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Identifying and describing teachers' scaffolding practices in mathematics

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Significant developments in our understanding of how children learn mathematics have prompted renewed interest in the role of the teacher in mathematics classrooms. A recent study, aimed at identifying and evaluating a range of numeracy teaching approaches in a structured sample of Victorian primary schools, demonstrates the efficacy of a structured process of peer observation and review as a powerful means of making explicit what teachers know and exercise intuitively in the context of primary mathematics classrooms. As part of this study, three groups of teachers participated in an activity referred to as Behind-the-screen. Teachers took turns to teach a small group of children from their own class in a room with a one-way mirror. Observing teachers were asked to comment on what they noticed and suggest labels or metaphors that captured the essence of the teacher's communicative acts. Analysis suggests that this technique is a valuable tool in identifying and describing scaffolding practices in mathematics teaching and enhancing teachers' understanding of their professional practice.

Background and context

The research to be reported here represents a small but significant part of the *Researching Numeracy Teaching Approaches in Primary Schools Project 2001-2003* (see Acknowledgements). The project had its origins in the *Early Years Literacy Research Project* (see Hill & Crévola,1997 in the reference list at the end of this paper) which demonstrated the effectiveness of a small number of generic teaching strategies on the development of young children's reading and writing. More commonly referred to as the literacy teaching approaches (see State of Victoria, 1999), they were differentiated by the relative levels of teacher support and student independence. For instance, the teaching approaches known as *modeled reading* and *modeled writing* are considered to involve high levels of teacher support and low levels of student independence. *Shared reading* and *shared writing* are used to refer to a more collaborative relationship between the teacher and the students, and *guided reading* and *guided writing* are regarded as teaching approaches that involve low levels of teacher support and high levels of student independence.

While three of the more generic of these approaches were advocated for teaching mathematics in Victorian schools, specifically, *modeled mathematics, shared mathematics* and *guided mathematics* (see State of Victoria, 2001); there was a need to identify and describe these in more detail and to evaluate their efficacy in practice. Researching numeracy teaching approaches also had the potential to contribute to the development of a coherent and consistent way of enacting and talking about the complex practice of teaching mathematics in a variety of settings to meet a range of different learning needs.

As a consequence, the *Researching Numeracy Teaching Approaches in Primary Schools* project was set up to research numeracy teaching practice through the identification of effective classroom teaching approaches in mathematics for students in Years Prep to 6 in a range of Victorian schools including a Special School and their potential for improving student outcomes.

Basis in theory

Apart from their origins in literacy, the notion of 'numeracy teaching approaches' can be grounded in theory and research more generally. For example, it is widely recognised that teachers play a vital and significant role in students' learning (Cuttance, & Stokes, 2001;

Siemon et al, 2001); that focussed time-on-task is most consistently linked with pupil achievement (eg, Brophy & Good, 1986); and that childrens' development is enhanced through social interaction with others who have expertise (eg, Vygotsky, 1978; Wertsch et al, 1995).

More particularly, current interactionist perspectives on the teaching and learning of mathematics acknowledge the reflexive relationship between classroom culture and the individual construction of meaning (see for example, Voigt, 1995; Lerman, 1998; Cobb & McLain, 1999). While recognizing the inherent interdependence of teaching and learning, such a view points to the need for a deeper understanding of the ways in which teachers contribute to the shaping of those cultures and the interactions that occur within them (Bauersfeld, 1995).

> As an agent of the embedding culture, the teacher functions as a peer with a special mission and power in the classroom culture. The teacher, therefore, has to take special care of the richness of the classroom culture – rich in offers, challenges, alternatives, and models, including 'languaging' (Anghileri, 2002, p.283)

One of the ways in which the teacher's role has been conceptualized is through the use of the metaphor of scaffolding which according to Anghileri (2002),

> was first used by Wood et al (1976) to explore the nature of adult interactions in children's learning, in particular, the support that an adult provides in helping a child to learn how to perform a task that cannot be mastered alone (Anghileri, 2002, p.49)

This is consistent with Vygotsky's (1978) notion of the Zone of Proximal Development (ZPD) which suggests an inverse relationship between teacher support and student independence. Students who are most dependent on teacher support might be expected to be working at the margin of their ZPD, requiring the teacher to model, prompt, demonstrate, or coach, in order to come to new understandings and insights. Students who are least dependent on teacher support might be expected to be operating well within their ZPD, requiring little or no intervention from the teacher, and accessing a range of appropriate metacognitive strategies to monitor their own learning. In this case, a different set of teacher actions might be invoked, for example, reflecting, celebrating, inviting and listening.

