PROFESSIONAL LEARNING COMMUNITIES AND TEACHER CHANGE
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Professional learning communities are increasingly seen as a sustainable and generative method of professional development in mathematics education. However links between the actual work of the community and changes in teachers’ practices are rarely made. In this paper I examine part of a journey of one teacher in a professional development project that focused on teachers’ learning to engage with learner errors in their teaching. I show how her classroom practice and the conversations in the community informed each other, and supported her to change her teaching.

Professional Learning Communities
Professional learning communities are increasingly seen as a sustainable and generative method of professional development in mathematics education (Clark & Borko, 2004; Jaworski, 2008). Professional learning communities support teachers to use their experience, evidence from their classrooms, their own and their colleagues’ insights, and knowledge from research to decide what they need to learn and how they can learn it. Teachers monitor their own and their learners’ learning in ongoing ways (Boudett, City, & Murnane, 2008), thus engaging in deepening cycles of analysis, reflection and action, interrogating current practice and exploring alternatives. The collective nature of professional learning communities is important - teachers collaborate and learn together about how their learners’ needs can influence and improve their practice.

There are strong theoretical arguments for professional learning communities and some evidence that they do produce improved teaching practices and learner achievement (Boaler & Staples, 2008; Katz & Earl, 2010). There has been extensive research on how successful communities work and the difficulties in sustaining them (McLaughlin & Talbert, 2001). Less research has been done on explicitly connecting the actual work of the professional learning community to shifts in teachers practices, or as Kazemi and Hubbard (2008) argue, how teachers’ development in both the professional community and the classroom co-evolve. They suggest (2008, p.453):

One methodological entry point … is for researchers to identify a practice that is the focus of the PD effort, track how teachers reason and work with that practice as it travels to their classrooms, and track how they reason with that practice when they return to PD.

Professional learning communities typically investigate artefacts of practice, such as tasks, student work, lesson plans and classroom teaching (Clark & Borko, 2004). However, we cannot assume that what teachers learn in the community, outside of the classroom, travels intact to the classroom and vice versa (Kazemi & Hubbard, 2008). Different aspects of the learning in the community will be salient in different ways for different teachers and links between teachers’ experiences in the community and their developing practices need to be established.

The focus of our professional development project was learning to work with learner errors. Our position on errors and the main learning point of the program is that errors are evidence of reasonable and interesting mathematical thinking on the part of learner (Borasi, 1994; Prediger, 2010) and errors do not signal a deficit in teaching or learning, in fact they are a normal part of learning mathematics. At the same time, teachers can learn to work with learner errors in better ways. Many teachers tend to work away from errors: avoiding them through narrowing tasks; pretending to work with them through the use of leading questions; or re-teaching concepts with the assumption that errors mean that learners haven’t learned
“properly” the first time. We work with the notion that teachers can embrace learner errors in ways that can advance learners’ mathematical thinking by understanding the validity in the reasoning behind the errors and the source of the errors as over-generalisations of previously successful ideas (Smith, DiSessa, & Roschelle, 1993).

In this paper I examine part of a journey of one teacher in a professional development project that focused on teachers’ learning to engage with learner errors. I show how analyses of the teacher’s classroom practice in the professional learning community informed her subsequent classroom practice.

The empirical site and data analysis

The data for this paper comes from a three-year professional development program, located in Johannesburg, South Africa. The project engaged teachers in a number of activities including test and curriculum analyses, interviews with learners, readings and discussions on learner errors in particular topics, lesson planning and lesson reflections. All of the activities focused on building teachers’ understandings of and engagement with learner errors. The teachers worked in small grade-level groups of 3–4 teachers, with a group leader who was member of staff or post-graduate student at our university. At particular times in the programme, the small groups presented their ideas to a larger group that was facilitated by one of the project leaders, the author of this paper. In this paper I focus on the learning of one Grade 8 teacher, Andrea, through the first two years of the project, by analysing her teaching before the project began and through two cycles of the project.

In each of the two cycles, each small group planned and taught lessons to develop learners’ understanding of the relational meaning of the equal sign or learners’ use of visuals in solving problems. They had read and discussed papers on these topics and analysed tests results and the curriculum in these areas. One teacher from each group volunteered to teach the lessons and the teaching was videotaped. The small groups discussed the videotapes and then the teacher presented two episodes to the larger group: one where the small group thought the teacher had dealt well with learner errors and one where the small group thought the teacher had not dealt so well with learner errors. The presentation included a brief background to the episodes to contextualise them within the set of lessons and a justification for why the group had chosen each episode. Each group gave a 10-minute presentation and about 50 minutes were given for discussion where other groups could comment, question, challenge and give feedback.

