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Jennifer Holm, Ann Kajander
Lakehead University

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Lessons Learned about Effective Professional Development: Two Contrasting Case Studies

Jennifer Holm*, Ann Kajander
Lakehead University

Abstract

Professional learning groups are becoming a popular form of teacher development in mathematics. Due to the personal nature of the groups, as well as differences in initial beliefs and capacity, teachers may respond differently to such opportunities. A total of 14 teachers were observed over a three-year period, and two contrasting participants, each involved for two years, were chosen for in-depth study in order to illustrate a range of responses. The teachers were chosen from the larger sample to exemplify differences in initial capacity as well as varying responses to the group activities. Both teachers, regardless of their differing initial beliefs and knowledge, demonstrated growth over a two year period. Such development however was in relation to their initial beliefs and capacity.

Key words: Professional development, Teacher knowledge, Teacher beliefs, Mathematics professional development, Professional learning groups.

Introduction

To ensure quality instruction, mathematics teachers require specialised knowledge for mathematics teaching (Ball, Thames, & Phelps, 2008; Davis & Simmt, 2006; Kajander, 2007; Ma, 1999; Shulman, 1986; Silverman & Thompson, 2007). Although this knowledge can be increased during teacher education programs, past work suggests that more support may be needed for teachers in order to embrace new teaching methods (Kajander, 2007). A lack of knowledge may lead to a cyclical effect – if students have experienced inadequate mathematics learning themselves, and then subsequently become teachers without the appropriate knowledge base, confidence, or beliefs, they may find it difficult to attempt new methods in teaching mathematics – and so the problems persist. Thus, continued in-service development may be important for many teachers, to help them gain new knowledge and skills, as well as provide them with support over a longer time period. As Confer and Ramirez (2012) note, most schools find that professional development is critical for teachers as they journey through new, unchartered territory" (p. 12).

In order to support changes in mathematics teaching practices of in-service teachers, professional learning groups or communities are one possible way of addressing teacher needs. Professional learning groups have potential as a form of sustained professional development in mathematics. The main focus of these groups of teachers is that they are created with the intention of exploring the everyday struggles and triumphs of teaching in order to accomplish a goal set by the group itself. As Arbaugh (2003) summarises, these groups are "a group of educators who come together on a regular basis to support each other as they work collaboratively to both develop professionally and to change their practice" (p. 141, italics in original). Another definition of this type of professional development is "a group of people with a shared interest in the knowledge, application, and improvement of professional education standards" (Loughridge & Tarantino, 2005, p. 76) by giving "job-embedded opportunities for staff to engage in professional conversations around classroom instruction, assessment, and student learning" (p. 74). In the Canadian province of Ontario, the Ministry of Education (2007) has advocated the use of professional learning groups in schools. Although the Ministry notes there are many definitions for this type of collaboration, they note that "a professional learning community is always a group of people who are motivated by a vision of learning and who support one another toward that end" (p. 1). For the purposes of the current research, we used the term "professional learning group" as it was used by the group itself.

* Corresponding Author: *Jennifer Holm, jholm@lakeheadu.ca*

This research study investigates two different teachers involved in the same professional learning group for two years who engaged in the same activities, yet reacted to the activities and gained knowledge in different ways. These cases are drawn from a three-year longitudinal study of 14 teachers. The case studies provided here were chosen as illustrative of different responses of teachers, and are provided to inform our understandings of how different teachers may apply new strategies and their own learning to their practices. Two areas had the greatest impact on how these individuals applied and reacted to the activities: beliefs about mathematics and mathematics teaching, and knowledge of mathematics.

Our research study focuses on examining difficulties encountered when teachers with differing knowledge and beliefs about mathematics engage in professional development such as a professional learning group. Our goal is to highlight issues that teachers and administrators need to consider as they navigate the intricacies of planning professional learning groups in mathematics. We first summarize how professional learning groups as well as teacher beliefs and knowledge are described in the literature, followed by the framework for the current study. Finally, we present the two cases and discuss our findings on how the experiences add to the existing literature, in order to present our suggestions for mathematics professional development and future research.

Literature

Ball, Hill, and Bass (2005) argue the need for teachers who understand mathematics and the curriculum to be teaching mathematics in schools. Ensuring effective professional development is especially important because a high-quality professional development is needed in order to have high-quality, effective teachers in the field (Gojmerac & Cherubini, 2012). As well teachers are the ones who ultimately enact changes in the classroom (Blegen & Kennedy, 2000; Brahier & Schäffner, 2004), so it is important to provide professional development and support to in-service teachers. In the past, "teachers have been considered as passive receivers of prescriptive programs, [and] given little time or incentive to integrate these new programs into their classroom practice" (Lieberman, 2000, p. 226). A "one size fits all" fix is simply recommending teachers employ the same strategies in all schools and is unlikely to be effective. Research supports the conclusion that these "one shot" or "top down" professional developments simply are not working (Arbaugh, 2003; Ball & Cohen, 1999; Brahier & Schäffner, 2004; Gojmerac & Cherubini, 2012; Hawley & Valli, 1999; Hofman & Dijkstra, 2010; Lieberman, 2000; Schmoker, 2006; West & Curcio, 2004; Wetzel, 2001); rather, professional development needs to encourage teachers to expand their pedagogical horizons and potentially make changes. Avoiding this traditional form of professional development in favor of what is being termed "sustained and significant" learning opportunities (Brahier & Schäffner, 2004) appears to be the current best route for development.

