Teachers' attention to student thinking, mathematical content and teachers' role in a professional learning community

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The past decade has witnessed increased efforts in studying what mathematics teachers do to improve their teaching. This study builds on and contributes to the research on collective learning in professional learning communities. It aims to uncover the teachers' attention to different aspects related to their work and how these have been developed during one year of collaboration. The focus is on teachers' norms and their attention to student thinking, mathematical content and the teachers' role. By videotaping teacher's participation in the Boost for Mathematics project (*Matematiklyftet*) *five cycles of collective planning and reflection are analysed. The findings indicate a shift in the teacher groups' attention from their role as an organiser to the mathematical content and student thinking.*

Introduction

The past decade has witnessed increased efforts in studying what mathematics teachers do to improve their teaching. One of the specific interests has been the nature of various collaborations through which mathematics teachers are engaged in working and learning, particularly after the report about the Lesson Study in Japan from the TIMSS classroom video study (Robutti et al., 2016). Based on the idea that teachers' professional development can foster improvement in their teaching, many professional development (PD) programmes have been developed. Most of these programmes conform to the concept that a group of teachers should meet regularly, share their expertise and work collaboratively, which can be labelled as a "professional learning community" (PLC). According to Brodie (2014a), PLCs refer to "groups of teachers collaborating to inquire into their teaching practices and their students' learning with the aim of improving both" (p. 501). This goal is also compatible with the aim for the Boost for Mathematics (Skolverket, 2017). Several successful characteristics of a PLC have been identified, such as a productive relationship, a de-privatised practice, fostering collaboration and a collective responsibility for teachers' learning (Brodie, 2014a). Despite an agreement on the importance of PD programmes, there is little consensus about how it is expected to alter teaching practices and how it fosters

teachers' learning (Kennedy, 2016), which Goldsmith, Doerr, and Lewis (2014) described as the black box of teachers' learning.

This study builds on and contributes to the research on collective learning in PLCs, specifically in the field of mathematics education. Although some studies (Goldsmith et al., 2014) have examined several successful characteristics of a PLC, there is hardly any consensus on the processes of how teachers develop their knowledge, as well as the interactions through which a PLC constitutes a resource for teachers' learning and innovations in teaching practice. As such, this study provides additional insights into how PLC groups collaborate to improve their teaching. It aims to uncover the teachers' attention to different aspects related to their work and how these have been developed during one year of collaboration. This study analyses the discussion of one group aiming to attain the Boost for Mathematics during one school year.

The research question guiding this paper is as follows: How has the teachers' attention to student thinking, mathematical content and the teachers' role been changed in a PLC during one year of collaboration?

PLC in mathematics education

Efforts to understand what teachers do to improve their teaching have led to an increased interest in studying different activities, processes and the nature of various collaborations through which mathematics teachers are engaged in working and learning. The organisation of work within schools has undergone changes over recent decades towards more collaborative forms. Teachers are expected to open up their practices to collective investigation. This modification has led to a stronger emphasis on school-based development and collective approaches to practice (Flitton & Warwick, 2013). The focus has shifted from individual autonomy to the development of teachers' practice as a collective enterprise. A central tenet of much of the PLC literature is that collaborative settings allow for individual and collective learning, critical examination of existing practices and joint development of pedagogical/mathematical ideas and artefacts. Collaboration implies that teachers work together and can also learn as a group. It involves teachers performing joint activities for a common purpose (for instance, a shift in practice and its implications for the mathematics learning of students), supporting one another in addressing issues that challenge their existing teaching practice and students' learning. Such collaboration will offer the teachers the possibility to reflect on their role in school (Brodie, 2014a).

The analytical task entails showing how teachers' attention to student thinking, mathematical content and the teachers' role is developed in a PLC during their collaboration. Through interactions with one another, the teachers will present and discuss their experiences and knowledge as educators. A central task is to examine what aspects of teaching practice are taken up in conversations in a PLC. From a

sociocultural perspective, the individual and the group contexts cannot be separated since knowledge does not occur in isolation. Knowledge is constructed through interaction and in a context (Vygotsky, 1978), not primarily through individual processes. How teachers engage in discussions about their practice can be considered examples of their knowledge as their various perspectives are presented and shaped through a year of collaboration. Teachers change by transforming their participation in sociocultural activities that are formed by individuals with other people in cultural communities.

