Mathematics coaching and the coaching cycle: The Math GAINS project

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Abstract

Instructional coaching is a very effective model of professional learning. Over the last 5 years, Ontario has supported mathematics coaching through funding, training, and other resources to enable every school board to develop locally sensitive programs that have increased internal coaching capacity. This paper reviews the strengths of instructional coaching in mathematics, and reports on an instructional coaching initiative in one large school district in Southern Ontario. Evaluation of this initiative showed high levels if teacher satisfaction, as well as significant increases in instructional capacity and teacher self-efficacy. The current study adds to the literature supporting job embedded instructional coaching, and illustrates a structure for large scale implementation of mathematics coaching. It also illustrates the need for sustained and supported professional learning programs to produce lasting change in practice.

Keywords: instructional coaching, mathematics coaching, math GAINS, teacher education, teacher professional development.

INTRODUCTION

This paper reports on a study of mathematics coaching as a model of professional learning, in a large urban school district in Ontario, Canada. The project was supported financially by the Ontario Ministry of Education (2008), as part of the provincial professional learning strategy. However, for this paper, the Ontario Ministry of Education had no input or funding support.

Over the last 30 years, there has been a major paradigm shift in our understanding of the principles of effective professional development. The impetus for this shift was dissatisfaction with traditional professional learning models (West & Staub, 2003). Concerns were expressed that there was very limited transfer from traditional professional learning sessions to classroom practice. Estimates of implementation of new learning were as low as 10% (Hartman, 2013; Joyce & Showers, 1983a).

The theory of organizations describes teaching as a professional bureaucracy (Mintzberg, 1979). This means that major directions and frameworks are specified top down, while the operating core of the enterprise is staffed by trained professionals who have considerable latitude and autonomy in their work. Thus, to implement change, the professional teachers must be convinced of the value of the change, and be given support throughout the implementation process. Traditional, single workshop based professional development is incompatible with this model.

Based on the groundbreaking work of Joyce and Showers (1983b), a number of alternative professional learning models were developed. These included various coaching models, professional learning communities, action research, mentoring, collaborative study groups, lesson study, demonstration classrooms, and collaborative inquiry. All these models need to satisfy seven principles, namely, the professional learning must be sustained over time, job-embedded, interactive, integrated (and differentiated), practical, collegial, and results-oriented (Fogarty & Pete, 2010).

REVIEW OF THE LITERATURE

Theoretical Framework

Instructional coaching explicitly assumes a knowledge-based constructivist paradigm (West & Staub, 2003). West and Staub point out that

> For the cognitive constructionist, learning is an active process through which learners construct new knowledge on the basis of the cognitive structures already available. The teachers' role is to initiate learning and to prompt and assist particular learners as they construct rigorous, specific knowledge. Coaching conversations that are meant to help teachers develop practical ways to initiate and guide student learning thus need to be very content specific. (p. 8)

The aim is to change beliefs before behaviours (Knight, 2007). This related directly to teachers as professionals within a professional bureaucracy. This emphasis on changing values is also seen in work with mathematics teachers in Thailand (Kadroon & Inprasitha, 2013).

Instructional Coaching

Coaching is a form of experiential professional development (Burke, 2013). It is related to apprenticeship, but differs in that both teacher and coach are co-learners, and guidance is informed by a conceptual framework (West & Staub, 2003). Both participants engage in a cycle of co-planning, co-teaching, and co-reflecting. This is referred to as the coaching cycle, as illustrated in Figure 1 (Ontario Ministry of Education, 2008b). The key elements of the cycle include collaboration and reflection (Hill & Rapp, 2012; White, 2013). In addition, coaching develops a shared language and common understanding to enable the acquisition of new knowledge and skills (Showers & Joyce, 1996).

Instructional coaching is sometimes called academic coaching, peer coaching, collegial coaching, content coaching, change coaching, each of which has nuanced differences from the basic coaching cycle outlined above (Hartman, 2013). It is, however, significantly different than mentoring, which implies a supervisory relationship between the participants (Lipton & Wellman, 2003).

