

# **The Collaborative Teacher Inquiry Project: A Purposeful Professional Development Initiative**

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## **Abstract**

The transition from Grade 8 to Grade 9 is particularly difficult for students who were not very successful in mathematics in Grade 8. Research into ways to improve this transition as well as improve the teaching practices at the Applied level will be helpful for teachers, administrators, and policy makers. The Collaborative Teacher Inquiry Project was a professional development initiative that brought together educators from nine schools across four neighbouring school districts in Ontario seeking to improve their Grade 9 Applied Mathematics program. As part of the Collaborative Teacher Inquiry Project, participants attended topic-specific workshops based on schools' goals for professional growth and had opportunities to collaborate with other participants to create and share teaching materials for the Grade 9 Applied Mathematics course. Qualitative data from teacher interviews and written reflections indicate that the teachers felt that a mixture of collaboration and professional development made this project successful. Teachers also reported that

the Collaborative Teacher Inquiry Project motivated further collaboration at the school and district level.

*Keywords:* mathematics education, professional development, school improvement, teacher collaboration

## **Résumé**

La transition de la 8<sup>e</sup> année à la 9<sup>e</sup> année s'avère particulièrement difficile pour les élèves qui ont eu des difficultés en mathématiques en 8<sup>e</sup> année. Les recherches sur les moyens à mettre en œuvre pour faciliter cette transition et améliorer les méthodes d'enseignement en mathématiques appliquées aideront les enseignants, les administrateurs et les décideurs. Une initiative de perfectionnement professionnel, désignée sous le nom de *Collaborative Teacher Inquiry Project*, a rassemblé des enseignants de neuf écoles dans quatre districts scolaires voisins en Ontario en vue d'améliorer leur programme de mathématiques appliquées en 9<sup>e</sup> année. Dans le cadre de ce projet, les participants ont assisté à des ateliers thématiques axés sur les objectifs des écoles en matière de perfectionnement professionnel et ont eu l'occasion de collaborer avec les autres participants et ainsi de créer et de s'échanger du matériel pédagogique pour le cours de mathématiques appliquées de 9<sup>e</sup> année. Les données qualitatives tirées des entrevues avec les enseignants et de leurs remarques consignées par écrit indiquent qu'à leur avis, la combinaison des volets collaboration et perfectionnement professionnel expliquent le succès du projet. Les enseignants ont également signalé que ce projet a favorisé une collaboration encore plus grande au niveau des écoles et des districts.

*Mots-clés :* enseignement des mathématiques, perfectionnement professionnel, amélioration de l'école, collaboration entre les enseignants

## Introduction

In Ontario, students in Grade 9 are generally streamed into either Academic or Applied level classes. Grade 8 students confer with their teacher(s) and parents to determine into which Grade 9 classes they will enroll. Students in the Applied-level stream tend to work towards entry into college programs or directly into the workplace after completing their secondary diploma. Research has shown that students in the Applied-level stream tend to struggle academically and often are disengaged from their learning (King, Warren, Boyer, & Chin, 2005). Specifically, King et al.'s study (2005) found that students who failed the Grade 9 Applied Mathematics or English course rarely completed secondary school after four years. Thus, the Grade 9 Applied Mathematics course may be seen as a gatekeeper to academic success. As such, schools should focus efforts on ensuring that their Grade 9 Applied Mathematics program is effective and that teachers teaching this course are able to create a learning environment to support their students' mathematical development.

Some mathematics education reform documents (National Council of Teachers of Mathematics, 1991, 2000, 2007) identify the goal of creating a community of learners that engage in mathematics investigation and exploration. This community of learners focuses on conceptual understanding of mathematics, connecting new knowledge to existing knowledge through discussion and communication with others. Learning in this way contrasts the traditional model in which students learn through rote methods involving memorization and the teacher is seen to be the source of knowledge at the front of the classroom (Ball, 1990; Miller, 2010). Communities of learners provide opportunities for students to discuss, respond to, and question each other about problem solving techniques as well as mathematical ideas, thus supporting the mathematics learning of all students in the class. There are many challenges to creating a community of learners as many teachers do not have models or examples of good teaching in this format. Moreover, these teachers may struggle as they try to drastically change their practices without having had any experience with these new methods as a teacher or learner (Smith, 2000).

In this article, we advocate for purposeful professional development programs that provide teachers with opportunities to learn about and experience new instructional strategies and with time to plan teaching materials and share resources. We present a case of a university and school district collaborative professional development initiative that meets these goals. Using qualitative data collected from participants, we illustrate, from

their perspective, how this model of professional development supports teachers seeking to improve their Grade 9 Applied Mathematics program.

