DESCRIBING TEACHER CHANGE: INTERACTIONS BETWEEN TEACHER MOVES AND LEARNER CONTRIBUTIONS

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This paper focuses on a teacher's changing practice in the context of curriculum change in South Africa. The teacher taught in a low socio-economic status school and worked to engage and develop learners' mathematical reasoning. Using a range of analytic tools, I show that his pedagogy was responsive to learners and enacted a number of key aspects of the new curriculum. At the same time he maintained a number of 'traditional' practices and there were strong continuities in his teaching across 'traditional' and 'reform' contexts. The paper shows that a key issue for teaching in this classroom was learners' very weak mathematical knowledge, which was made visible by the teacher's approaches and which simultaneously constrained his teaching. The paper argues for complexifying our notions of teacher change, and that issues such as the interaction between learner knowledge and pedagogy be taken into account if we are not to exacerbate existing divides among rich and poor contexts.

In this paper I draw together two strands of research that have occupied me for the past ten years. These are a concern with how mathematics teachers develop their practice, particularly in the context of curriculum reforms[1] and a methodological concern with how to describe mathematics teaching practices. To date, I have addressed these two concerns in different socio-economic contexts of teaching, informed by a strong concern for equity and social justice in mathematics teaching, particularly in an era of mathematics curriculum reform. In this paper, I present a case study of a teacher teaching in a school that serves poor learners whose mathematical achievement is low. I draw on a range of tools to describe his developing practice and the successes and challenges that the new curriculum presents to him and his learners.

DESCRIBING PRACTICE

Practices involve patterned, coordinated regularities of action directed towards particular goals or goods (MacIntyre, 1981; Scribner & Cole, 1981). Practices are simultaneously practical and more than practical as they involve particular forms of knowledge, skills and technologies to achieve the goals of the practice (Cochran-Smith & Lytle, 1999; Scribner & Cole, 1981). Practices are always located in historical and social contexts that give structure and meaning to the practice and situate the goals and technologies of the practice. Thus "practice is always social practice" (Wenger, 1998, p. 47), and practices involve social and power relations among people and interests (Kemmis, 2005). In the case of classrooms, classroom discourse is always co-produced between teacher, learners and their social contexts.

For MacIntyre a practice is a means whereby goods and standards of excellence internal to the practice are realised and "human powers to achieve excellence … are systematically extended" (MacIntyre, 1981, p.175). Thus learning is central to a practice, because as social goods and goals shift, so to do the means to achieve them. According to Wenger (1998) practice entails community, meaning and learning; practices learn and people, both teachers and learners, learn in practice. Given the complex nature of practices, how to describe them, is an ongoing methodological concern for researchers. It is inevitable that we need to foreground some aspects of practice, while backgrounding others (Lerman, 2001), particularly in presenting our research. At the same time, as we do this, it is important not to sanitise practice, and to try to present at least some of the real "noise" of classrooms (Skovsmose & Valero, 2003). There is no doubt that we need a range of methodological tools and lenses to capture the complexity of classrooms.

TEACHER CHANGE

Since learning and development are key to practice, it is also important to be able to capture changes in practice. This is especially the case in the context of curriculum reforms, where mathematics teachers are being encouraged to shift their teaching practices in ways that support a different kind of mathematics learning – the development of conceptual and reasoned understandings on the parts of learners rather than the procedural learning that takes place in many classrooms (Ball & Bass, 2003; Kilpatrick, Swafford, & Findell, 2001). Supporting learners' reasoning suggests kinds of classroom interaction where learners discuss their reasoning with each other and their teacher, and where learners and teachers communicate and justify their mathematical ideas to each other.

The research on teacher change in contexts of reform tends to make two major claims. The first is that teachers, the world over, struggle to change their practices in the direction of reform-oriented teaching (Brodie, Lelliott, & Davis, 2002; Hayes, Mills, Christie, & Lingard, 2006; Kitchen, DePree, Celedon-Pattichis, & Brinkerhoff, 2007; Sugrue, 1997; Tabulawa, 1998; Tatto, 1999). In a historical study of United States schools over the last century, Cuban (1993) shows that, through a number of reform movements, curricular and pedagogical aspects of reforms rarely took hold in classrooms and that major changes were usually in interpersonal relationships between teacher and learners. A second outcome of research on reform teaching is to describe models of exemplary reform teaching, making the claim that such teaching is possible, albeit with many challenges, illuminating different approaches to reform teaching and showing how the challenges can be overcome. Such cases come mainly from well-resourced contexts (Boaler, 1997; Boaler & Humphreys, 2005; Chazan & Ball, 1999; Hayes et al., 2006; Heaton, 2000; Lampert, 2001; Staples, 2007). Some research takes the middle road, presenting more textured descriptions of points of difficulty for teaching and when, how and why teaching in reform-oriented ways breaks down (Gamoran Sherin, 2002). In my own work with colleagues and students,