Instructional coaches may be called upon to provide a number of activities beyond the coaching cycle. Among these are planning, facilitating, or leading workshops, leading study groups, designing and leading data analysis sessions, assisting with action research, finding resources, modelling and demonstration teaching, leading lesson study, and organizing peer coaching (Shanklin, 2009). This paper will focus on the roles related to the coaching cycle.

Mathematics Coaching

Hull, Balka, and Miles (2009) define a mathematics coach as "an individual who is well versed in mathematics content and pedagogy and who works directly with classroom teachers to improve student learning of mathematics"(p. 3). This definition emphasizes the attributes, work, and goal of mathematics coaching. The overall goal of math coaching is to improve student achievement. This is problematic since the relationship between coaching and student achievement is murky (Polly, Algozzine, & Mraz, 2013; Quick, Holtzman, & Chaney, 2009; Sailors & Shanklin, 2010). Some studies show a small positive link, while others demonstrate no statistically significant relation. Research does support links between coaching and teacher efficacy (Joyce & Showers, 1983a) and between coaching and instructional capacity (Hartman, 2013; West, 2002).

Role of the Coach

Both Shanklin (2009) and Hull et al. (2009) list the various activities of math coaches:

- work with teachers to improve mathematics achievement,
- manage and control curriculum and instructional materials,
- manage and regulate professional development,
- monitor program implementation,
- build the mathematics program by using its strengths and reducing its weaknesses,
- maintain and share best-practice research,
- build collaborative teams and networks, and
- gather, analyse, and interpret data, such as from assessments and benchmark tests, to inform instruction. (Hull et al., p. 5)

Some or all of these activities will occur as part of the coach's involvement in the coaching cycle.

Ontario Provincial Math Coaching Program

Beginning in 2008, the Ontario Ministry of Education supported the development of mathematics coaching in all 72 school boards across the province. Boards were provided with funding for release of math coaches, training, supply coverage, and other resources. The program was sensitive to local needs. Each board was required to submit a preliminary plan for their coaching initiatives, and a final report at the end of the funding period. As a provincial Education Officer, my responsibilities included designing the funding model, monitoring implementation, and providing support. For boards lacking internal coaching capacity, support was available through a system of Provincial Math Coaches. These coaches were master teachers who could be requested by boards to work with teams of teachers to develop coaching capacity, and costs were covered by ministry funding. The funding for coaching initiatives has been continued through the school year 2013-14, although details have changed as boards' coaching capacity has increased over time.

CASE STUDY: THE MATH GAINS PROJECT

Research Questions

(1) How can a large school district effectively implement a professional learning program coherent with the Ontario Ministry of Education's emphasis and support for instructional coaching in mathematics?
(2) What are the most effective strategies for implementing instructional coaching in mathematics?

Program Description

The following description of how the provincial initiative was enacted in one school board was provided by a former provincial math coach, who was the board lead for the project. This project was chosen as an exemplar in part because the school board research department conducted an effectiveness study in the school year 2010-2011.

The Math GAINS Co-Teaching Initiative in this board was a Ministry funded professional development initiative that provided job-embedded professional learning opportunities for grade 7-12 mathematics teachers. A lead co-teaching facilitator set up partnerships between cross grade, cross school, and cross panel teams to facilitate discussion, increase opportunities to share expertise, and promote creative thinking and problem solving regarding teaching practices. Collaborative team work occurred during the school year through teacher release days, funded by the Ontario Ministry of Education (2008).

Co-planning

The Math GAINS Initiative incorporated a collaborative inquiry approach, using a cyclical co-planning, co-teaching, and debriefing model. Classroom teachers worked in small grade, panel, or cross-panel teams, together with a co-teaching facilitator. Each group's purpose, challenges, and questions were discussed, and then a balance of guided instruction and collaborative learning opportunities were provided to meet the groups' goals.