## **Literature Review**

The most powerful mechanism for overcoming barriers to reform is professional development. It is generally agreed that one-off professional development opportunities are not an effective means to improve teacher practice. These one-day, one-shot sessions are seen to be fragmented, disconnected from classroom practice, and not providing enough resources that teachers believe can easily be implemented into their teaching (Stein, Smith, & Silver, 1999). Traditionally, these professional development sessions are presented using a transmission model rather than using transformative strategies in which teachers experiment and try out the new strategies being presented and have the space to consider how the practices might be adapted to their teaching context (Guskey & Yoon, 2009; Richardson, 2003).

Current literature on professional development describes long-term, inquiry-based models that allow for participants to be active learners in the process. First, facilitators of the professional development session model exemplary teacher practices, during which time the teachers have the opportunity to experience the strategies as learners (Cohen & Hill, 2001; Snow-Renner & Lauer, 2005). Following this experiential learning opportunity, the teachers have time to reflect upon and critique the practices necessary for rich learning (Borko, Jacobs, & Koellner, 2010). This is especially important for teachers who are being presented with new practices that may be drastically different from the way that they currently teach or were taught. As active participants in the process, teachers will also feel as though their experience and opinions are valued (Borko et al., 2010).

Sustained interaction is needed between classroom teachers with professional development leaders external to the school together with provision of local support such as district or school consultants. There needs to be a dual emphasis on new classroom strategies while attending to teachers' cognition about their existing practice. There should also be a dual focus on developing teachers' disciplinary knowledge (knowing the subject) and their pedagogical content knowledge (i.e., knowing how to present mathematical content to students and being able to anticipate and respond to students' misconceptions about the

material to be learned) (Birman, Desimone, Porter, & Garet, 2000; Knapp, 2003; Stein et al., 1999). In making the argument for a professional development focus, Spillane, Reiser, and Reimer (2002) have pointed out that successful implementation of recent instructional reforms depend in some measure on the broader policy environment in which classrooms are nested. If teachers work in policy environments where they have few opportunities and few incentives to learn about revising their practice, then they are less likely to enact the recent reforms. School districts can and do influence these conditions.

Professional development programs need to be grounded in teachers' work, feelings, and experiences. Fullan and St. Germain (2006) mentioned that teachers' professional development must be not only for the benefit of achieving skills for individual teachers but also to lead to the improvement of school organization. In this sense, efforts should be focused on teaching and learning and not only on training specific or isolated skills.

## **Collaboration**

Conclusions have been mixed regarding the relationship between collaborative efforts and student achievement. The predominant focus of these studies has been on the accrued benefits to individual teachers, and potentially their students, of participatory collaboration (e.g., Louis, Marks & Kruse, 1996; McLaughlin & Talbert, 2001). The collegial practices, which constitute the professional development initiatives in most studies, are considered separate from the daily work of the teachers involved.

The relatively formal structure of subject departments is a long-term and widespread phenomenon at the secondary school level. Such a structure serves administrative, communicative, and pedagogical purposes (Lee & Smith, 1996; Neild, Stoner-Eby, & Furstenberg, 2004). Not surprisingly, professional development at the secondary level, collaboratively based or otherwise, has been traditionally department-based (McLaughlin & Talbert, 2001; Siskin & Little, 1995). It has been assumed that the natural cohesiveness of subject departments provides a logical starting place for collaboration among teachers. There is evidence that these loosely knit teacher communities can influence approaches to classroom practice (Gutiérrez, 1996; Johnson, 1990), as well as shape responses, positive or otherwise, to reform (Ball & Bowe, 1992; Coburn, 2001; Little, 1995).

Most research into teacher collaboration has focused on the logistical parameters of delivery and evaluation. Recent efforts have looked at the potential for improving “on-the-job” collaborative opportunities for teachers in a seamless, situated fashion. Examples of such opportunities include professional learning communities (e.g., Andrews, & Lewis, 2002; Vescio, Ross, & Adams, 2008), co-teaching (e.g., Nevin, Thousand, & Villa, 2013; Rytivaara & Kershner, 2012), and peer coaching (e.g., Jao, 2013; Murray, Ma, & Mazur, 2009).

