individuals may contrast the interpretation being offered with their own thoughts and modify them appropriately (Clarke, 1994).

This requires a form of teaching and learning which encourages a “discourse of inquiry” where people can communicate freely in search of understanding each other and in order to solve shared problems: such a culture would aspire to being an “Ideal Speech Situation” (Habermas, 1979 in Young, 1992). Within such a culture, pupils would be empowered to pursue issues of personal significance to them, appropriating the conventions of mathematical thought, transforming their existing knowledge, and publishing their own constructs for testing against the approval of the group (Harrϑ, 1983; Stables, Morgan & Jones, 1999).

The unequal power relationship between teacher and taught makes a genuine discourse of inquiry difficult to achieve in schools (Young, 1992). The teacher’s comments carry great weight. What is significant is the way that this is expressed in action (Cobb et al, 1992). Two qualitatively different forms of interaction may be used to scaffold pupils’ learning: funnelling and focusing (Bauersfeld, 1988; Wood 1994). In funnelling it is the teacher, as the person with the expert knowledge, who selects the thinking strategies and controls the decision process to lead the discourse to a predetermined solution. In focusing, the teacher's questions draw attention to critical features of the problem which might not yet be understood. The pupil is then expected to resolve perturbations which have thus been created (Wood, 1994 p160).

However, scaffolding is a problematic construct for application to classrooms as it was originally designed to explain learning in individualised situations. Nonetheless, research suggests that scaffolding does not have to be optimal for each pupil in order for learning to occur (Wood & Wood, 1996 p7). Criteria for scaffolding to occur successfully include a classroom culture where teacher and pupils can work jointly on problem-solving activities in a conjecturing atmosphere (Mason & Davies, 1991) and teachers who are able to draw on their subject knowledge to identify more than one way to achieve the desired learning outcomes and hence to follow the learner's path (Askew et al, 1995; Wood & Wood, 1996). The ability of teachers to scaffold successfully in this dynamic fashion has been documented in an experimental study designed to enhance mathematical thinking (Tanner & Jones, 1999).

The most successful teachers in this study did not rely solely on dynamic scaffolding, however, but encouraged pupils to reflect on what they had learned. When reflective discourse is encouraged within a classroom, teachers can be pro-active in encouraging construction, focusing the attention of students on significant aspects of the discourse for collective reflection. What was previously done in action can then become an explicit topic for discussion and thus participation in this type of discourse constitutes conditions for the possibility of mathematical learning (Vygotsky, 1978; Cobb et al, 1997).

The study reported here explores teachers’ interpretations of these recommendations from research in the context of the approaches advocated by the National Numeracy Strategy.

METHODOLOGY

In the spring of 1999, as the NNS was being introduced into primary schools in England, an action research group was formed of eight teachers from four secondary schools in South Wales. The aim of the group was to explore the potential of the Strategy's recommendations for enhancing their own practice with pupils in the first two years of secondary school. The project lasted for five months during which the group met monthly to develop, trial and evaluate teaching strategies. Participant observations of lessons were undertaken to record the types of teaching approaches being used. Over half of the observed lessons were also videotaped. Before and after each lesson observation the teachers were interviewed to ascertain their aims for the lesson and to discuss their evaluation of it. Teachers were also interviewed in depth after the end of the project to discuss its impact and the results. (Pupils were also tested before and after the project but these results are beyond the scope of this paper.)

THE DIFFERING APPROACHES AND INTERPRETATIONS

Teachers interpreted the discussions about the key features of the NNS and the strategies agreed in the group meetings in a variety of ways. However, we will focus here on the quality of the discourse that developed within the classrooms and the strategies used to encourage reflection.

Types of classroom interactions

In every classroom pupils were encouraged to contribute their ideas and to explain their methods to the class. The class atmosphere was supportive and pupils were eager to contribute and willing to go to the board to demonstrate their approaches. Every teacher considered their pupils to have become far more confident about their mathematics. Mathematics lessons were judged to have become "more fun" and to have more "street cred" in the pupils' eyes:

> Maths has become a "buzzy" place. They become really involved – it's become quite exciting for them.
>
> They are far more confident, willing to get involved, willing to have a go and discuss things, putting their own views forward even if the rest of the class don't think that way. It's really great – they've come on a treat!