Different levels of scaffolding have been identified in the situated cognition literature. For instance, Rogoff (1995) identified three qualitatively different 'planes of socio-cultural activity' in an out-of-school setting which she referred to as *apprenticeship*, *guided participation*, and *participatory appropriation*. The different levels trace the development of an individual within a socio-cultural enterprise from dependent novice to independent practitioner. A similar three stage model was proposed by Brown, Collins and Duguid (1989) to describe the gradual progression from embedded activity to reflective artisan.

In a seminal analysis of teachers' scaffolding practices in mathematics, Anghileri (2002) distinguishes three levels of teacher support. Level 1 scaffolds tend to refer to those prompts and stimuli that exist in the environment, either as a result of conscious planning or by default, that serve to support student learning in mathematics. These might take the form of a poster recording generalisations or key observations from past lessons, carefully chosen, self-correcting games, engaging tasks or puzzles, materials/manipulatives, and/or mathematical tools. In this case, the teacher's immediate involvement might be low but the level of support might be described as high depending on the thought and effort expended by the teacher in deciding which displays, tasks, and materials would be made available. Level 2 scaffolds involve

> direct interactions between teachers and students specifically focussed on the task in hand. Such strategies vary from direct instruction – showing and telling – to more collaborative meaning making" (Anghileri, 2002, p.51).

Scaffolds at this level, according to Anghileri, include the types of interaction patterns commonly found in 'traditional' approaches, that is, where the teacher retains control,

structures conversations, elaborates, and explains. But, they also include two categories of practices that involve students more directly in the enterprise, that is, reviewing and restructuring.

Level 3 scaffolds aim to make connections between students' prior knowledge and experience and the new mathematics to be learned. Developing representational tools and generating conceptual discourse are the two areas considered here. By negotiating social norms and values that value conceptual (as opposed to computational) explanations,

> students are likely to engage in longer, more meaningful discussions and meanings come to be shared as each individual engages in the communal act of making mathematical meaning. (Anghileri, 2002, p.56)

This is indirectly supported by Turner et al., (1998) who compared high and low involvement by teachers, and reported that a 'higher press for understanding' - characterized by the determination of the teacher to keep working with students until they appreciate the relevant connections, applications, generalisations and extensions - was associated with greater involvement of students in mathematics classes.

In Anghileri's (2002) framework, teacher support appears to be conceptualised in a different way to that evident in both the literacy teaching approaches and the situated cognition literature where learners are much more clearly recognised as inductees into a specific socio-cultural practice (reading, writing, making cookies, learning how to become a tailor etc). The practices outlined in Levels 2 and 3 of Anghileri's framework tend to be focused much more specifically on qualitatively different interaction patterns. This is perhaps not surprising given the diversity of practices embraced by school mathematics, but it offers another, possibly more useful, way of talking about the nature of the teacher's role in shaping classroom communication and culture.

In the past, much of the work on classroom communication has tended to focus on turn taking and the "almost incessant repetition of the sequence I(nitiation) – R(esponse) – F(eedback) in teacher pupil exchanges" (Pimm, 1994, p.138). While there are some limitations of this work, it has established that teachers and students reflexively learn how to communicate in classrooms in very specific ways, in particular, they learn who can say what, when and to whom. This suggests that while teachers might adopt a particular interaction pattern intentionally, such 'moves' will only be effective to the extent that the 'new language game' is appreciated and understood by students (Morine-Dershimer, 1985; Zevenbergen, 1996).

Wood (1994,1996) has written extensively about the *funnelling* and *focusing* 'patterns of interaction' observed in Year 2 mathematics classrooms. She makes the point that these patterns of interaction are alternatives to the traditional I-R-E interaction. Both operate to enhance rather than constrain student learning and "serve the teacher's central intention of trying to create learning situations which enable students to construct mathematical meaning for themselves" (Wood, 1994, p.159).

