Mathematics Teachers' Knowledge Growth in a Professional Learning Community

Million Chauraya
School of Education,University of the Witwatersrand, South Africa
Million.Chauraya@wits.ac.za; Mchauraya04@yahoo.com

Abstract
Professional learning communities are regarded as a viable teacher professional development model, but knowledge about how teachers learn in such communities is not yet well developed. This paper reports on how a conversation about ratio in a professional learning community of mathematics teachers supported the teachers' conceptual understanding of the concept. Features of a professional learning community that were found to support teacher learning include: diversity of opinion; challenging each others' ideas; voicing uncertainties; collective construction of meaning; and regarding learners' learning as the focus of the group's activities. The paper argues that professional learning communities that reflect these characteristics can support significant teacher learning.

Introduction

Contemporary teacher professional development models are mostly underpinned by the notion of professional learning communities. Professional learning communities are regarded as effective organizational structures in which teachers can learn and develop their instructional practices. Such communities enable teachers to learn from one another, and have the capacity to promote and sustain teachers' learning with the ultimate focus of improving learners' learning (Stoll & Louis, 2007). The effectiveness of professional learning communities in fostering teacher learning lies in ensuring that the nature of the collaboration can produce shared understandings, focus on problems of curriculum and instruction, and that they are of sufficient duration to ensure progressive gains in knowledge (Little, 1993). However not all professional learning communities manage to succeed in achieving these ideals. Little (1999) highlights the distinction between 'traditional communities' that coordinate to reinforce traditions, and 'teacher learning communities' where teachers collaborate to reinvent practice and share professional growth. Katz, et al. (2009) point out that "together can be worse", for example when collective activities, that may be well-intentioned, lack a clear needs-based focus and fail to address real teaching problems. These observations about the effectiveness of professional learning communities raise the need for more research-based knowledge about how professional learning communities foster real professional learning among teachers. In this paper I draw from an on-going research study to address the question: How do professional learning communities foster teachers' knowledge growth?

Learning in Professional Learning Communities

The conception of a professional learning community adopted in the study is that of 'a group of teachers sharing and critically interrogating their practice in an on-going, reflective, collaborative, inclusive, learning-oriented, growth-promoting way' (Stoll & Louis, 2007, p. 2). Learning in professional learning communities is conceptualized from a situative perspective, which regards learning as increased participation in communities of practice (Koellner-Clark & Borko, 2004; Lave & Wenger, 1991). Learning and participation are inseparable as they involve both the 'interpersonal and informational aspects of an activity' (Greeno & Gresalfi, 2008, p. 171). In professional learning communities, learning 'involves working together towards a

common understanding of concepts and practices' (Stoll & Louis, 2007, p. 3). Understanding how professional learning communities foster teacher learning therefore entails paying particular attention to the interactions within the professional learning communities, and how new understandings are created and negotiated. Such interactions and learning are enhanced if teachers view the professional learning community as a safe, non-threatening environment in which they can raise uncertainties or difficulties, with the confidence and trust that they will be supported and helped by others (Koellner-Clark & Borko, 2004). Open acknowledgement of what one does not know leads to possibilities for real new learning (Katz, et al., 2009).

Learning in a professional learning community is enhanced by: having a supportive leadership; collaborative inquiry that involves questioning and reflecting on practice (Jaworski, 2003b); and having a shared and clear learning focus that guides activities (Katz, et al., 2009). Such learning involves: challenging each others' assumptions about teaching and learning; discussion of new ideas that challenge existing knowledge; diversity of opinion; discussion of points of disagreement rather than of agreement; maintenance of the mathematical substance of the conversations; treating participants' ideas as objects of inquiry; and joint sense-making (Katz, et al., 2009). Analysing how these characteristics are manifested in the activities of a professional learning community helps determine the quality of the teacher learning that occurs. In what follows I use these concepts to show how a conversation among teachers helps them to develop a conceptual understanding of ratio and give meaning to an algorithm related to ratio.

Methodology

The qualitative case study extended over a period of nine months in 2010. Five mathematics teachers (Grades 7-10) from one school and the researcher (the author), met once a week for two hours at the school to work on activities which included: analysing the conceptual and skill demands of test items relating to ratio; interviewing learners about errors they made on the test items; analysing the errors made by the learners; planning and teaching lessons for dealing with learning needs based on the errors; and reflecting on the impact of those lessons. The activities were adopted from the Data Informed Practice Improvement Project (DIPIP), an on-going teacher professional development project based at Wits University. The researcher acted as a 'critical friend' in the group.