This articulation by pupils of their own methods was not unproblematic. It took far longer than an explanation given by the teacher and this led to concerns about "getting through the syllabus". There was also a tension between the teacher's wish to encourage pupils' confidence and involvement by accepting their contributions uncritically and the need to progress to more mathematically acceptable strategies. To overcome this, some teachers struggled to debate each proffered method in full, thereby often running out of time. In an attempt to maintain the pace and focus of the lesson other teachers funnelled pupils towards pre-planned strategies thus signalling that pupils' own methods were really incidental - the "proper maths" was that told to you by the teacher. These teachers subsequently reported, however, that their pupils tended to revert to their original, informal strategies.

Other teachers were able to share their criteria for evaluating methods explicitly with the pupils, as this lesson extract illustrates:

Teacher: Give me a number between 2 and one-third and 2 and a half.
Pupil: Miss, 2 and three-eighths.
T: *(In a non-evaluative tone)* How do you know? Can you convince me that you are right?
Pupil goes to the board and draws "fraction cakes" - circles divided roughly into halves, thirds and eighths.
T: (*To the class)* What do you think? Is he right? Are you convinced? *(Some nods from class)*
Pupil 2: But, ... the fraction parts need to be exactly the same size really ...
T: Yes, they should be, shouldn't they. If you could draw them accurately then maybe that would be OK but with just rough sketches on the board I'm not convinced ... Can we find a more precise way to show it?
Pupil 3: Miss, we could change them to decimals ... *(and the pupil is invited to the board to demonstrate the conversion)*
T: What do we think about that method? Is that OK? .... Yes? OK, any other ideas?

Pupil 4: Change them to a common denominator ...*(and the pupil is invited to the board to demonstrate this and a similar evaluation follows.)*

Teaching in this fashion requires the selection of suitably challenging questions and accurate anticipation of the likely responses. For some teachers, however, the variety and calibre of pupils' individual methods was unexpected:

> Getting them to explain their own methods has been a bit of an eye-opener - it was surprising how many ways they were doing it and that I wasn't aware of. It's opened a can of worms from our point of view!

The legitimisation of the pupils' own mathematical thinking was explicitly emphasised in some classes with activities which required them to adopt the teacher's role. Explanations offered by pupils were focused on by the teacher to generate the notes to be copied into their books, or to provide further problems to be explored. Pupils were encouraged to take a sceptical role, to ask "Why?" and "How do you know ...?" of the teacher as well as each other. They were challenged to identify and to correct (deliberate!) mistakes made by the teacher during explanations or worked examples. As the pupils explained *why* the mistake had been made: - "you multiplied instead of squaring and you forgot to change the sign so you put $(-3)^2 = -6$ instead of +9", the attention of the class was drawn to common errors. Several teachers taught pupils to mark such errors with a "hazard sign" in the margins of their work and to try to predict, before starting a task, where such "danger points" might occur.

Such strategies helped pupils to "stay with the teacher", to monitor the discussions and to contrast them with their own understandings. This helped pupils to understand the mathematical explanations but, more importantly, it created a sense of involvement and ownership within the classroom culture. As one of the teachers expressed it – "my aim was to avoid [pupils] simply being in on the action but to create some of the action for themselves, in order to participate."

Developing strategies for scaffolding

Whenever a range of strategies had been described by pupils all the teachers encouraged the class to choose the methods "they felt more comfortable with and were most efficient". A comparative evaluation of the merits of each approach was often done "in the action" at the end of the discussion phase and as the lesson moved on to a seatwork exercise. This left little time for pupils to reflect on the advantages of each approach and relied on them being able to evaluate strategies as they were being described. Little scaffolding was available to help the pupils.