> The funnel pattern, can generally be described as an interaction in which the teacher creates a series of questions that act to continually narrow the students' possibilities until they arrive at the correct answer. In this situation, the teacher recognises that the student is unable to respond appropriately with the correct answer, and therefore attempts to offer guiding questions for the purpose of enabling the student to solve the problem…. This form of exchange always ends with a solution to the problem at hand.
>
> The focus pattern can also be described as a situation in which the essential aspects for solving a problem are brought to the fore. Furthermore, this pattern of interaction can be described as one which the teacher's inquiries act to indicate to the child the critical features of the problem that are not yet understood. … In this particular interaction, students always have some aspect of the problem still to solve. (Wood, 1994, pp.159-160)

In common with the scaffolding levels described earlier, these interaction patterns can be seen to be representing different levels of teacher support. That is, as the student's level of

understanding increases, the level of teacher support diminishes. However, the nature of this support is much more clearly framed in terms of teacher-student interactions.

Given the emphasis on classroom interaction in the mathematics education literature, it was agreed that, for the purposes of the project, the notion of numeracy teaching approaches would refer to the communicative acts engaged in by teachers as they sought to scaffold students' numeracy learning in the context of Prep–Year 6 classrooms. In particular, how teachers supported students to make conceptual connections and understand their own learning process.

The *Researching Numeracy Teaching Approaches in Primary Schools Project* was conducted in 16 Victorian primary schools including a special school between October 2001 and December 2002.

Research questions addressed by the study were:

(i) What are the key components of teaching approaches that lead to improved learning outcomes for numeracy in the primary years of schooling?

(ii) If teachers implement a defined suite of numeracy teaching approaches does this result in improved learning outcomes for students?

(iii) How can these teaching approaches in numeracy best be described to support teachers to implement them effectively in their primary school classrooms to improve student learning?

Methodology

The 20 month project was essentially set up as an action research study (see for example, Kemmis & McTaggert, 1988) where teachers in the 16 research schools were expected to focus on the nature of their communicative practice as they supported students making connections in their mathematics learning. The research team was responsible for working with teachers from the research schools as they enacted their action plans. This took the form of school and classroom visits as well as a number of Statewide Action Research Meetings. Student data in the form of sample-based interviews were collected by commissioning authorities at the beginning and end of the project from both the research schools and a matched set of reference schools in order to evaluate the effectiveness of the proposed numeracy teaching approaches.

In an effort to better understand the nature and effectiveness of the teaching approaches or communicative acts, the research team collected a range of data based on an interactionist model developed by Clarke and Peterson (1986) and elaborated by Sullivan et al (2002). Specifically, data on teachers' beliefs and understandings, perceptions of opportunities and constraints, and teaching intentions and actions, were collected using a range of task-based activities, surveys and interviews. Additional information was derived from field notes of classroom observations, case-studies of individual teachers and the records of a 'Behind-the-screen' activity, which involved the structured observation of up to 16 teaching episodes by a group of teachers facilitated by members of the research team. This paper will report on one aspect of the data collection, the derivation of the scaffolding practices from the 'Behind-the-screen' activity.

Working 'Behind-the-screen'

The Behind-the-Screen activity (or BTS as it became known) had its origins in Reading Recovery training (see Clay 1993) where a trainee Reading Recovery tutor works with a student behind a one-way mirror while up to twelve other trainees observe and listen to a commentary provided by a certified trainer. The trainer labels important aspects of the teacher's practice and asks questions of the group such as "How would you describe what was happening there?", "What else could she have done at that point?" and "Why did she pause?" Unsolicited observations are made from time to time by some of the trainees. To the

naïve outsider the session is very intense with a significant amount of specialist terminology used to describe the teacher's actions and perceived intent.

For the purposes of the project, a modified version of the Behind-the-Screen activity was developed to support a much more finely-grained, intensive study of the communicative acts engaged in by teachers as they sought to scaffold students' numeracy learning. In this case, teachers took turns to engage with a small group of students in front of their peers (who were literally 'behind' a screen or one-way viewing window). Observing teachers were introduced to a range of possible approaches at the outset but were also encouraged to use their own words, labels or metaphors in-the-moment to capture the essence of the observed student/teacher interaction or scaffolding practice. The essential purpose of this technique was to explore the principles of the teaching approaches in more detail and to arrive at ways of describing teachers' communicative acts that resonated with teachers' experience. In common with Reading Recovery training, this was not meant to be a critique of the teacher, but an in-depth, focused exploration of the nature of the specific teaching and learning processes embodied within a particular teaching approach or set of communicative acts.