Lead co-teaching facilitators gathered data from teachers at the beginning of each co-planning session on their areas of comfort, expertise, challenge, and students to tailor the co-planning conversation to the teachers' unique needs and students. Ideas were gathered from teachers, research, and resources to provide a variety of instructional choices fitting the lesson goals and student needs; therefore, teachers could choose the level of risk they wished to pursue in their teaching and learning. Teams determined the main ideas they wished to grow in students' mathematical understanding, and worked toward common language, strategies, and representations that would build upon students' knowledge as they transitioned across grades and schools.

The lead co-teaching facilitator encouraged teams to plan lessons with diagnostic opportunities, rather than use only written tests or quizzes to diagnose student gaps. The teachers brainstormed key "look fors" in advance, and discussed how to listen to gather diagnostic data from student conversations and how to assess through observation. The lead co-teaching facilitator also shared ways of tracking student observations (e.g., SOLVE from Anne Davies, 2007), to help teachers build more observations into their overall assessment plans.

Co-teaching

When necessary, the lead co-teaching facilitator taught the math being explored to the teachers, without devaluing anyone's expertise. Common misconceptions as outlined in the research were explained to focus planning conversations around the "math that matters" and the "math that challenges" in order to help close gaps in student understanding.

Co-teaching focused on strategies used to deliver lessons, and on observing student responses and reactions to planned lessons. Teachers were encouraged to build higher order questions into their lessons to help build problem-solving skills in their students; good questions were brainstormed in advance with the teaching team so higher order questions surfaced appropriately in the lessons with students. Open questions and parallel tasks were introduced to school teams, and teachers incorporated a variety of questioning techniques in their lessons and assessments as a result of accountable talk around good questions in the co-planning conversations.

When teachers were teaching their lessons, they knew they could count on the lead co-teaching facilitator's support during any part of the lesson. Independent practice was promoted, while still providing a safety net so teachers were encouraged to take more risks in their teaching practice.

The lead co-teaching facilitator practiced setting criteria with teachers, helped teachers set criteria with their students, and helped teach students how to use criteria to inform their learning. Feedback that could be given and questions that could be asked were brainstormed in advance of a lesson in order to increase the quality of the feedback given to students in the moment of a lesson.

Teams explored the use of journal entries in math, performance-based assessments, presentation rubrics/checklists, self-assessment rubrics/checklists, project ideas, and summative assessments reflecting appropriate attention to achievement chart categories and math processes to expand their assessment practices.

Co-debriefing

The debriefing component of the co-teaching cycle involved observational and reflective activities meant to inform future learning goals for students and teachers. Thinking tools, questioning templates, a lesson observation guide, and a debriefing template were provided to guide teachers' observations of the lessons being taught. These resources helped teachers formulate their own assessment of the student responses to the lesson, and laid the groundwork for future reflective thinking. The lead co-teaching facilitator also worked with teams to review students' products together, to assess the effectiveness of both the instructional strategies and the assessment tools so improvements could be made to assessment practices as well.

The lead co-teaching facilitator offered Adobe Connect sessions to provide an opportunity for cross family of schools sharing and learning. Self-assessment surveys were also shared with teaching teams so they could independently assess their skill level with a variety of tools and strategies. Teachers were asked to use their self-assessment to guide their learning goals, so teachers could enhance their practice in the directions they most needed or preferred.

The lead co-teaching facilitator supported teachers' continued learning and growth by responding to teacher e-mails requesting feedback as they integrated new ideas into future lessons planned independently from the co-planning team.