we have shown that some aspects of reform practice are easier for teachers to work with, for example selecting tasks of higher cognitive demand (Modau & Brodie, 2008) while others are more difficult, for example interacting with students while maintaining the level of task demand (Jina & Brodie, 2008; Modau & Brodie, 2008). We have also argued that adopting reforms requires teachers to coordinate a range of new practices and to think about their practice in new ways. Such coordination is an immense task and means that teachers' taken-for-granted practices might break down in the face of new practices (Slonimsky & Brodie, 2006). It is thus highly likely that teachers attempting to work with reforms may resort to traditional practices, more or less deliberately (Brodie, 2007a).

So in describing changing practice, it is important to capture some of the 'noise' of change, that reform-oriented teaching can and should include some traditional practices. Such practices are both an integral part of reform teaching as well as possibilities for further development. Methodological tools should be able to capture this complexity as well as distinguish key moments of and for change.

REFORM AND EQUITY

There has been much debate as to whether current mathematics reforms can be a mechanism for ensuring more equitable participation and achievement in mathematics (see Brodie, 2006b, for a summary of these debates). Empirical evidence in well-resourced countries is beginning to show that reforms do mitigate achievement gaps between marginalised and other learners (Boaler, 1997; Hayes et al., 2006; Kitchen et al., 2007; Schoenfeld, 2002). However, as mentioned above, the evidence also shows that implementation is not widespread and in fact it is likely that implementation of reforms is inequitably distributed (Kitchen et al., 2007). Particularly in African contexts, issues of resources, including big classes and few materials, teacher confidence and knowledge, and support for teachers, can be major barriers to developing new ways of teaching (Tabulawa, 1998; Tatto, 1999). If reforms are successful in promoting equity and if they are not taken up in less-resourced countries, then existing divides between rich and poor countries are likely to be exacerbated.

In what follows, I will present a case study of a teacher, called Mr. Peters in this paper, in a Johannesburg school with learners of low socio-economic status. All of the learners are black and their parents and caregivers work in menial jobs or are unemployed. The school has old furniture, intermittent electricity, peeling paint and broken windows. There is gang activity in the area, and learners are often assaulted on their way to and from school. During the period of the research, an armed robbery was committed against a teacher on the school premises, by a former learner at the school. This research focuses on Mr. Peters' grade 10 class of 45 learners. Through learner interviews and classroom observations, the learners' mathematical knowledge was established to be at least two years below grade level. Mr. Peters' mathematical knowledge, established through an interview, was very strong. He was enrolled in a

post-graduate degree programme at Wits University at the time of the study, and was one of five teachers who chose to participate in this study and formed a purposive sample for the study. Mr. Peters had learned much about the new curriculum during his studies but this was the first time that he was attempting to systematically shift some of his practices. He can thus be characterized as new to reform-oriented teaching, as were his learners.

Two weeks of Mr. Peters' lessons were observed and videotaped. In the first week, Mr. Peters taught from his usual syllabus in his usual way. In the second week, Mr. Peters worked to develop mathematical reasoning among his learners and to listen to their developing reasoning as he interacted with them. Using a range of analytic tools, I will show that in parts, his pedagogy was responsive to his learners and enacted a number of key aspects of reform mathematics. Definite shifts from his prior teaching to his teaching of mathematical reasoning could be discerned. At the same time there were aspects of continuity in his practice and he maintained both positive and negative aspects of his prior practice.

TASKS

A key aspect of reform-oriented practice is choosing tasks that allow for conceptual thinking, reasoned justification and communication of mathematical ideas. Mr. Peters' choice of tasks shows interesting shifts and continuities across the two weeks. In the first week he chose standard textbook tasks on the topic of factorising differences of two squares and spent substantial time teaching learners the procedure for factorising these. He chose examples of varying difficulty, and each time went through the procedure again with learners. More conceptually, he consistently asked learners to 'test' their answers, showing them that they could evaluate their own answers by multiplying. He also spent some time asking learners if $a^2 + b^2$ could factorise, and getting them to generate possible factors and then multiply to test whether they did give $a^2 + b^2$. So while Mr. Peters chose standard textbook tasks and taught procedures, he did attempt to support learners to make links between the different ways of writing expressions and to recognise why the difference of two squares could factorise and the sum could not. Even though Mr. Peters did have some conceptual goals for these lessons, an analysis of his questions and his moves (see below) show that when learners did not respond as he wished, he often, but not always, resorted to funneling (Bauersfeld, 1988) them towards the correct answer.