In mathematics, effective professional development is especially important given studies that suggest teacher content knowledge needs to be improved (Ball, Thames, & Phelps, 2008; Silverman & Thompson, 2008) at the same time as teachers need to examine their existing beliefs about teaching mathematics (Philipp, 2007; Wilkins, 2008). In order to support changes in the mathematics teaching practices of in-service teachers, professional learning groups are one possible way of addressing teacher needs. The spread of professional learning groups through educational systems attempts to inform and shape teaching practices in today's changing field (Johnson, 2009; Laufgraben, Shapiro, & Associates, 2004). In mathematics in particular, more research needs to be done to explore why certain learning communities are more effective than others because as Kajander and Mason (2007) illustrated, there is a wide range. Research in professional development indicates that it is imperative to consider the opinions of the teachers in making any development decisions (Anderson, 2005), so the opinions and experiences of the teachers are essential to any research into professional development.

Professional learning group research acknowledges that the teachers meet with a focus on student learning (DuFour & Eaker, 1998; Hall & Hord, 2006; Loughridge & Tarantino, 2005) by discussing individual teaching contexts. This allows teachers to explore and diagnose difficulties within their own environments with the goal of increasing student success. Confer and Ramirez (2012) discuss that the first step in making changes to schools is to "keep the end in mind" (p. 5). They focus first on how in mathematics, the teachers need to determine what it is they want students to know and be able to do as a result of the mathematics instruction. This would then become the guiding goal for the professional development or changes. Research has supported the notion that having teachers work together has an impact on student achievement (Hofman & Dijkstra, 2010) and on the classroom (Andrews & Lewis, 2002). This research focuses on how different individuals can work together on the same activities and apply the practices in different ways in their own classrooms. In studying all the members of the professional learning group, it was clear that the two areas that impacted the teacher

development most were the teachers' beliefs of mathematics and mathematics teaching and their knowledge of mathematics.

Philipp (2007) notes that "beliefs might be thought of as lenses that affect one's view of some aspect of the world or as dispositions toward action" (p. 259). As such, beliefs are "situated" and specific to the teacher and student interactions (p. 274). Philipp comments that teachers can also hold beliefs that run contrary to the methods they employ within their classrooms. If teachers have experience only with traditional mathematics education and hold true to that vision, somehow they need to become open to more reform-based methodologies and new pedagogies vastly different from their own experiences (McNeal & Simon, 2000). Researchers suggest that past efforts to change teacher practices have failed partially because of not accounting for the beliefs of the teachers affected (Grant, Hiebert, & Wearne, 1994; Handal & Herrington, 2003). Grant et al. (1994) set out "two dimensions of teachers' beliefs: (a) what kind of mathematics is important for students to learn, and (b) how this mathematics should be taught" (p. 9), and these were the areas of focus in the current research study.

Gresalfi and Cobb (2011) found there could be a tension between what a teacher believes is best practice and following the school mandate simply because it is what the teacher feels is what must be done. When planning professional development, this conflict could play a role in how participants enact the new practices explored. Recent research suggests that a teacher's beliefs have the strongest influence on a teacher's practice (Wilkins, 2008). In addition, Beswick (2012) examined teachers using problem solving approaches which differed from previous experiences with mathematics. She found that a teacher who had not realigned beliefs about mathematics experienced difficulties when attempting to use the problem solving approach. This highlights the importance of not only encouraging teachers to use new strategies for teaching mathematics, but also to confront their own beliefs about teaching. As Bray (2011) discusses, mathematics teachers need time during professional development "to critically examine traditional mathematics teaching practices and assumptions about student learning in order to inspire recognition of the need for alternative mathematics teaching practices and to initiate changes in beliefs" (p. 35).

Grant et al. (1994) determined that a teacher's beliefs impacted how he or she even viewed learning about new instructional strategies. Battey and Franke (2008) extended this idea to professional development, finding that teachers would fit the new learning into their existing practices and make determinations about what would or would not work based on their existing values. Shulman and Shulman (2004) found that the community a teacher is involved in has an impact on both the teacher's beliefs and practices; therefore professional learning groups could have an important role in changes. While the use of reform-based mathematics pedagogy is supported by both the NCTM (2000; Working Group of the Commission on Standards for School Mathematics of the National Council of Teachers of Mathematics, 1989), as well as the Ontario Ministry of Education (2005; Ministry of Education and Training, 1997), that does not mean that such pedagogies are universally taken up; teachers must *believe* that these methods work in order to appropriately enact them in their own classrooms, and they must also have sufficient knowledge of mathematics to support student explorations.