Two clusters of 3 research schools were selected to participate in the BTS activity based on their proximity to one another and access to a suitable venue. This resulted in a metropolitan cluster and a regional cluster. A special school was included in the regional cluster. Three teachers from each school participated in the BTS sessions. As far as possible, there was one teacher from P-2, another from Years 3-4, and a third from Years 5-6 from each school. Another research school in a relatively remote coastal town was also selected to participate in this activity based on their willingness to explore a video-based adaptation of the BTS activity for schools without access to Reading Recovery facilities. In this case, one teacher from each grade level was involved in the BTS group.

Members of the BTS groups met from 9:30 am to 12:30 pm on seven occasions over the course of the 2002 school year and on one additional occasion in Term 1, 2003. For the two cluster groups, the BTS sessions occurred in a Reading Recovery facility behind a one-way mirror. The students, usually 4 students of 'near' or 'mixed ability', were transported to and from the facility by a parent or a senior member of the presenting teacher's school. For the 'remote' group, the BTS activity was adapted using digital video of the teacher in his/her classroom being transmitted through the school's intranet to the library where the remaining 6 teachers (one from each grade level in this instance) observed and discussed the teaching episode on a large monitor. Each teaching session was preceded by a briefing session and followed by a reflective discussion. Observing teachers were expected to comment on what they noticed and suggest labels or metaphors that captured the essence of the communicative act observed. These were recorded on a specially designed form, the BTS Observation Record, together with what the observer regarded as evidence of the particular act observed. Table 1 outlines the procedure that was followed by each BTS group.

Table 1

Structure of a Behind-the-Screen Session

Time	Description	Record
9:30	Briefing - A Summary of the BTS Observations from the previous session was distributed and discussed briefly. The two teachers scheduled to teach in front of their peers distributed a summary of their lesson using the Teacher Intentions Form, briefed the group on key aspects of the lesson (e.g., focus, rationale, group composition and background, summary of planned events, connection to what is being done at school, resources), and answered any questions.	Summary of BTS Observations TIS Forms
10:00	First teaching episode - Observing teachers commented on what they noticed, responded to facilitator's questions, offered labels, metaphors or descriptions, and recorded terms and evidence for key interactions.	BTS Observation Record 1

10:30	Debriefing 1 – the facilitator and teachers discussed what they liked and explored particular interactions with the presenting teacher. Participants recorded what was noticed and what was learnt. At the conclusion of this session, the facilitator asked the group to comment on the level of teacher support (high, medium or low) and the perceived level of student independence (high, medium, low).	BTS Observation Record 1
11:00	Break	
11:30	Second teaching episode (as per first teaching episode above)	as above
12 :00	Debriefing 2 (as per Debriefing 1)	as above

Observations were discussed both at the time and after the event, and the written records were collected and summarised by a member of the research team who was also a member of the group. The summary record was reported back to the group the next time it met for clarification and confirmation. At least two research team members attended the cluster group sessions. One research team member worked with the remote group. Audio-tapes of the teaching episodes were collected at the Reading Recovery sites. Digital video-tapes of both the teaching episodes and the related discussion were collected at the remote site.

Analysis

As indicated above, the BTS records were summarised to provide an emergent list of approaches or practices, supported by a range of exemplars. To be included on the list, a particular practice or interaction pattern had to have been observed and reported by at least two of the BTS groups on at least five occasions. As these emerged they were elaborated, exemplified and circulated to all research schools. A further level of analysis was afforded by the availability of audio-tapes for the later BTS teaching episodes at the Reading Recovery venues and the videotaping of all sessions at the rural site. Access to the tapes facilitated a cross-checking or validation procedure 'after-the-event' that matched teachers' observations to particular instances in the teaching episode. It also allowed a more reflective and considered assessment of the evidence for particular scaffolding practices. This additional layer of analysis was used to confirm what had been sensed in the earlier BTS sessions that while there was little evidence for generic teaching approaches of the type described for literacy, there was strong evidence for a range of discernable scaffolding practices. This evidence, together with the results of a *Sorting Task* completed by all teachers at the final Statewide Action Research Meeting and the *Project Impact Statements* completed at the end of the project, was used to inform the refinement and elaboration of the final list of scaffolding practices.