Scope of the Program

Over a 3-year period, 15 families of schools were involved in the Math GAINS Initiative, with a total of 49 schools participating (33 elementary and 16 secondary schools). Participants included 270 teachers who were teaching grades 7-12 mathematics, and demonstrated an interest in expanding their mathematics teaching practice. In addition, four co-teaching facilitators assumed leadership roles, providing ongoing expertise and direction throughout the collaborative process. In some cases, resource teachers shadowed the co-teaching facilitators to further support teachers' professional learning. Schools involved in the Math GAINS Initiative were selected based on student achievement data (e.g., EQAO, credit accumulation), and/or had identified numeracy as a primary area of need.

Program Evaluation

Guskey (2000, 2002) identified five levels for evaluating professional development: participants' reactions; participants' learning; organization support and change; participants' use of new knowledge and skills; and student learning outcomes. For a specific school year (2010-11), the school board described above conducted an evaluation of the Math GAINS program, using elements of Guskey. Based on the timing of the evaluation, the review examined participants' reactions, participants' learning, and participants' use of new knowledge and skills. There was no way at that point in time to evaluate student learning outcomes. Organization support and change was also not evaluated.

The authors of this article were not directly involved in the board research, but we have permission from the school board to cite some of the results and conclusions. The following information is excerpted from the school board research report (Gray, 2011).

Methodology

The study utilized a mixed methods approach. Teacher surveys were analysed using SPSS 16.0, and MANOVA. Teacher comments were compiled using Nvivo. A report was issued in September 2011, and presented to the board's senior administration, as well as made available to participants in the program.

Results and Discussion

Overall participant satisfaction levels were very high, ranging from 83% to 92%, depending on the program component (Gray, 2011). Teachers' understanding of various instructional strategies improved significantly (Table 1).There was reporting of significant improvement in teachers' ability to use various instructional strategies (Figure 2). Ratings for the usefulness of the various components are shown in Figure 3. All components were rated useful, especially the co-planning portions of the coaching cycle. Significant comfort levels with the different teaching strategies involved were also high (Table 3). The report contains a number of anecdotal comments from teachers, giving very positive comments on the program, the process, and the relationships formed with the coaches and other teachers. Because the initiative involved teachers from both the elementary and secondary panels, within each family of schools, strong, ongoing relationships were recognized as a major positive outcome. Some interesting differences in comfort levels were identified. Elementary teachers were much more comfortable than secondary teachers with the 3-part lesson, student grouping, differentiating instruction, and using manipulatives. Secondary teachers reported somewhat more use of technology in their classes following their participation in the Math GAINS project (Gray, 2011). Teachers reported using their learning in their own classrooms following participation in this initiative, as shown in Table 2. Some strategies were implemented particularly often, such as differentiated instruction, problem based learning, all parts of the 3-part lesson, and assessment for learning, all rated Sometimes or Often by over 90% of respondents.

Teachers, regardless of their experience level, reported positive outcomes from their participation in this initiative. In particular, teachers with 5 years or less experience reported significant improvement in their understanding of student misconceptions. Teachers with more than 5 years experience indicated a better understanding of the benefits of group work, comfort with manipulatives, and use of parallel tasks (Gray, 2011).

Validity

Internal validity is supported by the Math GAINS initiative satisfying all seven of the principles of professional learning identified by Fogarty and Pete (2010): sustained over time--the project is now in its 7th year; job-embedded--the majority of the activities occurred in the teachers' home schools; interactive--the collaborative nature of the project mitigated interaction among the participants; integrated (and differentiated)--each coaching interaction within each coaching cycle was individualized; practical--teachers learned multiple research-affirmed strategies; collegial--the relational nature of the activities was identified by the participants as one of the most valuable; results-oriented--there were clear increases in instructional capacity, as well as in teacher self-efficacy.

In addition, teachers reported increased understanding of the major components of the program (Table 1), as well as significantly increased comfort levels with individual strategies (Table 3). For example, comfort with the use of parallel tasks increased from 20% of participants before the program to 64% after the program.

External validity and reproducibility was supported by the longevity of the program (now in excess of 7 years), as well as the extent to which teachers employed the strategies learned during the program once the program had been completed (Table 2). While the program has had minor variations each year, the core components remain unchanged.