Silverman and Thompson (2008) claim that mathematics knowledge for teaching only becomes the knowledge needed by teachers when understandings of content are linked to pedagogical knowledge. An example of this intersection with pedagogical knowledge is "understanding why a student may arrive at a particular answer or knowing different instructional approaches for demonstrating a mathematical concept" (Chamberlin, Farmer, & Novak, 2008, p. 441). Teachers would also need to know how to base mathematical lessons on the knowledge students already possess in order to bring students toward the lesson goals (Baumert et al., 2010; Silverman & Thompson, 2008). As such, the understandings needed by teachers are complex and varied.

Framework

The framework used in this study focused on two specific areas of social constructivism that pertained to the social nature of teaching, and also to professional learning groups. The first aspect examines the emotions of teachers using the work of DiPardo and Potter (2003). DiPardo and Potter expanded the work of Vygotsky on the social nature of emotions to include the difficulties faced by teachers in their profession. According to DiPardo and Potter, Vygotsky "condemned the tendency to separate intellect and affect into distinct fields of study, believing that this separation had created the false illusion that thinking is somehow segregated from the fullness of life and from the needs and interests of the thinker" (p. 318). They provide evidence for the emotional nature of the teaching profession and advocate for the need to provide supportive, social contexts for teachers in dealing with stress encountered while teaching. Not only would support come from the social group,

but according to DiPardo and Potter, as well as Gergen (1995), emotions are being constructed in social contexts as well.

The second area deals with how individuals react during a conversation, and is based in the work of Blumer (1969, 2004). Through examining the work of Mead, Blumer (1969, 2004) discusses how people engage in conversations by responding to each other's gestures. There are two types of responses that can occur: reflexive and symbolic interactions. Symbolic interaction occurs when individuals consider the response by interpreting the gestures and consider the follow-up response in the interaction (Blumer, 2004). Blumer concludes that conversation only occurs when participants in the interactions are actively trying to figure out the other person's desired response to their stimulus.

These two areas became important in our research as a professional learning group has the potential to support teachers, but could also impact the emotions of the individual teachers. Furthermore, the tenets of symbolic interactionism allow for the potential that individuals may misinterpret conversations by interpreting their responses to the stimuli. It is these individual reactions that are both a result of the group situations, as well as, in part, a product of individual experiences, which supports how two different individuals can have vastly different responses to the same activities.

Methods

This study took place in a mid-sized town in the Canadian province of Ontario, a region in which significant curriculum changes in school mathematics over the last 15 years has provided a challenging environment for teachers. The responses of the fourteen mathematics teachers of grades six to ten who were members of a professional learning group (the number of participants varied throughout the study) were studied over a three year period. The current discussion is focused on two individuals, Blaine and Wesley (pseudonyms). These two teachers were selected from the dataset of all teachers in the group because they provide examples of distinctly contrasting experiences that highlight some of the professional development challenges experienced by mathematics teachers based on mathematics knowledge and beliefs.

The goal of the current analysis was to provide an illustration of varying characteristics which could potentially influence how an individual applies knowledge gained during professional development. This study sought to highlight specific areas that need to be considered in providing high quality professional development in mathematics that would support using effective pedagogy. Although past literature has pointed to the need to examine beliefs and knowledge of mathematics in professional development, this study focused on how these areas affect individuals during sustained professional development.

Due to the very personal nature of goal setting in the professional learning group, narrative inquiry was used to illustrate the stories of the members of the group. Since "the province of qualitative research, accordingly, is the world of lived experience, for this is where individual belief and action intersect with culture" (Denzin & Lincoln, 2005, p. 8), our research highlighted the journeys of teachers within a single professional learning group in their activities, discussions, setting, and interactions to paint a picture of the experiences of this group of teachers wrestling with issues in mathematics education. Narrative inquiry posits that the stories of the participants are the focus of the research and should be merged with the story of the researcher as they interact in the social situations of the research (Chase, 2005; Clandinin & Connelly, 2000). In order to accept the personal nature of the professional learning group, narrative inquiry was used to relay the stories of the participants as they navigated within the group. As is important for a narrative researcher (Chase, 2005), we attempted to respect the stories and the journeys of each of the teachers as they functioned within the professional learning group not just discover themes that link the stories of the individuals together. Kajander and Mason (2007) discuss how the researchers had to set aside their "agenda" in evaluating the effectiveness of a professional learning group because of the teacher-driven nature that is a characteristic of professional learning groups. They note that "the PLG [professional learning group] approach is organized to value the autonomy of teachers and to trust in their capacity to be self-directed and purposeful…research on PLG process should grant to participants' conceptions of success a privileged position in its design" (p. 436). As such, our research expanded upon the conversations of the teachers by moving away from only "defining success" from a research perspective to exploring the stories of the teachers who engaged in the professional learning group. In order to accept the personal nature of the professional learning group, narrative inquiry was used to relay the stories of the participants as they navigated within the group.