Results from 'Behind-the-screen'

A total of 46 teaching episodes or lessons were observed between March 2002 and March 2003 (16 at the regional centre, 15 at the metropolitan cluster and 15 at the remote rural primary school). The lessons were fairly evenly distributed over the year levels with approximately 30% at Years P-2, 37% at Years 3-4 and 33% at Years 5-6. The majority of the lessons were on Number (51%), but all other curriculum strands were represented with 20% on Measurement, 13% on Chance and Data, 9% on Reasoning and Strategies, and 7% on Space.

Inevitably, the Behind-the-screen activity evolved over the course of the 8 sessions. In part, this was due to the exploratory nature of this approach to researching teachers' practice, but it also evolved as a consequence of the accumulating knowledge, shared language and increasing confidence of the participants themselves. That is, as teachers became more familiar with the activity and each other, they began to trust and value the comments of their peers. Conversations became richer, deeper and more precise and teachers were more prepared to offer their own descriptors, labels and/or metaphors for the interactions they observed. This in turn progressively informed, expanded and ultimately refined the sense of what it was that was being observed. This is reflected in the analysis of the Records of

Observation suggesting that this is a valuable technique for elaborating the communicative acts teachers engage in as they seek to scaffold student numeracy learning. Unfortunately, due to space limitations, it is only possible to include a small extract from one teaching episode here, but it will serve to illustrate what was noticed, how it was described, and the evidence that was seen to support the observations made.

Rhonda

The teacher and her four, 'near ability' Prep students were from a primary school located in a regional centre. The aim of the lesson was to move the students on from using a 'count-all' strategy to using a 'count-on from' strategy for numbers less than 10. The lesson was conducted in Term 1.

Table 2

Lesson Overview

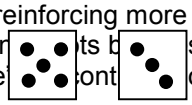
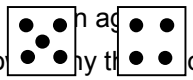
Segment	Description
1	Teacher and children counted, teacher questioning relating to more than/less than, between, revision of numerals to 10 and written numerals to 3.
2	Tossing two dice (with dots) - students looked at one die and counted on the number on the second die. Students used 'count-all' strategy. Teacher introduced 'count on' strategy
3	Bus story - teacher gave students counters and 'tens frames' in the shape of a bus, eg, six people on the bus and three more got on. Students used and identified 'counting-on' or 'counting-all' strategies.
4	Party story - teacher gave students pre-filled, sealed and labelled lolly bags, then more lollies to each student. How many lollies altogether. Students identified number of lollies in the bag, then used and identified 'counting-on' or 'counting-all' strategies.
5	Teacher gave students empty, labelled lolly bags. Students placed the number of lollies indicated in the bags, teacher gave additional lollies and students used and identified 'counting-on' or 'counting-all' strategies.
6	Students made up 'lolly-bag stories and lolly bags on their own, by selecting the number of lollies to put in their lolly bag and then selecting the number they added to their bag. Students told their lolly bag story and used 'counting-on' or 'counting-all' strategies to work out how many lollies altogether..

As the team had access to a video-tape of the replicated lesson, it was possible to provide a fuller account of the actual interactions. This was not always possible for the other *Behind-the-screen* sessions undertaken at this time.

Table 3.

Excerpt from Summary of Rhonda's lesson

Observed Teaching Approach/Interaction	Evidence (this is not a full transcript)
Discussing Reviewing	T: Do you really want to start at one? Would you like to start at 10? S: OK! [counted from 10 to 28] T: Let's count backwards from 10 S: 10, 9, 8…1 T: What would be here? S: 0 T covered 9 on the 1-100 number chart and asked "What number have I covered? Only one number is missing". S: 9
Show me/Convince me/asking	T: How do I know that 9 goes here? S: Because there's a straight line of nines…19, 29. 39 and 9 goes on top.