### **The Ten Dimensions of Mathematics Education Framework**

The conceptual framework for the project was the Ten Dimensions of Mathematics Education (McDougall, 2004). This framework identifies 10 dimensions or areas of mathematics teaching that can be used to identify areas of strength and areas in need of improvement. As well, it has a rubric that provides four levels of performance for teachers.

The 10 dimensions are (1) program scope and planning (teachers consider curriculum strands, expectations, outcomes, process, and key concepts when planning a mathematics program); (2) meeting individual needs (teachers engage all students in complex problem solving, providing appropriate levels of support); (3) learning environment (teachers use appropriate physical classroom organizations and student groupings to promote learning); (4) student tasks (student tasks are intricate, open-ended problems embedded in real-life contexts); (5) constructing knowledge (teachers use different instructional strategies and questioning techniques to help students construct knowledge); (6) communicating with parents (communication about student achievement and the mathematics program is through a variety of media); (7) manipulatives and technology (mathematical problems are undertaken in reform classes with the aid of manipulatives and with ready access to mathematical tools—calculators and computers); (8) students’ mathematics communication (instruction in reform classes focuses on the construction of mathematical ideas through student communication—oral, written and physical); (9) assessment (transparent and authentic assessment is integrated with everyday events, and taps a wide variety of abilities, through diagnostic, formative, and summative strategies); and (10) teacher attitude and comfort with mathematics (teachers’ attitudes toward mathematics and comfort with the subject matter affects student learning). The dimensions overlap and together constitute an orientation to instruction that differs from traditional practice.

A teacher can use the 10 dimensions as a framework to guide his or her professional growth. Through the use of a Beliefs and Attitudes Survey (McDougall, 2004), a teacher can score his or her attitudes and teaching practices by dimension. The higher the teacher scores in the dimension, the more consistent the teacher's attitudes and teaching practices are with current mathematics education thinking. A teacher may use the results of the Beliefs and Attitudes Survey to select dimension(s) of focus for professional development.

## **Method**

The Collaborative Teacher Inquiry Project focused on the improvement of instructional strategies in Ontario's Grade 9 Applied Mathematics course, with the goal of improving students' achievement and engagement in mathematics. Four public school districts from the same geographical area of an urban centre of southern Ontario were invited to participate in the project. A total of 11 schools, from four school districts, participated in the project, selected based on their school's scores on the provincially mandated large-scale standardized exam (EQAQO) and recommendations by school board superintendents. The first phase of the Collaborative Teacher Inquiry Project was conducted from January 2009 to May 2010 and included teachers, department heads/curriculum leaders, and administrators. The timeline of this three-semester project can be broken down as follows:

Semester 1: Introduction to the Collaborative Teacher Inquiry Project and the Ten Dimensions of Mathematics Education (McDougall, 2004); completion of the Attitudes and Beliefs Survey; selection of dimensions for department and personal foci, organized workshops focused by dimension; time for collaboration; and individual reflection of participation in the project.

Semester 2: Dimension-specific professional development workshops; co-planning and collaboration within and across implementation teams; school visits from researchers; and individual interviews with participating teachers.

Semester 3: Dimension-specific professional development workshops; individual and implementation team collaboration; team and individual reflections on the project; a panel discussion with educational researchers; and school presentations to share materials created for the Grade 9 Applied Mathematics course.

## **Participants**

Participating schools were selected by their school district through discussions with school district superintendents based loosely on weak performance on the provincially mandated large-scale standardized exam (EQA) for the Grade 9 Applied Mathematics cohort as well as challenging circumstances in the schools. An implementation team consisting of an administrator (either a principal or vice-principal), the mathematics department head, and all of the teachers teaching the Grade 9 Applied Mathematics course participated in the Collaborative Teacher Inquiry Project. Some implementation teams had three team members (and the department head/curriculum leader also taught the Grade 9 Applied Mathematics course) while other teams had upwards of five teachers (including the department head/curriculum leader). As the project spanned three semesters, and teaching assignments at the participating schools changed, the makeup of the implementation teams changed. The teachers ranged from those participating in the project for just one semester to others who remained consistently on their implementation team for all three semesters.

## **Data Collection**

In order to capture the experiences and impressions of teachers engaging in the Collaborative Teacher Inquiry Project, qualitative data were collected via teacher interviews and written reflections. We elected not to include administrators participating in the Collaborative Teacher Inquiry Project in our data collection as our focus for the study was to document teachers' experiences in a professional development model and their journey of improving their Grade 9 Applied Mathematics program at their schools. Additionally, the administrators did not attend many components of the Collaborative Teacher Inquiry Project, thus their experiences with the project were limited.