This research study focused on a professional learning group of intermediate mathematics teachers. This group was composed of both elementary (grades 6 to 8) and secondary (grades 9 and 10) teachers. Field notes, meeting recordings, and interviews comprised the data collection for the study. The first author attended all professional learning group meetings and recorded all the conversations. During each meeting, the first author recorded field notes about different actions or notes taken by the individuals during the professional learning groups. All documents passed out during the meetings were also collected, as well as any follow up emails to be analysed as part of the research study. Each of the members of the group were also asked to participate in semi-structured interviews with the first author. All of the pieces of data were then analysed and combined in order to create the narrative story of each of the members of the professional learning group. As mentioned however, for the purposes of this report, only two individuals are discussed. Although the original data collection of the study was drawn from three years of a professional learning group, both of the participants to be discussed here were members for the most recent two years only, which serves as the timeline for the current research report.

Case Studies

In this section, we present details of the two individuals' experiences during the professional learning group meetings. Whenever possible, the words of the participants will be used to give authenticity to the descriptions. The case studies provide a story of how the individuals navigated the social terrain of a professional learning group and what they felt and learned from the experiences, as well as how they reacted to the activities.

Blaine is an elementary school teacher who, at the end of the study, was teaching a grade 6/7 split class. He holds a Bachelor of Arts as well as a Bachelor of Physical and Health Education in addition to his education degree. At the time of the study, Blaine had been teaching less than 20 years. Wesley, on the other hand, is a secondary mathematics teacher, with a Bachelor of Mathematics in addition to his education degree. He also held additional qualifications in mathematics and had been teaching more than 30 years

Blaine

Blaine taught at the same elementary school as two other teachers in the professional learning group and mentioned that a lot of his lessons had come from things that the grade 8 teacher had created. Blaine valued striving to ensure that all of his students were working in mathematics and that no one was being left behind because "I believe that everyone is capable of doing something in math" (interview transcript). He worried about making sure he could address everyone in his class, from the lowest student to the highest achieving student, during each lesson. He noted that he used the three part lesson in his own teaching (a general lesson style which involves an activity or problem in the second part of the lesson), and had students work in groups, which he followed up with having students complete practice questions.

Blaine spoke less than fifty times during the two years of monthly half-day meetings and most of his comments were one or two word answers in response to a question or comment being directed at him. As he noted he was "just trying to soak it in" (Meeting #9 transcript). He never brought something to share during his two years working with the professional learning group. In only two of the meetings Blaine talked about his own classroom. During one meeting, the group was discussing rubrics and what it meant for students to be at different levels on the rubric, and Blaine discussed a quiz he had given to his students where his students had to create gift bags. He further explained the range of his students' answers for the problem from using factors to just drawing out the solution, "so to me the kids that are using factors and solving the problem that way that's pushing forward thinking" and to him was the definition of the highest level response (see Ontario Ministry of Education, 2005 for sample rubric). He also discussed one particular lesson he did with his grade 6/7 class that he had changed from previous years and met with more success. He talked about teaching the volume of rectangular prisms and triangular prisms together and that "I find that with grade 6's that if I say length times width times height for rectangular prisms then they're applying that to triangular prisms as well and they're just using a formula and not really understanding what they're doing" (Meeting #16 transcript). He decided to try the formula area of the base times the height in order to get students to start thinking about the process and met with more success.

Some of the professional learning group meetings focused on having pairs of teachers present how they would work with specific mathematics questions in their classrooms. During these discussions with the group, Blaine's teaching partner always presented the ideas. He did seem comfortable with the teachers in the group and often joked with the members about topics other than mathematics. "I feel like I'm the parasite in that group because I

really feel like I don't offer much to the discussion, but I take a lot from it in terms of certain things just because my knowledge is so limited I think compared with everyone else in that group" (interview transcript). As Blaine explained, "math was never a strong point for me as a student", and he felt that he had a lot more that he had to do in order to prepare for a mathematics lesson compared with his colleagues (interview transcript). He also told his students that anything good that they got to do in mathematics came from the grade 8 teacher at his school.

Blaine also asked questions during the meetings in order to clarify his own understandings of mathematics. For example, he expressed his confusion about the question $7\text{-}5^2$ being discussed because he did not realise the exponent was attached to the five, not a negative five. Later in the meeting he asked for further clarification to ensure his own understanding of the concept. Since mathematics is "just not a natural thing" for him, Blaine found a lot of benefit in going to the professional learning groups and gaining knowledge from his colleagues. He felt that since his "knowledge of teaching mathematics is so shallow…that anything is going to help", and he found that the meetings where they discussed student work would allow him to gain insights into the practices of his peers (interview transcript).