	T repeats this with 5 and 12, asking each time for children to explain "How do you know?"
Noticing/Drawing attention to	T showed flash cards with numerals or dots one at a time … students 'read' each number as it appeared… there is some hesitation when 5 dots are shown
	T: How do you know its five?
	S: Because its 4 here and a dot there [pointing these out]
	T: Good, there's a 4 there and a 1 there [repeating the pointing action]. What else can you see? … K?
	S: A 3 and a 2
	T: Good I can see a 3 and a 2 too.. What can you see J?
Modelling	This session continues with the teacher drawing attention to what children see in the dot representations, reinforcing more efficient 'readings', eg a 3 and 3 for 6. When students coun ts b s, the teacher models: "I can see a 3, a 3 and a 2 for that one cont on, doing this for 7 and 9 as well when they come up 
	T proceeds to dice activity, 3 and 5 thrown, teacher asks students to say what numbers are, then covers 3
Focussing	T: Is there a different way we could count? … How many altogether? Student pointed to 3 and covered the 3 with her hand – counting on.
	T: Is there a different way you could have done that? S: 1, 2, 3… T: That's counting all.
	Dice h ag  T: Ho ny th ow? 5  S: 5
Modelling, Making explicit	T: How many altogether? [points to both dice covers one die with a card that has the numeral 5 on it to encourage counting on]. T: Say 5 and count on. S: 6, 7, 8, 9
Labelling strategy	T: Fantastic! That's counting on.

In this instance, observing teachers commented on the teacher's reference to explicit strategies, the way Rhonda used a card or hand gesture to cover smaller then larger numbers to demonstrate the 'counting on' strategy (*modelling, noticing*), and how the students were observed to do the same when they counted. They also commented on the fact that the students were very task-oriented, that is, they remained on task for the duration of the lesson. This was attributed to the teacher's use of examples and different activities to demonstrate the 'counting-on' idea, and her staying focussed on the main point of the lesson and not bringing in too many other elements (*focussing, drawing attention to*).

The derivation of scaffolding practices

The notion of numeracy teaching approaches was broadly framed in terms of teachers' communicative acts with a view to accommodating a range of practices in addition to those identified early in the project. That is, *modelling, sharing* and *guiding* (derived from the literacy teaching approaches), *funnelling* and *focussing*, the interaction patterns identified by Wood (1998), *reciprocating* from the work of Holtan and Thomas (2001); and *noticing, excavating* and *Convince Me* from classroom observations early in the project. While research school teachers were exploring these to some extent, the BTS activity effectively put these practices 'under the microscope', opening them up for critical review and further refinement while providing a space for the emergence of additional approaches or practices.

At its peak, the list included up to 60 words or phrases that teachers in the *Behind-the-screen* sessions had used at some time to characterise an observed interaction pattern or communicative practice. As a result of the debriefing discussions, and a post hoc analysis of the summaries and video-tapes where available, these were collapsed to 12 discrete categories for which the team felt there was fairly consistent evidence.

As there was no clear evidence of something akin to the over-arching, sustained teaching approaches described in literacy, it was felt that it would be more appropriate to refer to these patterns of interaction as *scaffolding practices*, that is, practices engaged in by teachers to support student's mathematics learning that might ultimately be removed when the learner can 'stand alone'. The 12 scaffolding practices were tested for applicability and completeness by means of the *Sorting Task* and the *Project Impact Reports*. As a result, the list was slightly modified to reduce ambiguities and to tighten up descriptions.

In elaborating and exemplifying the list, it is acknowledged that the practices described are not necessarily new. Indeed, they will be recognised widely by many teachers as something they "already do". While this is a test of their robustness and relevance to some extent, what is new is that the list of scaffolding practices provides the beginnings of a professional language to describe what it is that teachers do as they seek to support student learning in mathematics.

An example of one of these practices is presented below with the synonyms that relate to the identified category (shown in italics), an elaboration of the category (shown to the right) and a number of examples (shown below).

Table 4.

Example of an elaborated scaffolding practice

Excavating	
drawing out, digging, uncovering what is known, making it transparent	Teacher systematically questions to find out what students know or to make the known explicit. Teacher explores children's understanding in a systematic way

For example:

1 At the beginning of a lesson on renaming fractions at Year 6, a teacher asks" "What do you know about ¾? Think about what you were doing with ½ …"

2 In a Year 3/4 lesson on polygons, the teacher systematically investigates what students know about terms such as corners ["where 2 lines meet"], edges, faces etc, building on students responses, "Do we have a mathematical name for that?" [vertex] "How can we remember this?"

3 In a Year 5 lesson on fractions, the teacher questions to identify what students know.

T: In front of you you've got some fractions, now who can tell me what a fraction is?

S: It is part of a number, it's not a whole number…

T: Can you give me an example of when we could use a fraction

S: If you said ¾ it would be like 75…point 75. It would be part of something.

T: It would be part of something, excellent…

T: E can you tell me what the numerator is? Have a think. We've done it before, have talked about it.