The activities described above supported conversations which sought to understand the errors made by learners on each test item with a view to collectively develop innovative lessons for dealing with observed errors and misconceptions. In this paper I focus on the conversations of the professional learning community in analysing learners' errors on the concept of ratio. I analyse how the conversations fostered the teachers' deeper understanding of the learners' errors, and their own subject content and pedagogical content knowledge about the concept of ratio. I also show how the teachers' developing confidence and trust in the professional learning community enabled them to voice some uncertainties; critically reflect on their knowledge about the concept of ratio; and jointly construct new understandings of the concept.

Findings: Developing Meaning for Ratio

The following two episodes drawn from the teachers' conversations illustrate some of the different ways in which the professional community led the teachers to a deeper understanding of some aspects of the concept of ratio, as well as addressing some of the uncertainties that they had. In the episodes the teachers' names are all pseudonyms, while 'Re' refers to the researcher.

Episode 1: Raising uncertainties in the group

In this episode the conversation was on the test item: 'Simplify the ratio 6:5'. In the conversation one teacher, Tsepo, raised his discomfort with the item. The following are some excerpts from the conversation:

Tsepo:	Don't you think that that ah giving learners questions like this is very much confusing because the learner will now try to work out this when it is already in its simplest form?
Re:	It depends on what we are testing. In this case I think we are testing understanding of a ratio and when a ratio is in its simplest form. But Tsepo is right, you have to think like a learner sometimes, because the moment you see simplify, in the mind you have to do something, and this is what some of the learners did.
Mandla:	And by doing that something they messing up everything.
Tsepo:	Ja, so they just have to leave it like that?
Re:	Yes, because it's already in its simplest form. How do they realize that, you can't have, six and five do not have a common factor.
Tsepo:	Uh because now the learner will think that maybe they have to give, I don't know out of how many marks is, is that, this question.
Karabo:	Two marks.
Tsepo:	So in the case like this we need to be careful with the marks also.
Karabo:	If they see the marks, they become scared the way I realize, wow, seven marks, it means I have got to work out here, whereas I am going to use a long method.
Tsepo:	I think there is a confusion with the total parts of a ratio, where you are given something like six as to five and then the total parts is six plus five which is eleven and then
Re:	Did they need to do that? They did not need to do that because they are not dividing a quantity into that ratio.

At this point the researcher pointed out that this item was testing more of the conceptual understanding of a ratio than the method of dividing a quantity in a given ratio, and marks allocated were not an issue. There was consensus that the learners who did some working as shown in the errors did not understand when a ratio is in its simplest form. It also became evident that Tsepo had a conception of ratio that was limited to dividing some quantity in a given ratio, but this became more apparent in subsequent conversations (see Episode 2 below).

In the episode Tsepo openly raised his discomfort with a test item, which could be an indication of his developing confidence and trust in the professional learning community. His public voicing of the discomfort initiated a conversation that supported an understanding that some items could test conceptual understanding only and did not necessarily involve some working or an algorithm.

Episode 2: Giving meaning to algorithms

The excerpts in this episode were drawn from an extended conversation in which the focus was on the conceptual meanings of a ratio and the algorithm for dividing a quantity in a given ratio. The conversation occurred after analyzing all the errors in the test and the professional learning

community was now identifying what they thought were the critical concepts for the learners in order to inform the lesson plans.

Karabo:	Ratio is the problem.
Re:	Karabo thinks ratio is a big issue.
Kholiwe:	It's a big issue when they move to grade ten, but when they are in grade nine
Re:	What do you mean, can you explain?
Kholiwe:	They understand when they are in grade nine but when they move to grade ten
Re:	What is it that they understand about ratios in grade nine, what is a ratio? I think lets talk about this, what is a ratio?
Tsepo:	Is dividing in parts, ratio is a total. The total parts of a whole.
Kholiwe:	If you say, if maybe we say you are three, and I give you twenty rand to share it
Re:	I think that's an application of ratio in a sharing context, but what is ratio?
Karabo:	We are sharing, it's a share.
Kholiwe:	It's a way of sharing
Re:	I beg to differ when you say it's sharing because we also talk of ratio, for example what is the ratio of men to women, are we sharing?
Kholiwe:	*Laughs*. You are sharing but not in equal parts.
Mandla:	You are distributing.
Re:	What is the ratio of men to women among the educators in this school?
Kholiwe:	Ten to fifteen.
Re:	What are we doing?
Tsepo:	We are comparing.
Re:	Yes, ratio is a way of comparing quantities.