This project demonstrated an effective, research-affirmed method of increasing instructional capacity over time. The project provided for the building of a critical mass of informed professionals, all with the common goal of improving student achievement through improved pedagogy.

CONCLUSIONS AND FURTHER RESEARCH

The Math GAINS project provides an exemplar for research question (1), How can a large school district effectively implement a professional learning program coherent with the Ontario Ministry of Education's emphasis and support for instructional coaching in mathematics? The school district was very large, involving almost 175,000 students. The program started with a few families of schools, and increased incrementally to involve 22 families of schools. While not the only possible implementation model, this particular model is reproducible in other districts, with local modifications as needed.

Based on the evaluation of this project, research question (2) What are the most effective strategies for implementing instructional coaching in mathematics?, demonstrates emphatically that utilizing the coaching cycle of co-planning, co-teaching, co-debriefing is an effective model for job-embedded professional learning. With respect to individual instructional strategies, a number of strategies were identified as particularly effective (Figure 2). The three most effective strategies were: problem solving approach, use of manipulatives, and differentiated instruction. These results support previous research on all three of the strategies.

The current study adds to the literature supporting job embedded instructional coaching, and illustrates a structure for large scale implementation of mathematics coaching. It also illustrates the need for sustained and supported professional learning programs to produce lasting change in practice. In this case, the impact of job-embedded professional learning is clear. Initiatives such as the Math GAINS project have demonstrated that significant gains in student achievement are possible through gains in teacher confidence and competence. This project, together with others throughout the province, emphasize a number of important dimensions, including research-affirmed practices, critical mass of teacher capacity, sensitivity to local conditions, and paying attention to affective as well as cognitive domains.

Further research is needed in several areas. First, with respect to the program described in this paper, research should be conducted to identify what institutional structures support or impede this type of whole-district implementation of instructional coaching in mathematics. Second, a study should be made investigating the longevity of teacher use of the strategies learned during this project. For example, since the program has now been in place for 7 years, what percentage of teachers are still using the coaching cycle, as well as specific instructional strategies?

On a broader level, research should investigate other models of job-embedded professional learning in the province, especially since the province has continued to fund such initiatives. A cost-benefit analysis of these programs would be useful to identify the most effective, cost-efficient programs, with a view to providing publicity and additional support for such job-embedded professional learning models.

REFERENCES

Burke, B. (2013). Experiential professional development: A model for meaningful and long-lasting change in classrooms. *Journal of Experiential Education*, *36*(3), 247-263.

Davies, A. (2007). *Making classroom assessment work* (2nd ed.). Courtenay, BC: Connections Press.

Fogarty, R., & Pete, B. (2010). Professional learning 101: A syllabus of seven protocols. *Phi Delta Kappan*, 91(4), 32-34.

Gray, E. (2011*). Evaluation of the math GAINS co-teaching initiative in Peel*. Mississauga ON: Peel District School Board.

Guskey, T. (2000). *Evaluating professional development.* Thousand Oaks, CA: Corwin.

Guskey, T. (2002). Does it make a difference? Evaluating professional development. *Educational Leadership, 59*(6), 45-51.

Hartman, S. (2013). Math coaching in a rural school: Gaining entry: A vital first step. *Journal of Education*, *193*(1), 57-67.

Hill, R., & Rapp, L. (2012). School-based coaches plant seeds of learning. *Journal of School Development*, *33*(4), 36-40..

Hull, T., Balka, D., & Miles, R. (2009). *A guide to mathematics coaching*. Thousand Oaks, CA: Corwin.

Joyce, B., & Showers, B. (1983a). The coaching of teaching. *Educational Leadership, October 1982*, 4-10.

Joyce, B., & Showers, B. (1983b). *Power in staff development through research on training*. Reston, VA: Association for Supervision and Curriculum Development.