For his teaching in the second week, Mr. Peters worked with the other Grade 10 teacher in the study to develop tasks that would engage learners in reasoning mathematically. Their first task was:

i. Someone says that $x^2 + 1$ cannot equal zero for x a real number. Do you agree with her/him? Justify your answer.

ii. What is the minimum value of $x^2 + 1$?

In this task learners can reason empirically by trying out numbers in the expression x^2+1 and noticing that x^2 will always give a number greater than or equal to zero. They can also reason theoretically by drawing on the property that as a perfect square, x^2 will always have to be greater than or equal to zero and therefore $x^2 + 1$ will always be positive and have minimum value 1. In planning the task, Mr. Peters expected predominantly empirical reasoning from learners and hoped that through the class discussion he could build on their empirical reasoning to develop their theoretical reasoning. The task is cognitively demanding, what Stein et al. (2000) describe as "doing mathematics", because it requires non-algorithmic thinking, self-monitoring and exploring mathematical relationships. Research has shown that when teachers choose tasks of higher demand, the task demands often decline during interactions with learners (Modau & Brodie, 2008; Stein et al., 2000). I will show below that as Mr. Peters worked with learners on this task, he both interacted more openly with learners to keep the task demands high and also resorted to more constrained interaction and funneling. These different interaction patterns occurred in response to different kinds of learner contributions.

A central argument of this paper is that in both weeks, Mr. Peters was very aware of and responsive to learner errors, but that his shifts in interaction in the second week supported the public expression of more learner errors, particularly what I have called 'basic errors', which are errors that would not be expected at a particular grade level. I will show that Mr. Peters responded differently to two different kinds of error. One response to what I have called 'appropriate errors', which are errors that could be expected at this grade level as learner grapple with new concepts, was to develop new tasks, which addressed the errors, and the underlying misconceptions, more directly. So in week one, when learners were struggling to see $(x + y)^2$ as a perfect square, he had them substitute a range of values into the expressions $x + y$, $(x + y)^2$ and $x^2 + y^2$. In week two, when learners claimed that $-x$ is a negative number, he had them answer the question: Are the following expressions less than, greater than or equal to zero: x; $-2x$; x^2; $-x^2$; $(x + 1)^2$ and $-(x + 2)^2$. Again, we can see differences in the task demands, with those in the first week requiring only empirical reasoning, while those in the second week required a combination of both empirical and theoretical reasoning. So in developing new tasks to address learners' errors, Mr. Peters maintained the level of task demands in relation to the preceding tasks in each week.

In the following sections I show how Mr. Peters' interaction patterns shifted over the two weeks, in response to particular learner contributions.

TEACHER MOVES

More than 30 years ago Sinclair and Coulthard (1975) and Mehan (1979) identified a key structure of classroom discourse, the Initiation-Response-Feedback/Evaluation (IRF/E) exchange structure. The teacher makes an *initiation* move, a learner *responds*, the teacher provides *feedback* or *evaluates* the learner response and then moves on to a new *initiation*. Mehan calls this basic structure a *sequence*. Often, the

feedback/evaluation and subsequent initiation moves are combined into one turn, and sometimes the feedback/evaluation is absent or implicit. This gives rise to an *extended sequence* of initiation-response pairs, where the repeated initiation works to achieve the response the teacher is looking for. When this response is achieved, the teacher positively evaluates the response and the extended sequence ends.

Neither Sinclair and Coulthard nor Mehan evaluated the consequences of the IRF/E structure. Other researchers have argued that it may have both positive and negative consequences for learning. Much research has shown that because teachers tend to ask questions to which they already know the answers (Edwards & Mercer, 1987) and to 'funnel' learners' responses toward the answers that they want (Bauersfeld, 1988), space for genuine learner contributions and classroom conversations are limited. At the same time, it is very difficult for teachers to move away from this structure (Wells, 1999) and so, in trying to understand a range of practices, it is important to try to understand the benefits that it affords. Whether the IRE has positive or negative consequences for learning depends on the nature of the elicitation and evaluation moves, which in turn influence the depth and extent of learners' responses.