The episode shows that the teachers initially understood ratio as a way of sharing, with Tsepo specifically alluding to the algorithm for dividing quantities in a given ratio. The researcher then explained that we use ratio as a way of comparison without necessarily knowing the size of the whole, for example using a ratio of 1 teacher to 35 learners to compare teachers to learners without necessarily talking about how many teachers or learners there are altogether.
The researcher then raised the issue of dividing a given quantity in a given ratio. From the transcript below it was evident that the teachers were familiar with the algorithm for dividing a quantity in a given ratio, but could not articulate a conceptual understanding of the meaning behind the algorithm nor of the concept of ratio. Excerpts from the ensuing conversation illustrate how a conceptual understanding of the algorithm was developed.

Re:	If you are dividing a quantity in a given ratio what basically are you doing? For example divide eight hundred in the ratio five to three, why do they need to add five and three?
Tsepo:	They need to get the total.
Re:	Why, what is the meaning of that total? If you were to do it physically what would you do?
Tsepo:	The total is the meaning of a whole; the whole consists of eight parts, five and three.

Mandla:	Are you asking for the process? This is what is not clear.
Re:	Yes. If we can explain that process, that gives meaning to five as to three in a sharing context, remember we are trying to give meaning to the algorithms that we use.
Tsepo:	It doesn't mean to bring them to their equal sizes? Ja, now we are saying in terms of the denominators when we are multiplying
Re:	Remember my question, how would you do it physically?
Mandla:	I will say this one you are five, you are three, and then I give you your five hundred and you get your three hundred *(laughter from everybody)*

Mandla could not explain how or why he would do that. The researcher then explained that sharing in the ratio 5:3 meant that for every 5 given to one person, 3 is given to the other one. Using this understanding the teachers were able to work out that each time a total of 8 is given out and the process would need to be repeated 100 times in order to exhaust the 800, and one person would get 500 while the other would get 300. This led to the following remarks:

Mandla:	Mister, I can start tomorrow, delivering to the learners *(Laughter from everybody)*
Kholiwe:	But this is a nice way of teaching.
Mandla:	No, I am going to apply the very same way.

The episode shows how, in the conversation, the teachers' algorithmic understanding of ratio shifted to a more conceptual understanding. The teachers' initial understandings about ratio were used as objects of inquiry in the conversation to develop a conceptual meaning of ratio and the algorithm for dividing a quantity in a given ratio. The conversation shows how challenging the teachers to explain their initial understandings about ratio facilitated collaborative reflection on their knowledge. The conversation also illuminates how the teachers' participation supported joint sense-making in developing conceptual understanding of the concept of ratio. The two teachers' remarks at the end of the conversation could be indicators of shifts in understanding. The two teachers' reference to their teaching could be evidence of their developing confidence in teaching the topic as a result of shifts in their understanding. The remarks also allude to the teachers' conscious awareness of learners' learning as the focus of the activities.

Conclusion

From the conversations it was evident that the teachers' initial conceptions of ratio reflected a procedural understanding. This is consistent with research findings which highlight that mathematics teachers generally depend on algorithms and memorization of formulae, and do not offer conceptual explanations for those procedures (Zakaria & Zaini, 2009). Ratio as a mathematical topic is considered a difficult topic to teach and learn (Misilidou & Williams, 2002). Deepening teachers' understanding in such topics improves their subject content and pedagogical content knowledge (Shulman, 1987). The analysis shows that the teachers' conceptions of ratio shifted to a more conceptual understanding through their engagement in the conversations, and they were able to develop meaning for an algorithm. A conversation about learners' errors supported the teachers' deepening of their subject content knowledge and pedagogical content knowledge. The teachers developed the beginnings of a conceptual understanding of ratio and how to teach ratio meaningfully.

The results highlight a number of features of a professional learning community that can support teacher learning. The researcher challenged the teachers' initial understandings of ratio and these conceptions were treated as objects of inquiry in a conversation that deepened their understandings of the concept. Diversity of opinions contributed to the inquiry process in this community. The teachers' explanations and justifications of their different viewpoints supported their collective interrogation of their understanding of ratio, leading to joint sense-making and collective construction of the new understandings. The teachers' frequent reference to 'they' (learners) in the conversations could be an awareness of learners' learning as the focus of the activities. The teachers' freely expressed their uncertainties and understandings without feeling threatened, which could be an indicator of their developing confidence and trust in others. Professional learning communities which reflect these features, among others, have been found to result in shared understanding of concepts (Stoll & Louis, 2007). Although data analysis is on-going, from episodes like those cited in this paper I argue that professional learning communities as a model of professional development can support growth of teachers' professional knowledge.

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