The main data for this paper are the presentations on the two concepts and the teacher’s lessons – two lessons before the project started, two on the equal sign and one on problem solving. Secondary data are the lesson plans, interviews with the teachers, and the teacher’s written reflections after the presentations. Analyses of the lessons were done with the Mathematical Quality of Instruction (MQI Plus) instrument (Learning Mathematics for Teaching Project, 2010). Coding is done according to a set of categories in eight-minute episodes, on a scale of 1 to 3. A second, more qualitative analysis of the lessons listed all the learner errors made in the lessons and the teacher’s responses to these. These analyses showed changes in the teaching and also confirmed that the episodes chosen for presentation to the larger group did in fact illuminate important issues relating to the teacher’s engagement with learner errors that came up throughout the lessons. Detailed summaries of the presentations were analysed by looking for how the teachers accounted for their actions to each other and what counted for them as important to speak about at each point. This meant looking for who said what and when, presences and absences in what they said, and tracing comments back to previous comments and forward to subsequent ones.

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1 All names in the paper are pseudonyms.
Changes in teaching practice
The two MQI Plus categories that are most relevant to teacher learning in our project are: working with students and mathematics and student participation in meaning making and reasoning. Each main category has subcategories, the first has remediation of student errors and difficulties; and responding to student mathematical productions, while the second has students provide explanations; student mathematical questioning and reasoning; and enacted task cognitive demand. Table 1 below gives the number of episodes in each of the three sets of lessons that were coded 1, 2 or 3 for each subcategory.

<table>
<thead>
<tr>
<th></th>
<th>Prior to project</th>
<th>Equal sign</th>
<th>Problem solving</th>
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<tbody>
<tr>
<td></td>
<td>11 episodes coded</td>
<td>12 episodes coded</td>
<td>7 episodes coded</td>
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<tr>
<td>remediation of student errors and difficulties</td>
<td>11</td>
<td>12</td>
<td>5</td>
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<tr>
<td>responding to student mathematical productions</td>
<td>8 3</td>
<td>11 1</td>
<td>3 2 2</td>
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<tr>
<td>students provide explanations</td>
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<td>12</td>
<td>4 3</td>
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<tr>
<td>student mathematical questioning</td>
<td>11</td>
<td>12</td>
<td>6 1</td>
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<tr>
<td>enacted task cognitive demand</td>
<td>9 2</td>
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Table 1: Shifts in Andrea’s practice
Table 1 shows that Andrea’s practice remained unchanged for the most part in the first set of lessons that she taught while in the project (equal sign) but shifted significantly in the second set of lessons (problem solving). The qualitative analysis of the shift shows that the teacher’s responses to learner errors in the first two sets of lessons were predominantly leading questions, while in the third she moved towards asking probing questions.

Conversations in the professional community
The shifts in Andrea’s practice can be linked to conversations about her practice in the two communities, the small group and the larger group. Her group chose the following episode to present on the equal sign. There were two expressions written on the board:

\[(+1) + (+1) + (+1) + (-1) + (-1) + (-1) = 0\]
\[(+1) + (+1) + (+1) + (+1) + (+1) + (-1) + (-1) + (-1) + (-1) + (-1) + (-1) + (-1) = 0\]

Andrea had asked the learners whether the left hand sides of both equations were equal to each other. The following interaction with one learner, Carol, occurred:

Andrea: Put up your hands if you say yes...[a number of learners put up their hands] put up your hands if you say no...[only Carol puts up her hand] Carol, very brave my darling well done, why do you say no

Carol: Mum, I said no because um, the numbers are different like there three negative ones there and there are six negative ones there, and there there are three negative ones there, I mean three positive ones, and there there are six positive ones, mum
Andrea: Well, except that here I’ve got six negative ones and six positive ones and they equal to zero that’s one number
Carol: Yes mam
Andrea: So does it matter how many numbers we’ve got on each side
Carol: No
Andrea: What matters
Carol: Um, if they equal to zero
Andrea: If they equal to zero, so is this top line gonna equal to zero
Carol: Yes mam [nods head]
Andrea: In this bottom line here, equal to zero
Carol: Yes mam [nods head]
Andrea: So we can say they are equal to each other

Initially the small group had thought that Andrea had dealt well with Carol’s error but after some discussion with the group leader they came to see that she had led Carol to the answer without asking her to explain her thinking and there was no evidence that Carol had in fact understood the difference between what the expressions looked like and their values. The group named what Andrea had done as using “leading questions”.

Two key questions structured the conversation in the larger group about this episode. The first question was asked about all the errors that teachers presented – what might the learner be thinking in order to make the error. The second question related specifically to Andrea’s teaching - what is the role of leading questions in engaging with errors. After some discussion the teachers reached consensus about Carol’s thinking, expressed here in Renee’s words:

I would imagine what was going through her mind was that she’s thinking that equals means the same and that in some contexts that is correct but we’ve got to be very careful that they’ve got to understand the difference between quantity and value, when we say equal we talking about the value of something.

Renee pinpointed both the validity in Carol’s thinking and where her error lay. She showed that the error is sensible given the meaning of “the same” in some contexts but that a full understanding of equivalence required a different meaning – in relation to the value of the expressions rather than the quantity of terms. Andrea took the discussion further saying:

The misconceptions are so deeply ingrained in them that actually they take them for granted and they don’t think about, and it doesn’t even cross their minds to change their thinking. I mean some of the stuff that I said, its pretty deeply ingrained in me as well. If I listen to some of the language that I use, I use things like the answer and all of that kind of stuff.