I developed a set of codes to describe the function of teacher utterances as they initiate and evaluate. When looking at how teachers interact with learners' contributions, a key code is *follow up*, which is when the teacher picks up on a contribution made by a learner, either immediately preceding or some time earlier. The teacher could ask for clarification or elaboration, ask a question or challenge the learner. Usually there is explicit reference to the idea, but there does not have to be. Usually the idea is in the public space, but it does not have to be; for example when a teacher asks a learner to share an idea that she saw previously in the learner's work. Repeating a contribution counts as *follow up* if it functions to solicit more discussion in relation to the learner's contribution. An initial coding of my data showed that there were a large number of *follow up* moves which functioned differently, so I further divided this category into different kinds of *follow up*. The five subcategories of follow up are described in Table 1.

Insert	The teacher adds something in response to the learner's contribution. She can elaborate on it, correct it, answer a question, suggest something, make a link etc.
Elicit	While following up on a contribution, the teacher tries to get something from the learner. She elicits something else to work on learner's idea. Elicit moves can sometimes narrow the contributions in the same way as funneling.
Press	The teacher pushes or probes the learner for more on their idea, to clarify, justify or explain more clearly. The teacher does this by asking the learner to explain more, by asking why the learner thinks s/he is correct, or by asking a specific question that relates to the learner's idea and pushes for something

	more.
Maintain	The teacher maintains the contribution in the public realm for further consideration. She can repeat the idea, ask others for comment, or merely indicate that the learner should continue talking.
Confirm	The teacher confirms that s/he has heard the learner correctly. There should be some evidence that the teacher is not sure what s/he has heard from the learner, otherwise it could be press.

Table 1: Subcategories of Follow Up

These codes are informed by various concepts in the literature. *Elicit* is closest to Edwards and Mercer's (1987) "repeated questions imply wrong answers" or Bauersfeld's (1980) "funneling", which, the authors argue, can constrain rather than enable learner thinking. *Press* is a category that comes from descriptions of reform pedagogy (Kazemi & Stipek, 2001), where the teacher wants to give the learners a chance to articulate and hence deepen their thinking, and/or wants to make sure that other learners gain access to their colleagues thinking. *Elicit* and *press* moves can sometimes seem similar to each other, they are distinguished in similar ways to how Wood (1994) distinguishes focusing from funneling – a press move orients towards the learners' thinking, rather than towards a solution. *Maintain* is similar to "social scaffolding" (Nathan & Knuth, 2003), and supports the process of learners' articulating their contributions, rather than the mathematics itself. It is also similar to revoicing (O'Connor & Michaels, 1996) and often involves a repetition or rephrasing of the learner's contribution which keeps the idea in the public realm for further consideration. *Insert* describes instances when the teacher gives information to learners as a follow up to what they had said. This category is motivated by a similar rationale to that of Lobato et al (2005), that teachers cannot avoid "telling" and that used appropriately, inserting or explaining is part of any teacher's repertoire.

The categories *confirm*[2]*, press, elicit* and *insert* all function to maintain learner contributions. The main difference between *maintain* and *confirm* and the other three codes is that *maintain* and *confirm* are more neutral, confirming the accuracy of what the teacher has heard or maintaining the contribution very similarly to how the learner said it. The moves can be arranged on a continuum of less to more intervention as follows: *confirm* is where the teacher makes very little intervention, she merely tries to establish what the learner said; *maintain* is where the teacher makes very little intervention, rather she repeats the contribution, in order to keep it going, either for later intervention or transformation, or for other learners to do something with the contribution; *press* tries to get the learner to transform her own contribution; *elicit* tries to get learners to transform a contribution by contributing something else; and *insert* is where the teacher transforms the contribution by making her own mathematical contribution. So *press* and *maintain* might be considered to be more "reform-oriented" moves while *insert* and *elicit* are more "traditional".

Table 2 gives the distributions of follow up moves in the two weeks of videotaped lessons in Mr. Peters' Grade 10 classroom. It should be noted that the percentage of *follow up* moves actually declined from 82% in week 1 to 68% in week 2, suggesting that follow up in itself does not indicate more responsive teaching. However, the distributions of the different kinds of follow up moves do suggest a different kind of interaction in the two weeks.

	Elicit	Insert	Maintain	Press	Confirm
Week 1	48	19	27	4	2
Week 2	23	24	30	20	4

Table 2: Distributions of teacher moves in Mr. Peters' lessons (percents)

The table shows a substantial increase in *press* moves and a decrease in *elicit* moves in Week 2. There were slight increases in *insert* and *maintain* moves. The four main moves were more evenly distributed in the second week than in the first. The table shows that while Mr. Peters shifted from *elicit* moves to *press* moves, a shift indicative of reform pedagogy, he still did do a lot of *eliciting* in Week 2, as well as *inserting* and *maintaining*. This resonates with a finding by Boaler and Brodie (2004) that teachers using reform curriculum materials in the United States asked significantly fewer recall type questions than those using traditional curricula, although they still asked a substantial number of these questions. So some shifts to reform pedagogy are evident, as well as some continuities with traditional practice.