All teachers (including mathematics department heads/curriculum leaders) participating in the project were interviewed. These one-on-one interviews were completed during the second semester of the project. The participants had an opportunity to indicate that they did not want to participate in the research component of the project. These interviews followed a semi-structured format and asked teachers about their professional and educational background, beliefs about mathematics education, teaching goals, and experiences with the project. Teachers were also asked to describe their teaching context and any challenges that they experience in this context. Each interview was 45 minutes in length. The interviews were audiotaped and transcribed.

At the end of the first semester of the project, teachers and mathematics department heads/curriculum leaders were asked to individually complete a written reflection form. Participants were provided with prompts that included “Something I tried this year that worked was...and know it worked because...”; “Something I heard about that I intended to try and will make as a goal for next year...”; “Something I want to learn more about...”; and “The support I would like for next year is...” At the end of the third semester (at the completion of the project), participants were invited to complete another written reflection. Participants could opt to complete the form individually or as an implementation team. Some participants did both. In this reflection form, participants were asked to reflect about their journey during the Collaborative Teacher Inquiry Project (specifically referring to the Ten Dimensions of Mathematics Education), the successes and challenges they encountered and any additional reflections, and their intended next steps for the future.

## **Findings**

In examining how the Collaborative Teacher Inquiry Project model for professional development supported teachers seeking to improve their Grade 9 Applied Mathematics program, two main themes emerged from the data. Participants described two components of the Collaborative Teacher Inquiry Project as critical for the success of the professional development initiative: (1) focused professional development based on topics selected by participating schools from the Ten Dimensions of Mathematics Education, and (2) the opportunity for collaboration. All names of schools and participants are pseudonyms.

## **Focused Professional Development Based on the Ten Dimensions of Mathematics Education**

As a result of taking the Attitudes and Beliefs Survey, schools selected one or two dimensions to focus on for the duration of the Collaborative Teacher Inquiry Project. Based on these selections, we organized workshops at each of the professional development sessions specifically focused on a dimension. As many schools ended up picking the same dimensions for school growth, it made it easier to ensure that the workshops addressed the schools' foci. In some instances, multiple workshops were offered simultaneously and implementation teams selected which workshop they would attend during the professional development session based on their chosen dimension of focus.

Many implementation teams selected "student tasks" as a focus for school improvement. Thus, a workshop centred on the TIPS4RM resources (Ontario Ministry of Education, 2005) was organized. For some participants, this workshop was their first encounter with this resource. One teacher described the relevance of this workshop for her school's needs and the impact that implementing this resource into her school's Grade 9 Applied Mathematics program had on the students:

We use TIPS4RM in our classroom. [It is] a lot of group activities, a lot of work with groups and partners. And [the students] feel that it can be fun. [The activities are] more social, instead of staying on a desk and working on a sheet of paper. (EG1, Interview)

When workshops were not available for implementation teams for their chosen dimension, we encouraged the teams to use the funds allotted to their school as a participant of the Collaborative Teacher Inquiry Project to seek out other professional development opportunities that addressed this dimension. One example of this was with the Srinivasa Ramanujan School. Having chosen to focus on the "learning environment" dimension, we encouraged the team to attend a Tribes (Gibbs, 2006) training session. In the Tribes approach, teachers create learning communities (or, "Tribes") within their classroom to foster a safe and caring learning environment. Tribes classrooms adopt four "agreements" (attentive listening, appreciation/no put downs, mutual respect, and the right to pass) and students develop skills in collaboration and conflict-resolution. As the training session was geared toward the elementary-school context, one teacher on the

team took the initiative to attend a series of six book-club sessions with other secondary school teachers in the school district. At these sessions, the Tribes resource book, *Reaching all by creating Tribes learning communities* (Gibbs, 2006) was discussed for the secondary level, several ideas were implemented in the classroom, and the participants of the book club debriefed what worked and what did not work in their classroom.

### **An Opportunity for Collaboration and Sharing**

The project plans for the Collaborative Teacher Inquiry Project had built-in time for teachers to collaborate both within and across implementation teams. Teachers were encouraged to create teaching materials and share resources that they used in their Grade 9 Applied Mathematics program. One teacher described how she was able to learn from other participants of the Collaborative Teacher Inquiry Project:

I [learned] from different schools on what they tried [in their teaching]...their success or lack thereof. [We] can look at the stories from another school, and say, “Okay, what did they try, did it work, can we try it, and do we think it might work for us?”... I want to hear what other people are trying so that I can steal it and use it myself. (AL1, Interview)

In a team reflection, the implementation team from Ada Lovelace School described the teacher materials that they created during the Collaborative Teacher Inquiry Project professional development sessions. They wrote: “The team has done a lot of collaboration in planning the lessons and preparing common assessments” (Ada Lovelace School, Team reflection).