Kadroon, T., & Inprasitha, M. (2013). Professional development of mathematics teachers with lesson study and open approach: The process for changing teachers values about teaching mathematics. *Psychology*, *4*(2), 101-105.

Knight, J. (2007). *Instructional coaching: A partnership approach to improving instruction*. Thousand Oaks, CA: Corwin.

Lipton, L., & Wellman, B. (2003). *Mentoring matters: A practical guide to learning-focused relationships*. Sherman, CT: MiraVia.

Mintzberg, H. (1979). *The structuring of organizations*. Englewood Cliffs, NJ: Prentice Hall.

Ontario Ministry of Education. (2008a). *Coaching for Math GAINS (2008-09)*. Retrieved from www.edugains.ca

Ontario Ministry of Education. (2008b). *Mathematics coaching actions*. Retrieved from www.edugains.ca

Polly, D., Algozzine, R., & Mraz, M. (2013). Implications for developing and researching elementary school mathematics coaches. *School Science and Mathematics, 113*(6), 297-307.

Quick, H., Holtzman, D., & Chaney, K. (2009). Professional development and instructional practice: Conceptions and evidence of effectiveness. *Journal of Education for Students Placed at Risk*, *14*, 45-71.

Sailors, M., & Shanklin, N. (2010). Growing evidence to support coaching in literacy and mathematics. *The Elementary School Journal*, *111*(1), 1-6.

Shanklin, N. (2009). Literacy coaching: What are we learning? *CEDER Yearbook*, *2009*, 31-44.

Showers, B. (1985). Teachers coaching teachers. *Educational Leadership, April 1985*, 43-48.*Transforming mathematics lessons*. Portsmouth, NH: Heinemann.

Showers, B., & Joyce, B. (1996). The evolution of peer coaching. , R. *Educational Leadership March 1996,12-16.*

West, L., & Staub, F. (2003). *Content-focused coaching: Transforming mathematics lessons*. New York, NY: Heinemann.

West, P. (2002). 21st century professional development: The job-embedded, continual learning model. *American Secondary Education, 30*(2), 72-80.

White, C. (2013). Improving math instruction with content-based coaching. *Principal 93*(1), *36-38.*

Table 1
Percentage of teachers reporting improvement in their understanding of instruction, assessment, and learning processes as a result of the Math GAINS initiative (adapted with permission from Gray, 2011, p. 4)

How different questioning techniques can deepen student understanding	72%
How the 3-part lesson helps students orgnaize their mathematical thinking	63%
The benefits of having students work in groups	55%
Identifying student misconceptions in mathematics	51%
How peer and self assessment informs planning	42%

Table 2

Extent to Which Teachers Use Instructional Strategies in their Classrooms Following Participation in Math GAINS

Strategy	Never	Rarely	Sometimes	Often
Use the *Minds On* strategy from a 3-part lesson (e.g., activate prior knowledge, captivate creativity)?	0%	11%	51%	38%
Use the *Action* strategy from a 3-part lesson (i.e., build understanding)?	1%	4%	29%	67%
Use the *Consolidation* strategy from a 3-part lesson (e.g., develop meaning, gather evidence of learning)?	0%	8%	44%	48%
Establish effective pair/group structures among students?	1%	3%	53%	43%
Create opportunities for student-to-student talk?	1%	3%	34%	62%
Teach from a problem solving focus?	0%	10%	50%	40%
Use open questions?	1%	15%	48%	36%
Use parallel tasks?	7%	34%	55%	7%
Use prompt questions?	1%	8%	41%	50%
Use consolidating questions?	1%	10%	53%	37%
Integrate a variety of technologies into your math lessons (e.g., LCD, Clickers, graphing calculators, smartboard, math software)?	2%	17%	40%	40%
Use math manipulatives?	1%	18%	42%	39%
Incorporate various curriculum-based math processes?	1%	8%	61%	30%
Differentiate instruction (based on students' interests, readiness, learning preferences, etc.)?	1%	11%	50%	38%
Use assessment <u>for</u> learning (e.g., as a check for understanding, to inform feedback, to adjust the lesson trajectory)?	0%	8%	49%	43%

From Gray, 2011, p.12. Reproduced with permission.