S: The top number.

T: it is, what does the top number tell you in a fraction?...

S: …part of a number… how many things there are.

T: How many parts there are, is that right is that what you mean?

S: Yeah, T yeah…

T: And S what's this number under this line?

S: The denominator

T: And what does the denominator tell us.

S: How many parts you're dividing by.

T: How many parts you're dividing by, yes, another way of putting that?

S: How many things make a whole

T: Excellent…or how many parts you could have altogether in that fraction

4 A Year 4/5 teacher draws out and makes explicit what the group knows about the role of zeros in recording whole numbers and decimals.

T: Circle your smallest number and if you haven't written it yet, maybe think about what it will be. Now there's a couple of questions I wanted to ask you and I need to look at your list. Is 3 hundred and ten point zero…would that be the same as 3hundred point zero zero.

S: Yes because the zeros don't mean/aren't worth anything if they're over that side.

T: Are they?

S: Well like if they're first, like 310…like if you did like 100, that's worth it but if you did two zero before…no actually no, it is…that does work doesn't it?

T: How does it work G

S: Because if you had 0.01 and 0.00…(students talk at once, puzzling and trying to articulate their thoughts)

T: Have you got a theory M…about the zeros…in the numbers? Have a look at them…I might write what you said; 130.0…is that the same as 130.00?

Ss: Yes

T: So how could I write that number if I was to write it really quickly and I'm just sort of talking that number?

Ss: One hundred and thirty

T: What if I have…(T writes 013.00)

S: Thirteen, just make thirteen

T: So

S: Because that's nothing if it's before a number

T: So this zero doesn't mean anything if it's before these whole numbers? … So let's use these two examples…(T writes 13.01 and 13.10). So what's that one worth?

S: That's thirteen and one hundredth and then the other one's thirteen and one tenth.

T: So if I'm doing triple jump which is the best distance? Which is the furthest distance?

S: 13.1

T: Why is that the furthest distance…13.10?

S: Because that's one tenth and that's one hundredth

T: Mmhmm. What if I add another zero over here. (T writes 13.100)

S: The top one (13.10) is still longest

T: Why is that one still the longest?… Which number V? How would I read that number?

Ss: 13.1

The emergence of a common and expanded professional language to describe mathematics teaching was consistently nominated by research school teachers, coordinators and principals as one of the most significant outcomes of the project. This outcome is important as it contributes to the development of a much-needed, coherent and consistent way of enacting and talking about the complex practice of teaching numeracy/mathematics in a variety of settings to meet a variety of different learning needs. The advantage of having a language is that it then becomes possible to subject these practices to further scrutiny in order to improve and refine the quality of the interaction with a view to improving learning outcomes.

Discussion and Implications

The Behind-the-screen activity has been shown to be a useful research tool in helping to identify and describe key aspects of teachers' communicative practices. Its value and uniqueness resides in the fact that classroom teachers were actively involved as codifiers of practice in real time. In many studies of classroom communication (for example, Cobb & Bauersfeld, 1995; Clarke, 2001), researchers from similar or differing perspectives work on the analysis of transcript and/or classroom video data, either individually or collaboratively to identify and label specific classroom interactions. Inevitably, the sense that is made of these 'after-the-event' analyses reflects the particular perspective of the researcher concerned. While these different interpretations and insights add to the collective understanding of classroom communication, they and the language that frames them are generally removed from the everyday experience of teachers and the language that they use to describe their practice.

By contrast, the teachers involved in the Behind-the-screen activity were required to identify 'in-the-moment' aspects of one another's practice that they believed to be significant in scaffolding student mathematics learning. The facilitator also participated in this process, drawing attention to particular events and/or clarifying what was noticed. This meant that what was noticed either resonated very strongly with the teachers' experience or, if it was something raised by the facilitator, it connected immediately with teachers' experience. The labels or metaphors generated 'in-the-moment' to identify or describe what was observed also resonated with the teachers' experience and as such were meaningful to the group. To some extent, the need to act-in-the-moment and the very unpredictability of what would happen next, added a certain 'edginess' to the process which mitigated against the possibility that teachers would try to 'second-guess' what they thought was wanted in the situation. This suggests that the Behind-the-screen activity is a valid and reliable tool for identifying and describing aspects of teachers' practice.