For Blaine, ensuring that the topics discussed were in the context of how they would be used in the classroom was particularly helpful, so on days where the teachers discussed mathematics questions, he felt they were not helpful since they were out of context for him. He felt that he would need more time with those concepts before he would actually gain anything from those discussions. According to Blaine "one time is not enough because when Emma [the grade 8 teacher] talks about renting a concept, I might get that at the moment, but when I walk out of there, that's not going to sit with me the next day in the one workshop thing" (interview transcript).

Blaine expressed how the professional learning groups were a source of focused and positive energy by working with a group of teachers who did not complain about the state of the world but worked together to make strides to improve. He found that he got a lot out of each of the meetings, including finding a focus for his own teaching based on the discussions of the group. Although he noted that he had always done long range planning, the topics of the group meetings would help him decide where he would focus between the meetings. He also noted "I find a lot of value in watching a high school lesson. When I'm talking to the students about what they can expect, I can at least have someone to look at" (Meeting #12 transcript). Overall, although Blaine lacked confidence in his own mathematical abilities as well as his ability to teach the subject, he felt that he was gaining more insight, knowledge, and support from attending the professional learning group meetings.

Wesley

Wesley was an older secondary teacher. He noted he was "too senior minded" and struggled to look at some of the teaching methods from an elementary perspective (Meeting #12 meeting transcript). For Wesley, his job as a teacher was "to be teaching and helping the kids at learning mathematics at their level and whatever they can do beyond" (interview transcript). Wesley stressed to students that they needed to be "speaking mathematically" (Meeting #12 transcript), such as ensuring his students only used "one equal sign per line" when sharing their work (Meeting #13 transcript). He shared his concern that many times his students were placed in the wrong mathematics classroom because they were given the freedom to choose their classes in secondary school. He felt that the grade 9 provincial mathematics test scores would be better if the students were properly streamed, and he counselled parents to listen to the grade 8 teachers' recommendations about course placement in grade 9.

The materials that Wesley brought to the group to share showed that he was more traditional in his classroom practices, with mathematics being viewed as a set of rules and procedures for students to memorise in order to be successful. He set up his lessons to start with giving students examples and then having students practice the skills demonstrated. Wesley talked about liking "little tricks" he could show to his students so that they would be successful (Meeting #9 transcript). For solving equations, Wesley brought to the professional learning groups a list of rules that he displays for his students to help them in his grade 10 Applied (non university level mathematics stream) classroom. He talked about how he only had two and a half weeks for students to learn the list of rules "so the kids have the tools and then to move on to the course" (Meeting #8 transcript). He went on to note that the paper list was not for all the students, but "it's made up for the kids who want to have some kind of structure to follow" and then he would give them repeated practice using all of the strategies in the list. "At this point in time in grade 10, we probably have zero time to go ahead and talk about, bring out the picture of the teeter totter" for students to gain a mental picture of the equation solving process: they just needed to learn the rules. He mentioned how he was quite surprised to see the amount of problem solving in the new textbooks. He noted his thought on seeing the textbooks was "oh gee whiz, I can't do this because there's an awful lot of skills that I have to really cover before I get to these. I find in our textbook we don't have a lot of skills, we have

a lot of problem solving, not a lot of skills" (Meeting #8 transcript). He expressed his desire for more questions to practice using the concepts instead of problem solving in the textbook.

In describing his grading practices, Wesley noted that "if the question is more than one mark, you have to show your work" (Meeting #8 transcript), and he struggled with the concept of possibly using a rubric in his own classroom. "I look at rubrics in the publications we get for grade 9 and 10 math, I take a look at it, and I just go gee, I don't know if I'm going to get around to that. I get the task, and it would be nice if I could see the strategies" (Meeting #8 transcript). He discussed how he could see the value in using a rubric because then students would know what they need to do in order to get their grade, but "I wonder though at times whether my information is falling on deaf ears", explaining that he felt parents are looking for a percentage for their child's grade (Meeting #8 transcript).

Wesley did enjoy the amount of technology that he had access to in his school and found it to be very beneficial for his teaching. He posted his SMART notebook lessons on his website for the students to review after class. He noted that in future years, he would like to record voiceovers with the lessons in order to give his students a commentary of what they were seeing on the file. He shared his concern that sometimes his students would simply punch numbers into a calculator and not have a concept of what the numbers mean or where they came from. "I kind of explain that that's pop machine mathematics, which is very useful at times. It's very useful to put in your dollar twenty-five and get the pop if you want it, but it's kind of neat to watch it move through the machine" (interview transcript). He said that he would "kind of emphasise that it doesn't have to be difficult mathematics to be good mathematics or useful" with his classes of students (interview transcript).

Wesley discussed having a higher mathematics degree and his comfort with the subject area of mathematics. He felt that he was "kind of thinking down a lot of the time" (interview transcript) when discussing the mathematics content in the professional learning groups. He said that he did learn a lot about teaching of mathematics through the group discussions. In discussions where the teachers were questioning the mathematics, Wesley usually entered the discussion about what the mathematical principles were. For example, the group was discussing whether or not it was mathematically necessary to include a break in a graph if you are not starting at zero, and Wesley noted that "it's just a procedure" and that it would matter in statistics only (Meeting #11 transcript).