Some of the teachers developed approaches which provided focusing scaffolding and created opportunities for reflection during the lesson. One approach was a variation on "Start-Stop-Go" - a technique developed in an earlier project (see Tanner & Jones, 1999 for details). Pupils were set a problem and asked to think individually about what information they would need and how they would attempt to solve it. After a few minutes they discussed their ideas in small groups whilst the teacher circulated probing their ideas. A number of groups were then asked to report their ideas which were brainstormed on the board. A teacher-led whole-class discussion was then used to identify key features in the possible approaches. Finally, each group was asked to decide on a strategy and proceed to solve the problem. Having attempted to think through the problem initially, the small group discussion helped pupils to generate and to evaluate strategies. The class discussion allowed the teacher to focus pupils' attention on key features and the merits of particular strategies without dictating a set approach. Pupils seemed able to appreciate the relative merits of the different approaches and these teachers reported that the pupils internalised the more effective methods into their personal mathematical repertoires.

Another effective strategy was to ask pupils to explain, in their own words, the method just suggested by another pupil. Pupils who struggled to find appropriate terminology to convey their thinking could be scaffolded by the suggestions of others. The pupils who tried to re-explain someone else's thoughts had to analyse the explanation in order to compose their own attempts. And, whilst so doing, they also had to reflect on how that explanation compared with their own mathematical knowledge. Throughout this the teacher would intervene as necessary to focus attention on key features of the mathematics.

Plenaries

Every teacher tried to finish her lessons with a plenary session. However, as we found in previous studies, all too often teachers talked of the plenary they would have had if only the bell hadn't gone! Two teachers struggled to find the time for regular plenaries. As one of them explained:

> I have got to confess my plenary still needs working on ... when I do them they work well but ... it's making that effort to stop before the bell goes. I am convinced it is the way to go. It's just changing old habits.

For two teachers the plenary always followed the format: "Write down three key things which you have learned this lesson", which led to this observation from one of them:

> At the end of the lesson, when I asked them [pupils] to write their summaries, after a couple of times they would groan. They didn't like doing it. They had to think "What did we do today?" and they had to learn how to explain that.

It is possible that the pupils groaned in anticipation of hard work. Alternatively, the groans could be an indication that they were unable to reflect on and evaluate their learning unaided and that more scaffolding was needed to assist them to do so.

The other teachers perceived plenaries to be a crucial factor in pupils learning and developed a variety of strategies to help pupils to reflect on what they had learned and what still needed clarification. One approach was to ask pupils to go back through their work and report on one or two things they had marked with the "hazard signs". The subsequent class discussion of these focused on what particular features of the task, or the pupil's own mathematical knowledge, had contributed to making them difficult. An extension to this approach was the question: "If I now had to teach this topic to your best friend's class, what warnings would you give them about it?" This provided formative feedback to the teacher about which aspects had been problematic and possibly needed further work. Another popular strategy was to ask pupils to use what they had learned about the topic to write the hardest problem they could, accompanied, of course, by its solution! Pupils would then exchange problems and, finally, any particular difficulties would be discussed as a class. Each strategy requires individuals to reflect but provides scaffolding through the discussions and the focusing questions asked by the teacher.

The on-going reflection that occurred during the whole-class brainstorming of pupils' explanations was developed into a plenary activity known as "Dear Diary". This included a writing frame to structure pupils' responses and to help them to compare alternative approaches. As the pupils became more expert in writing the diaries, after a brief class discussion of the key points, they would complete their diaries for homework. This provided another opportunity for delayed reflection and helped to consolidate pupils' metacognitive knowledge.

Conclusion

Every teacher was able to implement approaches which could be described as "whole class interactive teaching". The quality of the interaction, however, varied between teachers and was found to depend on the types of scaffolding used; the opportunities created for reflection; and the degree of pupils' ownership - the extent to which their articulated thoughts influenced the classroom processes. As two of the teachers explained in the final interviews:

> My lessons are [now] less didactic, with their content and direction being led to some degree by the class whilst I constantly appraise the learning as it takes place.

and:

> The culture in my classroom is now one where children feel at ease to develop their own methods, have the confidence to participate in discussion, and view mathematics as fun and achievable.

Underpinning these factors appears to be the teacher's ability to anticipate the possible responses and errors that might arise, and their confidence to "go with the pupils" whilst still steering the lesson to achieve its objectives. It is these pedagogical abilities which need to be enhanced in order to improve the quality of teaching and learning.

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