Norms in PLC

Norms are regular patterns of behaviour that affect the nature of learning (Van Zoest, Stockero, & Taylor, 2012). Much of the research on norms in mathematics education draws on Yackel and Cobb's (1996) distinction between social and sociomathematical norms. Social norms are regular patterns of behaviour that are not unique to a mathematics classroom, while sociomathematical norms are specific to mathematical activities. Fostering what is often labelled as productive norms, particularly the sociomathematical type, can improve learning at any level in school, as well as in a PLC (Clark, Moore, & Carlson, 2008).

Elliott et al. (2009) drew on and developed a framework of norms when they designed seminar activities for PLC leaders. They built their framework on Yackel and Cobb's (1996) distinction between social and sociomathematical norms, suggesting that learning opportunities would be guided by patterns of interaction, both explicit and implicit, that would establish how a group could work together. During seminars (using video cases of teacher seminars, among others), the PLC leaders were prompted to notice the nature of questioning and the treatment of errors and confusions as a way of paying attention to sociomathematical norms. This focus on the nature of explanations led Elliott et al. (2009) to identify four productive social norms. The first is sharing, where the group's participants listen respectfully to one another and exchange ideas. The second involves justifying, where teachers describe and give reasons for their thinking. The third entails questioning, where teachers query one another. The last comprises responding to confusions and errors.

Despite the growing body of research on sociomathematical norms that might affect teachers' learning, research on more general norms that influence teachers' learning is less prevalent (Van Zoest et al., 2012). Therefore, this research focuses on social norms in a PLC, the specific ways that teachers engage with one another, and how these norms are related to the way that they interact and discuss student thinking, mathematical content and the teachers' role.

Categories for professional knowledge required for teaching

Ball, Thames, and Phelps (2008) emphasised mathematical knowledge for teaching, which they divided into two domains – subject matter knowledge and

pedagogical content knowledge. To foster what Ball, Thames and Phelps (2008) label as effective teaching, the development of mathematical knowledge for teaching is an important factor. At least, familiarity with this model allows teachers in a PLC to reflect on the various domains of pedagogical content knowledge. According to Garet, Porter, Desimone, Birman, and Yoon (2001), PD programmes that focus on specific mathematics content and the ways that students learn are helpful, particularly regarding instruction designed to improve students' conceptual understanding. This is consistent with the study of Goldsmith et al. (2014), who reviewed articles related to professional learning and practising teachers of mathematics, searching for how and what teachers learn to provide high quality mathematics teaching for all students. They found six major categories related to teachers' learning, three of which are of particular interest for this present research. One category is teachers' attention to student thinking. Students often think about mathematics differently from teachers; therefore, it is important for teachers to understand and build on students' existing ways of knowing. The next category is teachers' instructional practice. Goldsmith et al. (2014) considered changes in teachers' instructional practice as evidence of professional learning, including lesson planning and post-lesson reflections, as well as classroom instruction as practice. Many of these studies included a PLC intervention, with different types of focus, such as mathematics, mathematics tasks, student thinking and pedagogy. The last category is mathematics content knowledge, and Goldsmith et al. (2014) identified particular ways that teachers' mathematical understanding affected practice and found a connection between mathematical knowledge and the ability to engage in productive professional conversations.

This section has presented some frameworks and constructs about norms in a PLC and several categories for the professional knowledge required for teaching. Based on this research, we have developed a framework to focus on teachers' norms when they contribute in the discussions and their attention to student thinking, mathematical content and the teachers' role. The next section, methodology, explains this framework.