Wesley shared his concern over the number of dominant personalities in the group and that "sometimes people talk too much" (interview transcript). But he also commented, "I think if you're coming to the group, and you're going to sit there and say nothing, why bother coming?" (interview transcript). Despite his concerns about the structure, Wesley did feel that the professional learning groups played an important role in keeping a teacher moving forward in their profession because it "keeps you refreshed" (interview transcript).

Throughout the majority of the first meetings, it was obvious that Wesley felt the groups were put in place by the school board to help the elementary teachers support the secondary teachers, and as a "vehicle" for setting up students for success later in their mathematics careers. For example, he was quite adamant that the grade 7 and 8 teachers needed to be showing their students some more advanced concepts for later on, such as with factoring binomials. To Wesley, this was important for the teachers to do because "I don't think we always have to think of our mathematics as being something that, oh it's got to serve a purpose now" (interview transcript). "I think it's an investment of a skill that they're going to need three years down the road" (Meeting #9 transcript). He brought up the discussion, based on a conversation he had with another secondary teacher at his school, that the grade 7 and 8 teachers should be showing students how to "get rid of" the fraction in an algebraic equation by multiplying by the common multiple. Figure 1 shows the example that Wesley used on the board to share this concept with the group (as a note, this example as given cannot be solved). In this case, he felt, students should automatically multiply each part of the equation by "12" in order to remove the fractions. Wesley saw this as a way for students to be more prepared for later in school and that it was important to "teach them" this skill.

Wesley noted however that the group meetings also gave him the opportunities to try new things, like algebra tiles, that he would have skipped over in his textbook before listening to the group talk about them. As he said, "you get stuck in doing the same old, same old" without having discussions with other professionals (interview transcript). For one of the meetings the group went to the university to view a presentation by noted social activist and mathematics teacher David Stocker. This presentation focused on using social justice type problems in the mathematics classroom. Following the presentation, Wesley became inspired to try the strategies in his classroom and worked on incorporating a theme from the meeting into a mathematics lesson to address concepts of number sense with his students. To Wesley, the message of the speaker was to "leave the kids with something

they're going to remember" and he felt that this use of real-world contexts would leave a longer lasting message so that the concept would not have to be retaught (Meeting #15 transcript). Wesley believed that "instead of cranking out a standard word problem about whatever, how about a word problem that involved tobacco use for kids. You still have your mathematics, but also have this other effective message going too" (Meeting #15 transcript). He was greatly disappointed when his attempted lesson did not work out the way he had hoped which he felt was due to the extremely low achieving students in his classroom. He did share his desire to try again in future years and hoped a different mix of students would produce a different outcome.

$$\frac{x}{3}+\frac{1}{4}=\frac{2x}{6}+\frac{1}{2}$$

$$\frac{x^{\times 12}}{3}+\frac{1^{\times 12}}{4}=\frac{2x^{\times 12}}{6}+\frac{1^{\times 12}}{2}$$

$$\frac{x^{\times \cancel{12}^{4}}}{\cancel{3}}+\frac{1^{\times \cancel{12}^{3}}}{\cancel{4}}=\frac{2x^{\times \cancel{12}^{2}}}{\cancel{6}}+\frac{1^{\times \cancel{12}^{6}}}{\cancel{2}}$$

$$4x+3=4x+6$$

Figure 1. Exact example used by Wesley to illustrate his point.

During the meetings, Wesley also asked the other teachers for advice if he had a particularly troubling case with a student. For example, he asked how to deal with a student who is totally engaged in the lesson but refuses to write notes or do the practice problems during the lesson. "He kind of misses out when it's time to sit back and do those questions because he didn't make that connection" (Meeting #11 transcript).

In summary, Wesley felt that the professional learning groups were important to keep a teacher from going stale, but that there needed to be "a little bit more personal creative freedom" (interview transcript). We were unable to find strong evidence that Wesley used the group time to focus particularly on developing the quality of his own teaching; rather, his focus was generally on his perception of his students and environment.

Discussion

Due to the personal nature of professional learning groups, this study described the experiences of the individual teachers within the professional learning group in relation to their participation in the group and the impact they described on their personal mathematics teaching. The two teachers described were chosen in order to give contrasting perspectives, in order to illustrate a range of characteristics and responses of the members within this group. We theorize that similar ranges of responses might be found in other such groups. Through examining the stories of these two, several important observations emerge for consideration when structuring mathematics professional development. These considerations fall into two broader categories: beliefs about mathematics and mathematics teaching, and knowledge of teaching mathematics.