As a result of collaborating during the Collaborative Teacher Inquiry Project, many implementation teams were motivated to continue working together back at their schools. The team from Ada Lovelace School described how after the first couple of team members would implement the lesson, the team would use these teachers’ experiences and collaborate to improve upon the lesson. In a team reflection, they wrote:

This collaboration has led to very valuable learning for the teachers on the progress of the students as it allows them to adjust and tweak lessons and tests that one teacher may have taught earlier in the day and found “bugs” so that the other teacher can avoid in the later class. (Ada Lovelace School, Team reflection)

Another school described how they continued to collaborate at their school in the form of co-teaching. In a team reflection, the teachers at Fan Chung School stated that with the support of their administrators, they were able to use the release time provided by the Collaborative Teacher Inquiry Project to focus on this mode of collaboration.

The teachers also addressed the challenge that ongoing collaboration takes an investment of time and resources. As participants of the Collaborative Teacher Inquiry Project, the teachers had access to funds to support their team's ongoing professional development in whatever manner best suited the team. The team at Fan Chung School reported that "the experience of participating in the [Collaborative Teacher Inquiry Project] has also allowed the team to collaborate on a frequent basis, including using the funding to pursue a co-teaching initiative" (Fan Chung School, Team reflection).

Many teachers involved with the project voiced that they did not have prior experience co-teaching, co-planning or collaborating with their colleagues. One implementation team reported, "Collaborative inquiry with co-teaching/peer coaching [was] new to many of us mathematics teachers. Like anything new, it requires time and space to flourish and grow" (Gottfried Leibniz School, Team reflection). The teachers appreciated having three semesters to work with their colleagues and having dedicated time during the professional development sessions for collaboration.

An additional benefit of the opportunity to collaborate and share ideas was the fact that participants were able to get reassurance from other teachers regarding the challenges and worries that they had teaching the Grade 9 Applied Mathematics course. One teacher described the comfort she felt as a result of working with other Collaborative Teacher Inquiry Project participants:

Just meeting the teachers from the other districts and hearing that they are dealing with the same types of students that we have that are coming to us without skills and for us to be teaching them curriculum that is often abstract and might be obvious to us as adults but is totally not obvious to the children. (MK2, Interview)

Teachers shared their appreciation for the format of the Collaborative Teacher Inquiry Project and most valued the collaborative component of the project. Teachers overwhelmingly reported that opportunities to discuss ideas, trade resources, share success stories, and hear about what is happening in other schools and school districts are few and

far between. One teacher described her experience with the Collaborative Teacher Inquiry Project:

One thing that the [Collaborative Teacher Inquiry Project] is doing, that I think we could use more of, is bringing people together to kind of give our best ideas. I certainly do not have all the answers, but I can go to a [Collaborative Teacher Inquiry Project] meeting and see what other people are doing, and then now I can use what they are doing really well, and now there are two schools doing that thing really well. There are great teachers in every school, every district, that are doing things really well, but I do not think right now, in education, there is really an atmosphere where those teachers who are doing really great things have the opportunity to share those with everyone who wants to know, and there are lots of teachers who want to know what other teachers are doing really well, so they can do it too. (FC2, Interview)

Another teacher from the same school echoed this sentiment. He shared his impression of the project:

The [Collaborative Teacher Inquiry Project] has been a good eye-opener. The fact that we had that time to collaborate and share our resources and discuss how we are running programs and how we are achieving success in our different courses, I think that is fantastic. (FC3, Interview)

The teacher continued to describe how he believes that this model of professional development improves teachers' practices. He said, "Finding out what [other teachers] are doing to help their kids to be successful...sharing assessments...I think the collaboration is what is helping us understand what can make mathematics or how to make mathematics more successful for the kids" (FC3, Interview).