A qualitative analysis of sections of discourse where Mr. Peters used the different kinds of moves, suggests further similarities and differences in his teaching approach during the two weeks. This will be discussed below, in relation to the discussion on learner contributions.

LEARNER CONTRIBUTIONS

An important part of teaching mathematical reasoning is to support learners to voice their mathematical thinking and reasoning, nascent or flawed as it might be. One of the key challenges identified in the research is how to respond appropriately to learner contributions, to engage learners' thinking and take it forward (Ball & Bass, 2003; Heaton, 2000; Lampert, 2001). In my previous research, I identified two issues that faced teachers attempting to shift towards reform teaching: supporting learners to participate, and when they did, dealing with the many mistakes that they made (Brodie, 1999, 2000).

In traditional mathematics pedagogy teachers tend to work with the categories of "right" and "wrong". They affirm correct answers and methods and negatively evaluate incorrect ones (Boaler, 1997; Davis, 1997). Teacher engagement with incorrect answers and methods aims for the production of correct answers, rather than an understanding of why the answers are incorrect and why the learners might be

making errors. Moreover, there is always the possibility of a correct response masking a misconception (Nesher, 1987), or of learners producing what they think the teacher wants to hear (Bauersfeld, 1988).

When teachers go beyond traditional teaching, and actively engage with learner ideas in order to develop conceptual links, promote discussion and develop mathematical reasoning, they are often confronted by a range of learner contributions. These contributions might be correct, incorrect or partially correct, well or poorly expressed, relevant or not relevant to the task or discussion, and productive or unproductive for further conversation and development of mathematical ideas. Interacting with a range of learner contributions makes teachers' decisions about how to proceed and when and how to evaluate learner thinking far more complex. I therefore developed a coding scheme to categorise learner contributions in my study. These are described, with examples, in Table 3 (the examples are in response to the task: what is the minimum value of $x^2 + 1$).

Basic Error	An error not expected at the particular grade level. Indicates that the learner is not struggling with the concepts that the task is intended to develop, but rather with other concepts that are necessary for completing the task, and have been taught in previous years.	$x^2 + 1 = 2x^2$
Appropriate Error	An incorrect contribution expected at the particular grade level in relation to the task.	-x is a negative number
Missing Information	Correct but incomplete and occurs when a learner presents some of the information required by the task, but not all of it.	x^2 is always greater than zero
Partial Insight	Learner is grappling with an important idea, which is not quite complete, nor correct, but shows insight into the task.	As you substitute lower numbers, the value of $x^2 + 1$ decreases.
Complete Correct	Provide an adequate answer to the task or question.	For $x^2 + 1$ equal to zero, x^2 must be equal to -1. But the square of any number cannot be negative
Beyond Task	Are related to the task or topic of the lesson but go beyond the immediate task and/or make some interesting connections between ideas.	The square root of -1 squared $[(\sqrt{-1})^2]$ equals -1, and then you say -1 + 1, then you get 0

Table 3: Learner contributions: description and examples

Table 4 gives the distributions of learner contributions in the two weeks of videotaped lessons in Mr. Peters Grade 10 classroom.

	BE	AE	MI	PI	CC	BT	O
Week 1	13	12	7	3	64	0	2
Week 2	22	19	11	8	34	3	4

Table 4: Distributions of learner contributions in Mr. Peters' lessons (percents)

This distribution shows a substantial decrease in complete correct contributions from the first to the second week, a substantial increase in basic errors and a small increase in the other contributions. It is notable and highly significant that in the four other classrooms in my study, almost no basic errors were seen, even in the one other classroom where learners' knowledge was also weak. While this suggests that Mr. Peters may be a teacher who supports the expression of and responds to errors, it also suggests that some forms of reform pedagogy can accentuate the visibility of errors, particularly basic errors. The fact that basic errors became increasingly evident in week two can be accounted for both by the very weak knowledge of the learners together with Mr. Peters' teaching practices, which allowed these errors to enter into the public arena. I will show below that the increase in basic errors in week two can be partially accounted for by Mr. Peters' changing teacher moves and that the larger number of complete, correct contributions in the first week can be attributed to his funneling (Bauersfeld, 1988) of learners' answers towards correct answers. Also significant is the wider range of other contributions in the second week: in particular more partial insights and beyond task contributions. Although the percentage of these is still small, a qualitative analysis suggests that the shift in Mr. Peters' practices does account for the wider range of contributions, and that learners with weak mathematical knowledge can be supported to make these kinds of contributions (see Brodie, 2006b, for a comparison with learners with strong mathematical knowledge).