Knowledge of Teaching Mathematics

Blaine participated very little in the discussions of the group, which he attributed to his lack of knowledge about teaching mathematics. Slavit and Nelson (2010) pointed to a potential problem with members who remained quiet during meetings noting that they did not often adhere to the consensus of the group. Blaine on the other hand claimed to have used the meetings to absorb the wisdom of his colleagues and applied this knowledge to his classroom. Blaine talked about changes in teaching coming from discussions about student work. To him, this set the stage for discussions about how the lessons were taught and gave him a context for his learning. He commented that the observations also provided a rich context for learning, through witnessing how a teacher handled situations within their own classroom. Due to his struggles with his knowledge about teaching mathematics, a context was extremely important for his learning. This observation links to the group needing to consider how discussions and activities are structured in order to support mathematical development. Wesley, on the other hand, participated quite frequently and was extremely confident in his mathematics ability, yet did not apply the majority of the strategies discussed by the group in his own classroom. He made small changes, such as using algebra tiles, but really did not reconsider his belief that mathematics was simply a set of rules and procedures to be memorized.

Research has shown that there is a specialized body of knowledge that is particular to mathematics (Ball et al., 2008; Chamberlin et al., 2008; Davis & Simmt, 2006; Kajander, 2010; Ma, 1999; Shulman, 1986; Silverman & Thompson, 2008) and that teaching in a constructivist classroom needs a deep and strong knowledge of the subject matter (Richardson, 2003). In order for professional learning groups to be effective for mathematics teachers, this essential body of knowledge needs to be addressed by the group. A strong and flexible understanding of mathematics is needed in order for a teacher to be effective, but, via our observations, we noted that it also had an impact on participation in group discussions. In particular, Blaine noted that his lack of knowledge of teaching mathematics discouraged his participation in the professional learning group. Instead he felt like a "parasite" sucking up the knowledge of the others. Research points to issues with elementary teachers' mathematics knowledge because they are generalists in all subject areas (Richardson, 2003; Wixson & Yochum, 2004), so ensuring ways of increasing this essential knowledge is critical. Battey and Franke (2008) pointed to another area of concern when they found that a teacher, who said little during the meetings because of the lack of knowledge, still attempted the strategies in the classroom. They found that the teacher's lack of knowledge made it difficult to engage students in sense making and discussing the multiple solutions. In our research, Blaine expressed concern over his being able to discuss anything during the meetings, but he did claim to use the strategies and the lessons in his classroom. His lack of knowledge could therefore have an impact on how these strategies were implemented in his classroom, but this was beyond the scope of the current study. Our research supported the general observation that this participant did not often have anything to add to the conversations, yet gained a lot of new information and strategies for his own practice.

In examining the teachers' background, it is worthwhile to note that Blaine did not have a degree related to mathematics; whereas, Wesley did. The concerns raised by researchers about elementary teachers being generalists (Richardson, 2003; Wu, 2009), as well as the need to have a strong mathematics knowledge to teach mathematics (Ball et al., 2008), raises concerns of the impact of elementary teachers in mathematics instruction with no special qualifications.

Beliefs about Teaching Mathematics

Wilkins (2008) noted that beliefs about teaching mathematics have the greatest impact on pedagogical choices while teaching, which aligns with the current data in which it appears that beliefs had an impact on participants' interactions in the professional learning group. Since a teacher's beliefs are important in making decisions in the classroom (Potari & Georgiadou-Kabourdis, 2009), we examined what the beliefs about mathematics teaching and learning were of the individual teachers in the professional learning group and how these beliefs were dealt with in the discussions of the group. Specifically the current study was concerned with two aspects of teachers' beliefs: "(a) what kind of mathematics is important for students to learn, and (b) how this mathematics should be taught" (Grant et al., 1994, p. 9).

Related to beliefs about how mathematics should be taught, there was often a dichotomy that arose between the secondary teachers and elementary teachers, which was typified by Wesley and Blaine. In the beginning, Wesley believed that mathematics was a set of rules and procedures to be memorized, and he structured his classroom to support the development of these formulas. Blaine, on the other hand, believed everyone could learn mathematics and recognized a plurality of methods that could be used, so he described that his lessons contained a lot of problem solving and explorations. These respective beliefs about teaching were apparent to various degrees with the other secondary and elementary teachers in the group as well.

A common theme that arose with the secondary teachers was "showing" their students how to solve mathematics problems. The secondary teachers were very concerned with the scores that their students were getting on exams and whether or not they were able to answer the questions. Wesley provided a telling example of this view when he shared a list of rules he wanted memorized by his students in solving algebraic equations, as opposed to using the "teeter totter", by which we assume he meant the balance analogy for an equation. The elementary teachers spoke about supporting a more reform-based approach to teaching mathematics as espoused by the NCTM (2000; Working Group of the Commission on Standards for School Mathematics of the National Council of Teachers of Mathematics, 1989). The elementary teachers, such as Blaine, talked about making sure their students understood the mathematics they were learning and did not just have procedures to solve the problems given to them. Manipulatives were commonly discussed by these teachers as being used to allow students to work with the mathematical concepts being introduced in their classrooms. Blaine gave an example of learning volume of right prisms by having students explore shapes to see that they would need to find the area of the base, then multiply by the height.