In relation to the leading questions, Andrea argued that:

I had not allowed her to let me know that she had fully grasped the concept, I just kind of barked out the orders … so I don’t actually know that she can actually do these questions by herself now

So Andrea articulated a direct link between her practice and her engagement with learner errors, indicating her group’s understanding of the teacher’s role in working with learner errors. The notion of “leading questions” became a depiction of practice (Kazemi & Hubbard, 2008) that was spoken about in a number of ways throughout the program. In this session a number of teachers contested the idea. Tawana argued:

I don’t see why her questions are leading towards a solution. She was using a model previously and they’ve now left the model behind and are looking at the numbers and equating things, so if someone had a misconception, it was important for them to refer back to something that they’d agreed upon
Tawana’s argument was that Andrea had explained the ideas previously, using conceptual resources, the model, and that it was appropriate for her to expect that this had been understood and she could therefore use leading questions to remind learners of what they had learned previously. Even though her leading questions were supported by other teachers, Andrea stood her ground and argued that she could act differently by asking more questions such as “why do you think that”, “how do you come to that”, take me through your thinking” to support learners to articulate their ideas. Such questions are referred to in the literature as probing questions or press questions (Kazemi & Stipek, 2001). Many of the teachers could not distinguish the difference between leading and probing questions at this point. Subsequent discussions articulated more clearly the differences between leading and probing questions. Andrea’s word “inrained” also became a shared term in the community. As the facilitator, I was able to pick up on the link that Andrea made, talking about teachers’ “inrained” practices such as leading questions, and how those are as difficult to shift as learners’ misconceptions.

In Andrea’s reflection she wrote that she had learned that leading questions were not useful in eliciting and engaging learner errors and that she was going to try to use them less in her teaching. Table 1 shows that she was more successful in engaging with learners’ errors and reasoning in the next set of lessons. Her group chose one of a number of possible episodes, which shows some of her success. An analogue clock drawn with the hands at three o’clock was on the board and Andrea asked the question: how many ninety-degree angles will there be in twelve hours? A number of learners made conjectures. In the chosen episode, Rabia conjectured that “every hour can have a ninety degree angle” and when Andrea asked for an example she said “like um two o’clock and eleven o’clock”. Millaine challenged Rabia’s claim saying, “at two o’clock and eleven o’clock it won’t necessarily be a right angle” which led Rabia to change her statement, saying that she meant five to two (i.e. the hands would be on eleven and two). Leanne listened to this interchange and then offered the possibility that “every right angle has two hours in between” and when Andrea asked her to elaborate she used the example of three o’clock on the board and Rabia’s example to explain.

Andrea’s responses were completely different from those in her interaction with Carol in the first episode. She asked for examples and elaborations and as she said in her presentation:

I didn’t refuse any of their answers, I put them on the board and I kind of left them there and I didn’t say no you’re wrong or wow you’re amazing you’re right, I just kind of put them there and we moved on, and talked about it a little bit and then put more up, and then some kids would say but these are wrong because of the following reasons, so the learners kind of deepened their understanding through their own questioning

This was not only the case in this one episode but in many others, and her teaching supported the learners to make key breakthroughs at later points – first that both hands move so that, for example, at five to two the hour hand will not be exactly on two, and second to get close to an answer, some arguing for 22 and some arguing for 24 and then deciding how to work out the answer. Andrea did not only work as she described above, she also made inputs where necessary, and asked some “leading questions” where appropriate, for example, she used leading questions to make the point that a ninety degree angle can be in a number of orientations. Her more flexible use of different kinds of questions supported me as the facilitator to make links between the different kinds of questions, to further support her learning and the learning of the other teachers.

Conclusions
The observed quantitative and qualitative shifts in Andrea’s teaching can be linked to the discussion of her teaching in the small and larger group. The notion of “leading” questions
came up in the smaller group and was further discussed in the larger group. As a “depiction of practice” these structured Andrea’s work and the work of some of the other teachers who began to distinguish between these kinds of questions, try them out in their classrooms and bring them back to the community for discussion.

The project’s methodological entry point (Kazemi & Hubbard, 2008), learner errors, supported this shift in Andrea’s teaching. The discussions of her teaching of the equal sign pinpointed the validity of Carol’s thinking that Andrea missed because of her use of leading questions. As she shifted her use of leading questions in the second set of teaching she also shifted her view of learner errors to conjectures (Borasi, 1994) and was happy to leave errors on the board as inputs to the discussion, to be taken up by other learners. Andrea’s reflections on her own language and practices as “ingrained” also provided a point of focus for discussions about how to link new teaching practices to the teachers’ developing understanding of errors.

So the two contexts, the community and the classroom came together and interacted with each other to produce learning in both contexts. Andrea was able to talk about her practice with others, build on or challenge their thinking, accept challenges from them and take forward what she learned into her classroom. At the same time, her classroom practice created possibilities for further discussion and for other teachers’ learning.

References