RELATIONSHIPS BETWEEN TASKS, TEACHER MOVES AND LEARNER CONTRIBUTIONS

The relationships between tasks, teacher moves and learner contributions are complex and so I will only be able to give a small taste of some of these relationships here. A first point to note is that tasks and teacher moves together support particular learner contributions, and learner contributions support particular teacher moves (and tasks in Mr. Peters' case). I have shown above that the tasks in week two required more conceptual mathematical reasoning from learners than those in week one. I will show below that the ways in which Mr. Peters interacted with learners in relation to the tasks both supported and responded to the wider range of learner contributions in week two.

In the extract below, taken from week one, learners were trying to factorise $a^2 + b^2$. In lines 12-20 below Tebogo made a suggestion: (-a – b)(a – b) and Mr. Peters wrote it on the board and asked if he tested it. In lines 21-30, the teacher led the class through testing Tebogo's suggestion and in lines 31-38 he confirmed with them that the test showed that Tebogo's suggestion did not work.

12	Tebogo:	Eh Sir, eh, I got negative a and negative b		
13	Mr. Peters:	Did you test it? (*pause*) Negative a	Follow up	Elicit
14	Tebogo:	Negative b		
15	Mr. Peters:	In the bracket	Follow up	Insert
16	Learner:	Yes Sir, and I said a negative b		
17	Mr. Peters:	And you said a negative	Follow up	Maintain
18	Learner:	b		
19	Mr. Peters:	And you tested it	Follow up	Elicit
20	Learner:	Yes, Sir		
21	Mr. Peters:	Let's see what you saying. You said minus a, its minus a times a, what is minus a times a yes, Pumzile	Follow up	Insert
22	Learner:	Minus a (*inaudible*)		
23	Mr. Peters:	What's negative a times positive a, Pumzile	Follow up	Elicit
24	Pumzile:	Negative a sir		
25	Mr. Peters:	Negative a	Follow up	Elicit
26	Learners:	Negative a squared		
27	Mr. Peters:	What is negative a (*pause*) multiplied by positive a	Follow up	Elicit
28	Learners:	Negative a squared		
29	Mr. Peters:	Mary, you awake (*learners laugh*) yes Mary	Follow up	Elicit
30	Mary:	Negative a squared		
31	Mr. Peters:	Negative a squared, what is, have we got negative a squared here	Follow up	Elicit

32	Learners:	No		
33	Learner	Sir		
34	Mr. Peters:	Have we got negative a squared, answer the question	Follow up	Elicit
35	Learners	No, Sir		
36	Mr. Peters:	So can these be the factors, already you, you running into problems, (*pause*) so our test, does our test work	Follow up	Elicit
37	Learners	No sir		
38	Mr. Peters:	Its not working. (*pause*) Who wants to try? Yes	Follow up	Elicit

Tebogo's contribution was an appropriate error because he was grappling with the task demands of factorising and testing $a^2 + b^2$. Mr. Peters did not correct the error, he wrote it on the board for the class to see and asked whether Tebogo had tested his solution. Although Tebogo said he had, Mr. Peters asked other learners to test it with him. Mr. Peters led the learners through the test, asking constraining questions. Pumzile made a basic error, in multiplying –a by a, which was quickly corrected by Mr. Peters using elicit moves and the other learners responding. Mr. Peters then used another series of elicit moves to make the point that they don't have $-a^2$ in the original expression so the test does not work and the factors are incorrect. So although Mr. Peters followed up learners' contributions, he did so in constrained ways, with mainly elicit moves in order to correct both the basic errors and the appropriate error.