Methodology

Between 2013 and 2016, the Swedish National Agency for Education launched a 649-million kr, curriculum-based PLC project. Called the Boost for Mathematics, this project aims to improve the mathematical classroom teaching. The most central components are 24 modules, eight per grade level 1-3, 4-6 and 7-9, developed to support teachers working in teams in planning, establishing and reflecting on mathematical classroom practices. The curriculum material is distributed digitally on a website (http://www.skolverket.se/kompetens-och-fortbildning/larare/matematiklyftet) and includes articles, instructions, images and video films. Each module is designed to support groups of teachers (during one

semester) in engaging in eight iterations of (1) individual reading, (2) collective planning with colleagues, (3) individual classroom teaching and (4) collective reflections on classroom instruction. A coach guides each group of teachers. This paper focuses on one group of eight teachers, including one coach, teaching grades 4 to 6. The participants in this group came from three schools. The data were collected by videotaping four cycles – two in the autumn and two in the spring, a total of eight sessions. Each cycle included collective planning and reflections with colleagues. In the autumn, the group worked on the module "Understanding and use of numbers", and in the spring, they participated in the module "Relationships and change".

Framework

Based on videotaped records of the interactions among the teachers from one working group, we wanted to study a) how teachers' attention to student thinking, mathematical content and the teachers' role were developed and b) the norms of professional interactions and the ways that they were related to the elements described in a). The analytical task entailed showing how the interactions among the teachers revealed particular considerations of practice. We therefore developed a framework that could help us document the norms and the practice that would constitute the collective learning (Cobb, Zhao, & Dean, 2009) of a teachers' group.

Concerning norms of professional interactions, sharing refers to teachers exchange their ideas. One example could be that they discuss how the classroom are organized, the size of the students working groups and so on. Justifying involve the ways that teachers describe and explain their reasoning. Do they refer to the Boost for Mathematics project, their own experience, the textbook, the research literature or other factors involved? Questioning refers to how they query one another and what aspects of teacher attention they are asking about.

Concerning teachers' attention, one aspect involves students and their abilities and misconceptions (among others), what Ball et al. (2008) referred to as knowledge of content and students. Another aspect is the teachers' role, specifically, how they describe their own functions in the classroom and knowledge of teaching. The mathematical content category covers specialised and common content knowledge.

Analysis

The analytical task involved showing how teachers, through their interactions with one another, constructed their representation of practice. Representation of practice refers to the students, the teachers, mathematics or the organisation of the lessons that are taken up in the conversations among the group of teachers. The results were based on one incidental group of teachers teaching levels 4–6, who were chosen among six different groups. Therefore, the representativeness of this group could not be considered. Central to the analysis were videotaped records of

eight teacher meetings in the course of a school year; these sessions' durations varied from 70 to 100 minutes each. We used the videotaped records to study the teachers' collegial interactions. The teachers' meetings were then transcribed, and the texts were coded using NVivo software. We identified relevant conversation episodes and categorised them according to the coding scheme presented in Table 1. A change in episode was registered when the teachers shifted their attention from one category to another or modified the aspect of an interaction (norm). These shifts were registered in each session and used to compare the sessions. One of my research members and I independently coded the first session, and we compared our results to adjust the rest of the coding of the materials. When disagreements occurred, we resolved them.

		Norms		
		Sharing	Justifying	Questioning
Teachers' attention to ...	Student thinking			
	Teachers' role			
	Mathematical content			

Table 1: Norms and teachers' attention to student thinking

Results

The first excerpt below is from the first videotaped collegial meeting in the autumn of the teachers' group. They are working with the module part "Number and number concepts, grade 4-6" and at this stage, the teachers are working on round 4 and session B, entitled "Reasoning". In the first 25 minutes, they have been discussing the questions about reasoning from the curriculum materials, for instance, "What do you mean by reasoning in mathematics?" In this excerpt, they are planning a lesson with the aim (given in the text from the Boost for Mathematics) that students should reason about fractions. Six teachers are working together, and Mary is the coach of this group.

Jenny: How many groups do you think we should form? How many groups could we gather?

Mary: Yes, that was what I was thinking; how many could be seated?

Frank: Four. With a large A3-sized paper.

Jenny: Then it would be five groups.

Frank: Yes.

Mary: I consider three … because I have attended some courses and heard ...

Nola: It should be three in every group?

Mary: I heard from some place that this will activate everybody.

Other: Mmm.

Mary: But I do not think that it is always correct. Sometimes, four could be right and sometimes, three.

Jenny: Sometimes, four could be too many.

Mary: Yes.

Jenny: Some will be passive, and some will push forward.

Mary: At the same time, everyone should also write.