Another valuable feature of the Behind-the-screen activity was that project teachers worked with small groups (slightly larger groups at the remote school) of 'near' or 'mixed ability', as opposed to an individual with highly identified learning needs (as in Reading Recovery). This is important as it allowed the groups to observe and reflect upon the importance of peer interactions and the different ways in which teacher's communicative acts were modified in response to different student's learning needs.

There are two further but inter-related findings to report in relation to the value of peer observation and review. The first is that teachers appear to learn most effectively from observing and being observed by others and the experience of other teachers. This was particularly evident in the evolving nature of the Behind-the-screen sessions, the interest shown in the school-based presentations at the third and fourth State-wide Action Research

Meetings, and in teacher's responses to the classroom visits made by members of the research team.

The second is that having access to professional language that goes some way towards describing the processes involved in teaching and learning mathematics helps build a professional culture in which teachers are more prepared to critically reflect on their practice, talk about what they do in mathematics, and share their experience with others. Qualitative evidence for this was provided in the Behind-the-screen discussions, the Project Impact Reports, the School Impact Statements and the Poster Task.

The power and utility of the Behind-the-screen activity to enrich teachers' understanding of their own practice cannot be under-estimated. Typical comments made by participants at the last Behind-the-screen session and in their Project Impact Reports included, "the best professional development I have ever done" and "this is powerful, more teachers should be able to do this". Many teachers reported a substantial increase in self-confidence and commitment to mathematics teaching as a result of their participation in the Behind-the-screen activity. Commenting on the impact of the project on her professional practice one teacher wrote,

> My BTS sessions have provided:
>
> - a forum for constructive criticism;
> - sharing of ideas from colleagues;
> - a chance to plan sessions in detail;
> - an opportunity to see other professional practice (this does not happen very often);
> - an opportunity to have your teaching approaches valued and recognised;
> - a chance to bring this type of professional development into our school, to give other staff the opportunity for self and peer reflection.(VM)

The opportunity to observe other teachers teach is widely recognised as one of the most valuable professional development experiences (e.g., Garet et al, 2001; Jacobs & Morita, 2002). The Behind-the-screen activity as it was modified and used here clearly satisfies this and the remaining criteria identified by Garet et al (2001) for effective professional development. That is, it

(i) is sustained over time (duration);

(ii) involves groups of teachers from the same school (collective participation);

(iii) is focussed on teaching-specific, mathematics content (focus);

(iv) affords opportunities to observe and be observed, plan classroom implementations and give presentations on their experience (active learning); and

(v) fosters coherence, that is, it connects with teacher and school goals and other activities and encourages professional communication among teachers.

The Behind-the-screen activity conducted at the remote site, which was video-taped and transmitted through the school's intranet, has the advantage of being more closely associated with the classroom teaching and learning environment and provides an on-going record for more extended and reflective discussions. This is an important feature as it supports multiple 'readings' over time and deeper analysis of the teaching episode.

While the Behind-the-screen activity offer enormous potential for development as a professional development tool, it is important to recognise the critical role of the facilitator in this process. The involvement of a 'more learned other', someone that has been through the process, understands the language and has a deep understanding of the content and processes involved in teaching and learning mathematics at this level, is needed to probe teachers' understanding, to prompt reflection, and draw attention to key aspects of what is being observed. For instance, to point to the assumptions (eg, about learning trajectories, materials, or representations) and/or conditions (eg, implicit classroom norms and values) that might underpin the teacher's actions. However, it is important to note that the facilitators

role is not to induct or train teachers in this process but to equip teachers to 'see for themselves' and articulate what they see to facilitate further professional discussion, planning and reflection. This process helps make public what Hiebert et al (2002) refer to as *practitioner knowledge*, the "kinds of knowledge practitioners generate through active participation and reflection on their own practice" (p.4), that is largely personal and unshared.

While there is clearly benefit in both forms of the BTS as it was used here, the video-taped sessions conducted at the remote site has the advantage of being more closely associated with the classroom teaching and learning environment and provides an on-going record for more extended and reflective discussions. This is an important feature as there is clearly much more that can be observed in any teaching episode than the nature of teacher's communicative acts. Three key features that warrant further analysis in terms of the data collected here are the obvious importance of a clear understanding of student learning needs and trajectories, task selection (the mathematical focus and how it is represented) and the specific nature of the classroom culture that clearly serves to shape and is shaped by the interactions that occur within it.

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