This pattern of interaction was similar throughout week one and also appeared during week two, although not as often. In week two, it occurred mainly when Mr. Peters worked to correct learners' basic errors. However, other kinds of interaction emerged as well in week two, where Mr. Peters spent more time *pressing* on learner errors, trying to help learners to transform their own reasoning. The extract below begins with Mr. Peters writing a solution on the board that most learners had written in their group discussions the previous day, that $x^2 + 1$ could not equal zero because x^2 and 1 are unlike terms and cannot be added. This is an appropriate error, because it shows learners grappling with current knowledge to address the task.

| 3 | Mr. Peters: | Grace and Rethabile. And most of you belong in this group (*writes Grace and Rethabile's solution*). Grace, do you want to say something about that? What were you thinking? What were the reasons that you | Follow up | Press |

(*inaudible*)

4	Grace:	Sir, because the x squared plus one ne sir, you can never get the 0 because it can't be because they unlike terms. You can only get, the answers only gonna be x squared plus one, that's the only thing that we saw because there's no other answer or anything else.		
5	Mr. Peters:	How do you relate this to the answer not being zero? Because you say there it's true, the answer won't be zero, because x squared plus one is equal to x squared plus one. You say they're unlike terms. Why can't the answer never be zero, using that explanation you are giving us?	Follow up	Press
6	Grace:	*(sighs and pinches Rethabile)*		
7	Mr. Peters:	Rethabile, do you wanna help her	Follow up	Press
8	Rethabile:	Yes, sir.		
9	Mr. Peters:	Come, let's talk about it.		Direct
10	Rethabile:	Sir, what we wrote here, I was going to say that the x squared is an unknown value and the one is a real number, sir. So making it an unknown number and a real number and both unlike terms, they cannot be, you cannot get a zero, sir. You can only get x squared plus one.		
11	Mr. Peters:	It can only end up x squared plus one	Follow up	Maintain
12	Rethabile:	Yes, sir. There's nothing else that we can get, sir. But the zero, sir.		
13	Mr. Peters:	So you can't get a value, you can't get a value	Follow up	Maintain
14	Rethabile:	That's how far we got sir		
15	Mr. Peters:	Come, Lerato, lets listen so you can contribute.		Direct

16	Mr. Peters:	So it will only give you x squared plus one, it won't give you another value, zero. Will it give us the value of one? Will it give us the value of two? x squared plus one.	Follow up	Press
17	Rethabile:	It will give us only one, sir, because x is equal to one, sir.		
18	Mr. Peters:	Is x equal to one	Follow up	Elicit
19	Grace:	Yes, sir.		
20	Mr. Peters:	How do you know x is equal to one	Follow up	Press
21	Learners:	(mutters)		
22	Grace:	Not always, sir, because		
23	Mr. Peters:	Shhh. Wait, let's hear this. Let's give her a chance.	Direct	
24	Grace:	Sir, not always sir, because, this time we dealing with a one, sir. That's why we saying x squared equals to one, sir. Because, that's how I see my x equals to one, sir. Because, a value of one, only for this thing, sir		

In the above extract, Mr. Peters both maintained and pressed a number of times on Grace and Rethabile's solution. In the transcript we see Mr. Peters pressing for explanations (lines 3, 5, 9), maintaining the girls' claim (lines 11 and 13) and trying to press them more specifically to think about the expression (lines 5 and 16). His press moves ranged from being very general (line 3) to more specific (line 16). Even this final question which could have enabled learners to think about $x^2 + 1$ as taking several values depending on the value of x, did not help. In fact it led Rethabile directly into a basic error, that x is equal to 1. Mr. Peters' response to her basic error was to try to understand it, using and elicit and press move. He continued to do this for a few turns after the extract and then he moved to correct the error with a sequence of constrained elicit moves, similar to his approach in week one. Once he corrected this (and a number of other basic errors that came up immediately afterwards), he came back to the discussion of the appropriate error.

In all the cases of appropriate errors in week 2, Mr. Peters' response was to work on them in two ways. First, he kept them in the public arena for discussion for some time and tried to get learners to justify and clarify their thinking. He did not always move to teaching the correct answer as he did with basic errors and when he did so, he worked less procedurally. Second, he planned new tasks, which he hoped would help

learners with their errors (which he did in week 1 as well). However, each time Mr. Peters began a discussion on an appropriate error a host of basic errors came up. Mr. Peters dealt with these basic errors relatively quickly, although he took more time to try to understand them than in week 1, and then came back to the discussion of the appropriate errors.

Mr. Peters' responses to the other kinds of contributions were similar. In the case of missing information contributions he maintained and pressed, and then moved to complete them with elicit and insert moves, similar to how he worked with basic errors. With partial insights, he maintained and pressed and kept with them, similarly to appropriate errors. In the case of the beyond task contributions he developed a conversation using all the moves (Brodie, 2007b).