Teachers described that they were thankful for the Collaborative Teacher Inquiry Project. Given the challenges of the teaching profession, the teachers worried that without effective and purposeful professional development opportunities, such as the Collaborative Teacher Inquiry Project, the teachers would not have efficient and effective opportunities for professional growth. One team shared their concern about losing access to the professional development opportunities such as the Collaborative Teacher Inquiry Project:

We will continue to need funding to support team-based planning work and are not sure if the [Collaborative Teacher Inquiry Project] will be a permanent fixture or phased out as the government tightens program spending. Without it, we fear a slight loss of momentum in continuing to support each other for what is essentially a very difficult course to teach considering the many issues our innercity students face. (Maria Kovalevskaya School, Team reflection)

## **Discussion**

The Collaborative Teacher Inquiry Project was a professional development initiative bringing together Grade 9 Applied Mathematics educators from schools across four different school districts in the same general geographic area. The Collaborative Teacher Inquiry Project sought to improve the teaching and learning in Grade 9 Applied Mathematics by encouraging teachers to work collaboratively in areas of foci as outlined by the Ten Dimensions of Mathematics Education framework (McDougall, 2004).

The Collaborative Teacher Inquiry Project organized professional development sessions during which participants could attend workshops about topics selected by the participants. The topics were drawn from the Ten Dimensions of Mathematics Education framework and schools selected dimensions as a result of completing an Attitudes and Belief Survey (McDougall, 2004) that scored the participants' beliefs and teaching practices by dimension. Additionally, the professional development sessions allotted time for participants to engage in discussions about their Grade 9 Applied Mathematics. Their discussions led to collaborations that resulted in the creation of new culminating and EQAO preparation tasks, among others. Teachers extended the collaboration that took place during the professional development sessions back to their school context. The Ten Dimensions of Mathematics Education framework allowed participants to focus on obtainable goals for school improvement as opposed to trying to improve their mathematics program in a general context.

Each participant enjoyed the opportunity to collaborate with other educators participating in the Collaborative Teacher Inquiry Project. As stated by Borko et al. (2010), professional development “experiences are particularly effective when teachers participate in developing the learning opportunities, and work collaboratively to inquire and

reflect on their practice” (p. 550). Participants overwhelmingly spoke of enjoying working with and meeting other Grade 9 Applied Mathematics educators. The opportunity to engage in discussions with colleagues provided some participants with reassurance that they were not the only person facing the challenges and issues that they experienced in their classrooms. Lortie (1975) has described teaching to be the isolated profession, thus the opportunity to collaborate brought teachers out of their teaching vacuum.

Many participants shared that the Collaborative Teacher Inquiry Project was the first opportunity they had to systematically work with colleagues and engage in collaborative models such as co-teaching and peer coaching. In some schools, co-teaching and peer coaching was used to help teachers improve their teaching practice. With the support of administrators and central district consultants, along with staff and funds from the Collaborative Teacher Inquiry Project, teachers could be released from teaching to focus on co-teaching. While there was much enthusiasm and novelty for these initiatives, there were also many challenges and frustrations associated with the process. We provided a more detailed description and discussion regarding the ways in which the participants of the Collaborative Teacher Inquiry Project collaborated and the successes and challenges they faced in another article (Egodawatte, McDougall, & Stoilescu, 2011).

The schools created an implementation team consisting of administrators, department heads, and teachers. These implementation teams ensured that there was a collective commitment to students, which is a critical characteristic of effective professional development (Desimone, 2009; Guskey, 1994, 2000). This collective commitment means that the teachers use tools and procedures to assist them in evaluating the progress that they make toward student learning goals. Although the Collaborative Teacher Inquiry Project focused on improvement in the Grade 9 Applied Mathematics course, participating teachers and administrators all had visions for school reform. The involvement of an entire course’s teaching team may have provided the critical mass needed for department- or school-wide reform to occur (Darling-Hammond & Richardson, 2009). Some participants spoke of the fact that areas of focus from the Ten Dimensions chosen for the Collaborative Teacher Inquiry Project as being closely related to broader departmental and school goals.

The implementation teams met regularly to discuss the Grade 9 Applied Mathematics course. Many teams reported that they worked together on many activities from planning, writing activities, and coordinating EQAO preparations. We were reassured that

the participants took the ideas that were generated from the professional development sessions back to their schools. A sign of effective professional development, the professional development sessions allowed for active participation in which teachers could experience the strategies and reflect on them (Borko, 2004; Garet, Porter, Desimone, Birman, & Yoon, 2001; Saxe, Gearhart, & Nasir, 2001). The implementation teams, which had already begun to consider how ideas from the professional development sessions could be adapted into their teaching context, continued to move these ideas forward once they were back at their schools to finalize the teaching resources. As Little (1990) has described, while these tangible products supported teacher practices, the discussions and opportunities to reflect that came with the collaborations to create these products were also of benefit.