This dichotomy may well occur in other professional learning groups where beliefs of different teachers differ greatly. Such group conversations need to be navigated carefully if the goal of the professional learning is to move teachers toward using more explorations. Confer and Ramirez (2012) describe the need to "keep the end in mind" (p. 5) so that the teachers can first describe as a group what it is that they want to do as a result of the mathematics instruction. The example Wesley presented of factoring binomials was one such conversation. The elementary teachers were quite concerned that by doing this it would simply become a procedure. As one elementary teacher noted with his students "they don't own it, and maybe they're not ready to own it" (Meeting #9 transcript). Another echoed the sentiment commenting that "I don't just want them to be procedurally fluent, I want them to have some conceptual understanding" (Meeting #9 transcript). One secondary teacher attempted to share a strategy that would create a bridge for the students to lead to the task, but again relied on a strictly procedural application of the concept. Another secondary teacher joined into the discussion to share how he would "show it" to students so that they could use it. The other elementary teachers commented on how their students were just gaining some of the knowledge they would need and this would be too much for where they currently were in mathematics. Such a range of beliefs supports the need for professional development that causes teachers to confront and potentially change their beliefs about mathematics teaching.

Wesley did begin to question his practices when he was exposed to a professional development opportunity that influenced and potentially changed his priorities in teaching. He questioned his beliefs about teaching mathematics as a direct result of being inspired by another educator who helped Wesley experience a new perspective in his teaching. As he noted, the talk gave him ideas to get "a little more power out of what I'm doing right now in my mathematics" (Meeting #15 transcript). He talked about using the ideas to do more substantial mathematics with his students instead of just common textbook problems that are not necessarily based in real-life ideas. Wesley attempted a new lesson with his students, but when it was unsuccessful he felt it was because of the academic difficulties of his students; he did not adapt the lesson and attempt it again with that class of students. He argued that it was his students' capacity (or lack thereof) that was at fault, rather than considering how he might adapt the lesson. If Wesley does try the lesson again using some of the reflections from the group, we feel the lesson has potential to meet with success.

Research has pointed to teachers needing to confront their own beliefs about teaching mathematics to make changes (Cross, 2009; Wilkins, 2008), and Wesley may have begun that journey. Given his expressed excitement over changing his mathematics lessons, Wesley may continue to grow and make changes in the coming years of his teaching career, but this was unclear at the conclusion of the current study.

Conclusions and Recommendations

This research supports the need for professional development in mathematics that accounts for both beliefs and knowledge of mathematics in order for it to be effective in supporting teachers to grow in their own practices. While these case studies provide only examples of selected teacher responses, the variance even between the two selected participants suggests challenges in teacher development. However, due to the nature of the professional learning group, namely that it was participant driven and members were able to develop at their own pace, some growth was noted in both cases. We caution however that extended time seems to be required for any substantive growth to be observable.

Professional development research stresses the need for constant growth and development to be part of teaching (Ball & Cohen, 1999; Opfer & Pedder, 2011). Brahier and Schäffner (2004) pointed out that in mathematics, teachers need concrete examples of reform strategies, a time to try the strategies, and then reflection for changes to actually occur in the classroom. The group discussed here attended presentations at the local university to learn new strategies for teaching mathematics. The group would then meet together and reflect on the new learning and how it could be applied to their personal classroom situations. During the meetings following the presentations, the group members would discuss strategies to try in the coming months so that they could reflect together on the effects. At one particular presentation, participants had the opportunity to try some new classroom problems designed for mathematics learning themselves, which research has pointed out is necessary before teachers will begin to implement new strategies in their classrooms more generally (Carnegie Corporation of New York, Institute for Advanced Study Commission on Mathematics and Science Education, 2009). After having the experiences for themselves and hearing how another educator was using the strategies in his teaching practice, Wesley attempted something new in his own classroom.

These cases also gave examples of how knowledge of teaching mathematics and mathematics content can have an impact on participation in professional development. Blaine's struggles with his own understandings made it

vital for him to attend the professional learning groups, yet impeded his participation. Ensuring support for teachers struggling with the mathematical ideas is important since teacher knowledge is closely linked to student achievement in mathematics (Baumert et al., 2010).

For changes to be effective, professional development or support programs need to address both knowledge and beliefs. As McNeal and Simon (2000) argue, "norms and practices do not change simply by virtue of the teacher using his [sic] authority to assert the new set of rules accompanied by student compliance" (p. 506). Instead teachers need experiences that have them analyze or question their own beliefs (Grant et al., 1994). Simply requiring teachers to use reform-based methods is not likely to have lasting effects on teaching practice. Teachers need professional development that allows their knowledge of mathematics to grow (Ma, 1999), and the knowledge needs to be combined with experiences that are designed to confront and challenge beliefs teachers have about teaching mathematics. Such development takes time.

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