CONCLUSIONS

The two extracts discussed above were chosen to maximise differences in Mr. Peters' teaching across the two weeks. At first glance these two extracts appear to suggest very different teaching in the two weeks. However, tables 2 and 4, together with the task analysis shows that although there were some major differences across the two weeks, there were also similarities. One similarity that emerged in the qualitative analysis was that Mr. Peters consistently noticed and engaged learners' appropriate errors and as he did so, basic errors emerged. A major difference was in how he engaged both the appropriate and basic errors in each week. In week one, he elicited correct responses from other learners while in week two, he pressed the learners concerned on their errors in order to understand them and to try to get the learners to transform their own thinking. This partially accounts for the predominance of basic errors in week 2. In both weeks he privileged appropriate errors, working on basic errors towards complete, correct solutions and then coming back to the appropriate error that generated the basic errors. However, in week two, he did this with more emphasis on getting the learners to focus on and transform their own and each other's errors. In both weeks he addressed appropriate errors by developing new tasks. In week one these tasks remained at an empirical level, even as Mr. Peters wanted learners to make a generalisation across them, while in week two the tasks required that learners work between the empirical and the theoretical.

This analysis resonates with other work (Boaler & Brodie, 2004; Hiebert & Wearne, 1993) which shows that as teachers take on some elements of reform, much of their teaching continues to look traditional. Boaler and Brodie show that a first level change is the press move or question, whereas developing conceptual questions is a more difficult skill for teachers to develop. In the case of Mr. Peters, the major shift was from elicit to press moves. This shift, together with a different approach to the tasks, did enable a broader range of learner contributions and teacher responses to these contributions[3]. The analysis suggests that focusing on specific instances in teaching, rather than finding ways to code for the bigger picture, can mislead and might account for the predominant finding that there is very little change among

teachers adopting reforms. If we are serious about finding even small changes in practice and suggesting ways in which these can become bigger changes, we need to develop analytic tools at a range of levels.

CONTINUING ISSUES

In this paper I have used a number of analytic tools to describe Mr. Peters' practices as he begins to adopt reform-oriented practices in his classroom and I have shown how what we see of his practice depends on how we look. I claimed at the beginning of the paper that I would show some of the "noise" (Skovsmose & Valero, 2003) that emerges from this kind of analysis. This noise occurs on two levels. First there is the noise argued for in the previous section, which suggests that we will never see clean reform or traditional practices and that our tools for analysing teacher change needs to take this into account. Second there is the noise of this particular classroom, a classroom of mathematically weak learners, who make many errors that, ideally, they should not be making. This is a reality for teachers in similar classrooms and complicates the practice of supporting learners' reasoning through communication and discussion. While Heaton (2000) and Staples (2007) argue that part of a reform teacher's role is developing learner contributions to a point where they can contribute to ongoing discussion, it is not trivial to see how this can be done with so many basic errors in one lesson. The fact that in Mr. Peters case the basic errors increased in relation to his shift in teaching, i.e. more were allowed to become public in the classroom, suggests a double demand of this kind of teaching.

In presenting some of the noise of changing classrooms, I have of course ignored other noisiness, in particular how the social and racial contexts of the school, the teacher and the learners play out in the classroom. I have not looked at particular learner-learner interactions, nor the emotional consequences of a shift of approach for teacher and learners (see Brodie, 2006a, for the beginnings of a discussion). While these are important, what I want to argue in this paper is that the bigger contextual discussions play out in classrooms in particular ways and that we need to think through how to help teachers think about them. This research, as well as my previous research suggests that one of the ways that poverty plays out in classrooms is through weak mathematical knowledge of learners (see also Fleisch, 2007) and we need to deal with this in the context of reform.

A second issue is whether and how complex social practices can be described with the tools that I have suggested here. In particular, how do codes that break down teaching and learning into turns of talk and individual contributions, come together to create an understanding of practice. It might seem reductionist to analyse classrooms in this way, first to code and then looking for relationships between the codes. However, as I have argued above, these codes form a first-level description of pedagogy and show trends across teachers. They need to work together, as well as with qualitative analyses to help develop stronger descriptions. In particular, if they are used in the qualitative analysis, as I have done above, then the codes develop a

liveliness in relation to particular classrooms and are able to tell us a story both across classrooms and for each classroom on its own terms.

NOTES

1. I use the terms "new curriculum" (South African) and "curriculum reforms" (international) interchangeably. Although there are subtle differences in 'reform' movements in different countries, for the purposes of this paper, 'reform' mathematics visions are similar enough across countries to be referred to as one concept.

2. There were very few confirm moves in any of my data so the analysis focuses on the other four moves.

3. Elsewhere, I have discussed the limitations of the press move (Brodie, in press).

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