Research has shown that, in order for professional development to be effective, it needs to be grounded in school-improvement goals (Cohen & Hill, 2001; Darling-Hammond & Richardson, 2009; Penuel, Fishman, Yamaguchi, & Gallagher, 2007). These goals may be school-wide goals or may be department specific. In the Collaborative Teacher Inquiry Project, school teams identified their professional-development goals using the Ten Dimensions of Mathematics Education framework. The Attitudes and Beliefs Survey was administered to help teachers identify the two dimensions that the school and teachers would focus on for the duration of the project. Some schools used these dimensions to keep them focused on their goals for professional development. We integrated these school goals into the professional development sessions by creating workshops based on school-chosen dimensions.

School improvement in mathematics is tenuous because the field has clear distinctions between standards-based teaching and traditional teaching. The Collaborative Teacher Inquiry Project energized teams of teachers within schools to activate and guide the teacher improvement process, thereby sustaining the learning. This research contributes to our knowledge of collaborative inquiry, and demonstrates that teachers' practices can be enhanced through close collaboration with their colleagues, and that the outcome of this enhancement is a meaningful improvement in instructional practice. The teachers felt that a mixture of collaboration and professional development made this project successful. Further investigation regarding the mechanisms for collaboration and the extent to which teachers collaborate in such models for professional development are needed. The opportunity for teachers to collaborate with colleagues outside of their school and



school district context is rare and it would be valuable to discover how such processes can be supported.

## References

- Andrews, D., & Lewis, M. (2002). The experience of a professional community: Teachers developing a new image of themselves and their workplace. *Educational Research, 44*(3), 237–254.
- Ball, D.L. (1990). Prospective elementary teachers' understanding of division. *Journal of Research in Mathematics Education, 21*(2), 132–144.
- Ball, S. J., & Bowe, R. (1992). Subject departments and the implementation of national curriculum policy: An overview of the issues. *Journal of Curriculum Studies, 24*(2), 97–115.
- Birman, B. F., Desimone, L., Porter, A. C., & Garet, M. S. (2000). Designing professional development that works. *Educational Leadership, 57*(8), 28–33.
- Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3–15.
- Borko, H., Jacobs, J., & Koellner, K. (2010). Contemporary approaches to teacher professional development. In P. Peterson, E. Baker, & B. McGaw (Eds.), *International Encyclopedia of Education* (Vol. 7, pp. 548–556). Oxford, England: Elsevier.
- Coburn, C. (2001). Collective sensemaking about reading: How teachers mediate reading policy in their professional communities. *Educational Evaluation and Policy Analysis, 23*(2), 145–170.
- Cohen, D. K., & Hill, H. C. (2001). *Learning policy*. New Haven, CT: Yale University Press.
- Darling-Hammond, L., & Richardson, N. (2009). Teacher learning: What matters? *How Teachers Learn, 66*(5), 46–53.
- Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measure. *Educational Researcher, 35*(3), 181–199.

- Egodawatte, G., McDougall, D. E., & Stoilescu, D. (2011). The effects of teacher collaboration in Grade 9 Applied Mathematics. *Educational Research in Policy and Practice, 10*(3), 189–209.
- Fullan, M., & St. Germain, C. (2006). *Learning places: A field guide for improving the context of schooling*. Thousand Oaks, CA: Corwin Press.
- Garet, M. S., Porter, A. C., Desimone, L. M., Birman, B., & Yoon, K. S. (2001). What makes professional development effective? Analysis of a national sample of teachers. *American Educational Research Journal, 38*(3), 915–945.
- Gibbs, J. (2006). *Reaching all by creating Tribes learning communities*. Windsor, CA: CenterSource Systems.
- Guskey, T. R. (1994). Results-oriented professional development: In search of an optimal mix of effective practices. *Journal of Staff Development, 15*(4), 42–50.
- Guskey, T.R. (2000). *Evaluating professional development*. Thousand Oaks, CA: Corwin Press.
- Guskey, T. R., & Yoon, K. S. (2009). What works in professional development? *Phi Delta Kappan, 90*(7), 495–500.
- Gutiérrez, R. (1996). Practices, beliefs, and cultures of high school mathematics departments: Understanding their influence on student advancement. *Journal of Curriculum Studies, 28*(5), 495–529.
- Jao, L. (2013). Peer coaching as a model for professional development in the elementary mathematics context: Challenges, needs and rewards. *Policy Futures in Education, 11*(3), 290–297.
- Johnson, D. W. (1990). Impact of group processing on achievement in cooperative groups. *Journal of Social Psychology, 130*(4), 507–516.
- King, A. J. C., Warren, W. K., Boyer, J. C., & Chin, P. (2005). *Double cohort study phase 4 report for the Ontario Ministry of Education*. Kingston, ON: Queen's University.
- Knapp, M. S. (2003). Professional development as a policy pathway. *Review of Research in Education, 27*(1), 109–157.