Jenny: I would like to try with three.

Clara: We go for three.

The above transcript illustrates a typical focus on the interaction during the first collegial meeting in the autumn were the teachers mostly focuses on sharing how they should manage the lesson they are planning. They discuss whether the students should be given a fraction to consider or if the teachers themselves should choose for them. The excerpt also shows that the teachers are concerned about how to manage the lesson, including the size of the paper and the number of participants in each group. The questions they are posing are related to managing the lesson. They do not push for deepening understanding as a productive social norm (Elliott et al., 2009) since they are in agreement. There seems to be a lack of an opportunity to compare and re-conceptualise ideas and explore contradictions.

The next excerpt is from the module part "Relationships and change, grade 4-6," round 3 and session B in the spring, entitled "Evaluation of students who are showing their knowledge." Six teachers are participating in this meeting. Frank is not present. Beth is participating this time, and she was absent from the first videotaped collegial meeting. Mary is still the group leader. In the excerpt below, two of the Grade 5 teachers present the task that they will give their students. "*Thirty percent of the students in one school play handball. How many students are there in total in this school, and how many play handball?*" The concept is new for the students, but the teachers think that the students are familiar with it from everyday life.

Jenny: We were thinking that we should change 30% to 50% of the students in the school.

Mary: Why will you change to 50?

Beth: Since it is a new concept, and let them understand from the beginning, and then, we were thinking that 30% could be for them something that would need a further step.

Mary: Like an extra task.

Jenny: Yes, you start with 50 right, and then you could take 30%, and then you perhaps could choose on your own if you take

	30%, and you can still choose your own percent number. And we thought that we should ask them if they had encountered the concept of percent and in which situations [...]. And we think they have done that in discount and when they load their mobile phones.
Beth:	Yes, downloading a computer program.
Jenny:	They see yes, 75% left in the battery and like that. When do you load your mobile phone? How much is left? You can start from that point.
Beth:	Returning to when the mobile phone is fully loaded – how much percent is that? When is one full?
Mary:	So for you, it will be some listening and some help?
Jenny:	Yes, we base it on their own knowledge.
Beth:	Connect it somehow to everyday [life].
Jenny:	What do we want that they should have learned after this?
Beth:	I think an understanding of percent as a hundredth at least. Eh, preconception, I don't know.
Jenny:	No, that 50% is one-half.
Mary:	That 50% is one-half and percent as a hundredth.

During the teachers' collegial work, there has been a shift from an emphasis on teacher role as managing lessons (the first module part) to a stronger focus on the mathematical content and student thinking (Ball et al., 2008). They are discussing what kind of mathematical content would be suitable for their students, along with the lesson's aim. The questions are also related to the mathematical "change to 50%" and to students in terms of "what [...] they should have learned". To a greater extent than the questions in the first excerpt, these are more productive norms (Elliott et al., 2009) since they push for a deeper understanding of student learning.

Conclusions and implications

The two preceding excerpts are presented to show how the teachers' attention and norms have changed in a PLC during their collaboration. When they started working on the curriculum materials for the Boost for Mathematics, the groups mostly focused on teachers' role as a lesson manager. In their subsequent meetings, their attention shifted to student thinking and mathematical content. Following the study of Gamoran et al. (2003), the teachers are now collectively concentrating more on student learning as opposed to their previously more common conversations about administrative details and lesson management. They are collaborating on ways to improve their students' understanding of mathematics, as well as engaging in dialogues about their role and the nature of teaching. The

groups' norms have changed in the sense that their justifications are now more productive in pushing for a deeper understanding, particularly of student learning (Elliott et al., 2009). On the other hand, the quantity of situations where teachers questioned each other was very low and did not change during the year of collaboration. Questioning is important because if you always feel safe, you cannot learn (Brodie, 2014b). Teachers have to be challenged to move outside their comfort zones to create new ways of thinking about their own role as a teacher and their students.

In this paper, we have focused on how norms and teachers' attention to student thinking, mathematical content and the teachers' role have changed in the course of a year's collaboration. Further developments and studies would compare this evolution among different groups of teachers and emphasise how such a transformation could constitute the collective learning of a teachers' group.

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