- Lee, V., & Smith, J. B. (2001). *Restructuring high schools for equity and excellence: What works*. New York, NY: Teachers College Press.
- Little, J. W. (1990). The persistence of privacy: Autonomy and initiative in teachers' professional relations. *Teachers College Record*, 91(4), 509–536.
- Little, J. W. (1995). Subject affiliation in high schools that restructure. In L. S. Siskin & J. W. Little (Eds.), *The subjects in question: Departmental organization and the high school* (pp. 172–200). New York, NY: Teachers College Press.
- Lortie, D. (1975). *Schoolteacher: A sociological study*. Chicago, IL: University of Chicago Press.
- Louis, K. S., Marks, H. M., & Kruse, S. (1996). Professional community in restructuring schools. *American Educational Research Journal*, 33(4), 757–798.
- McDougall, D. (2004). *PRIME school mathematics improvement: Leadership handbook*. Toronto, ON: Nelson.
- McLaughlin, M. W., & Talbert, J. E. (2001). *Professional communities and the work of high school teaching*. Chicago, IL: University of Chicago Press.
- Miller, J. P. (2010). *Whole child education*. Toronto, ON: University of Toronto Press.
- Murray, S., Ma, X., & Mazur, J. (2009). Effects of peer coaching on teachers' collaborative interactions and students' mathematics achievement. *Journal of Educational Research*, 102(3), 203–212.
- National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics*. Reston, VA: Author.
- National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics: An overview*. Reston, VA: Author.
- National Council of Teachers of Mathematics. (2007). *Mathematics teaching today: Improving practice, improving student learning* (2nd ed.). Reston, VA: Author.
- Neild, R. C., Stoner-Eby, S., & Furstenberg, F. (2004). Connecting entrance and departure: The transition to ninth grade and high school dropout. *Education and Urban Society*, 40(5), 543–569.

- Nevin, A. I., Thousand, J. S., & Villa, R. A. (2013). *A Guide to Co-teaching: New Lessons and Strategies to Facilitate Student Learning* (3rd ed.). Thousand Oaks, CA: Corwin Press.
- Ontario Ministry of Education. (2005). *TIPS4RM for Grades 7, 8, 9, Applied and 10 Applied Math*. Toronto, ON: Queen's Printer for Ontario.
- Penuel, W., Fishman, B., Yamaguchi, R., & Gallagher, L. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal*, 44(4), 921–958.
- Richardson, V. (2003). The dilemmas of professional development. *Phi Delta Kappan*, 84(5), 401–406.
- Rytivaara, A., & Kershner, R. (2012). Co-teaching as a context for teachers' professional learning and joint knowledge construction. *Teaching and Teacher Education*, 28(7), 999–1008.
- Saxe, G., Gearhart, M., & Nasir, N. S. (2001). Enhancing students' understanding of mathematics: A study of three contrasting approaches to professional support. *Journal of Mathematics Teacher Education*, 4(1), 55–79.
- Siskin, L. S., & Little, J. W. (1995). *The subjects in question: Departmental organization and the high school*. New York, NY: Teachers' College Press.
- Smith, M. S. (2000). Balancing old and new: An experienced middle school teacher's learning in the context of mathematics instructional reform. *Elementary School Journal*, 100(4), 351–375.
- Snow-Renner, R., & Lauer, P. (2005). *Professional development analysis*. Denver, CO: Mid-Content Research for Education and Learning.
- Spillane, J. P., Reiser, B. J., & Reimer, T. (2002). Policy implementation and cognition: Reframing and refocusing implementation research. *Review of Educational Research*, 72(3), 387–431.
- Stein, M. K., Smith, M. S., & Silver, E. A. (1999). The development of professional developers: Learning to assist teachers in new settings in new ways. *Harvard Educational Review*, 69(3), 237–269.

Vescio, V., Ross, D., & Adams, A. (2008). A review of research on the impact of professional learning communities on teaching practice and student learning. *Teaching and Teacher Education*, 24(1), 80–91.