Table 3

Comfort level of teachers before and after participation in the Math GAINS initiative (adapted with permission from Gray, 2011, pp.9-10)

Strategy	**Before %**	**After %**
Establishing effective pair/groups among students	77	92
Using the Action strategy from a 3-part lesson	71	92
Using the Minds On strategy from a 3-part lesson	56	91
Creating opportunities for student-to-student talk	71	90
Using consolidating questions	61	88
Using prompt questions	62	86
Using manipulatives	63	85
Using assessment for learning	55	85
Using the Consolidation strategy from a 3-part lesson	51	83
Teaching with a problem solving focus	50	82
Using open questions	44	82
Incorporating math process expectations	60	80
Differentiating instruction	49	78
Integrating a variety of technologies	53	71
Using parallel tasks	20	64

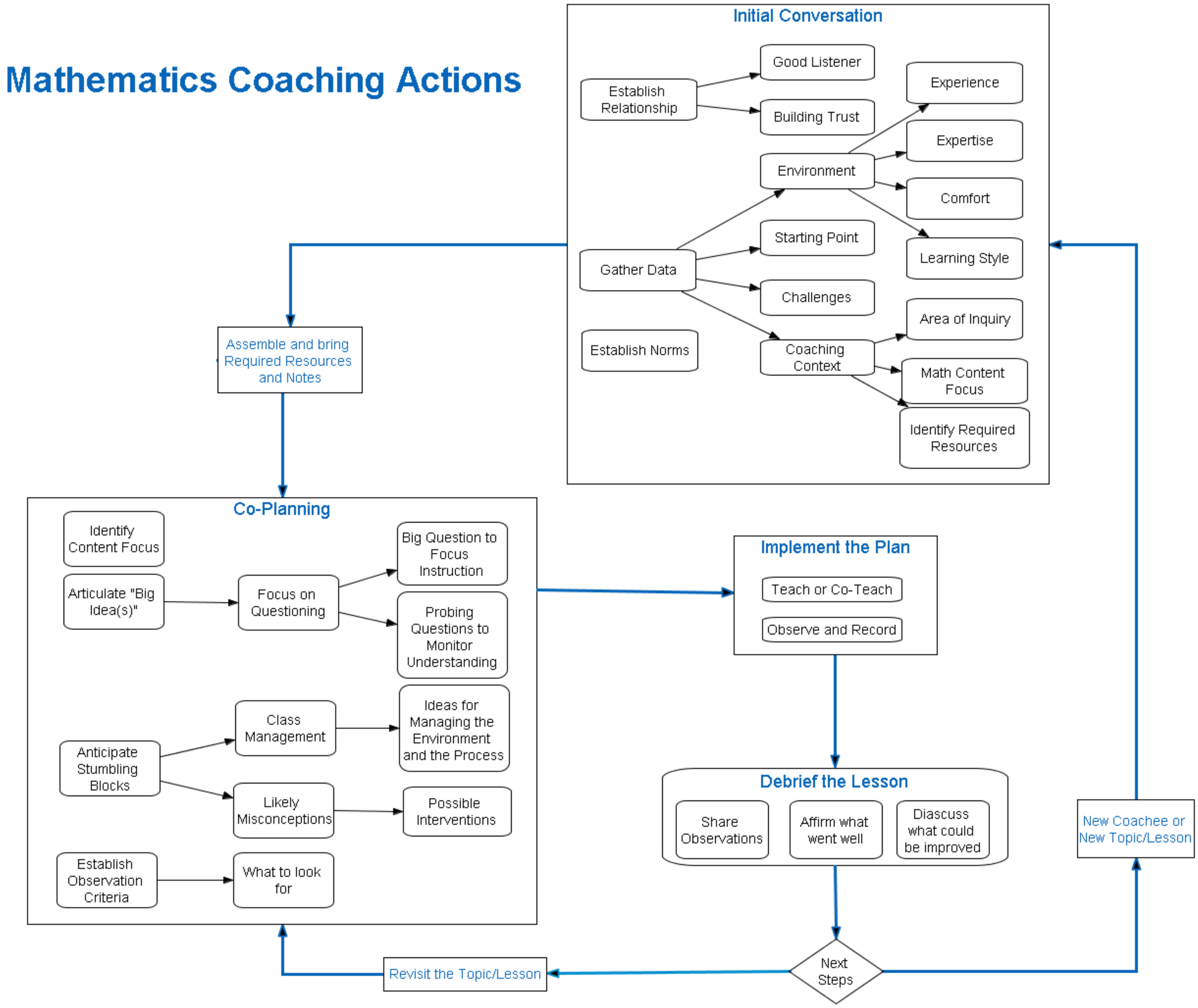
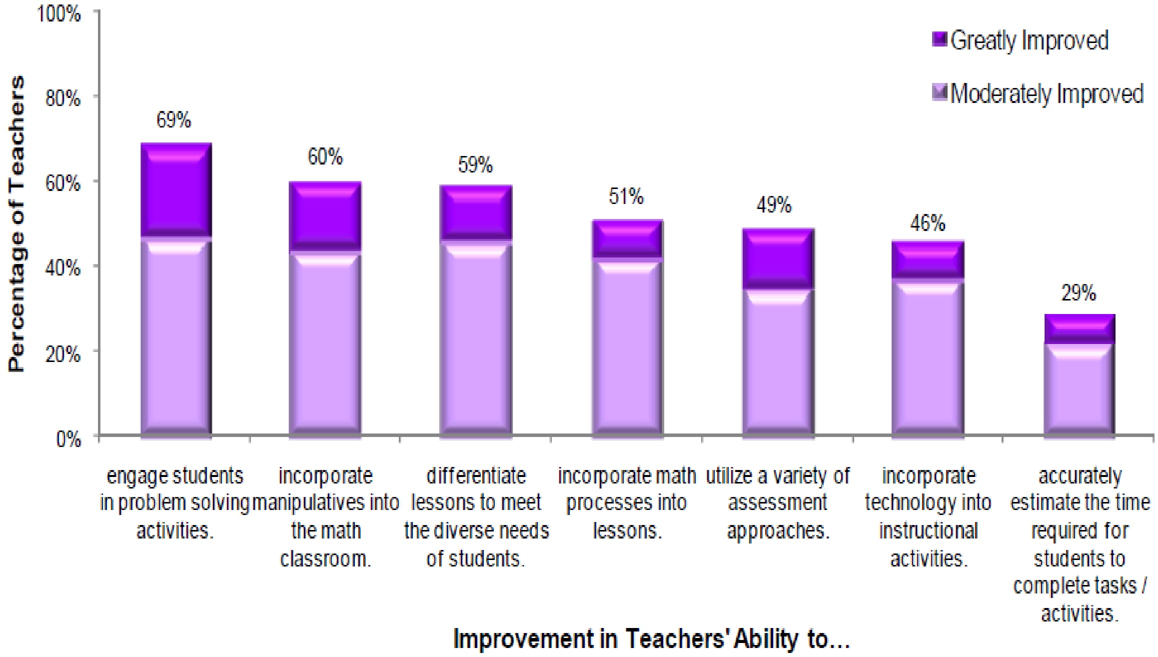


Figure 1. Mathematics coaching cycle. Ontario Ministry of Education (2008). Downloaded from www.edugains.ca.

Figure 2. **Percentage of teachers reporting improvement in their ability to use various instructional strategies as a result of the Math GAINS Initiative.**



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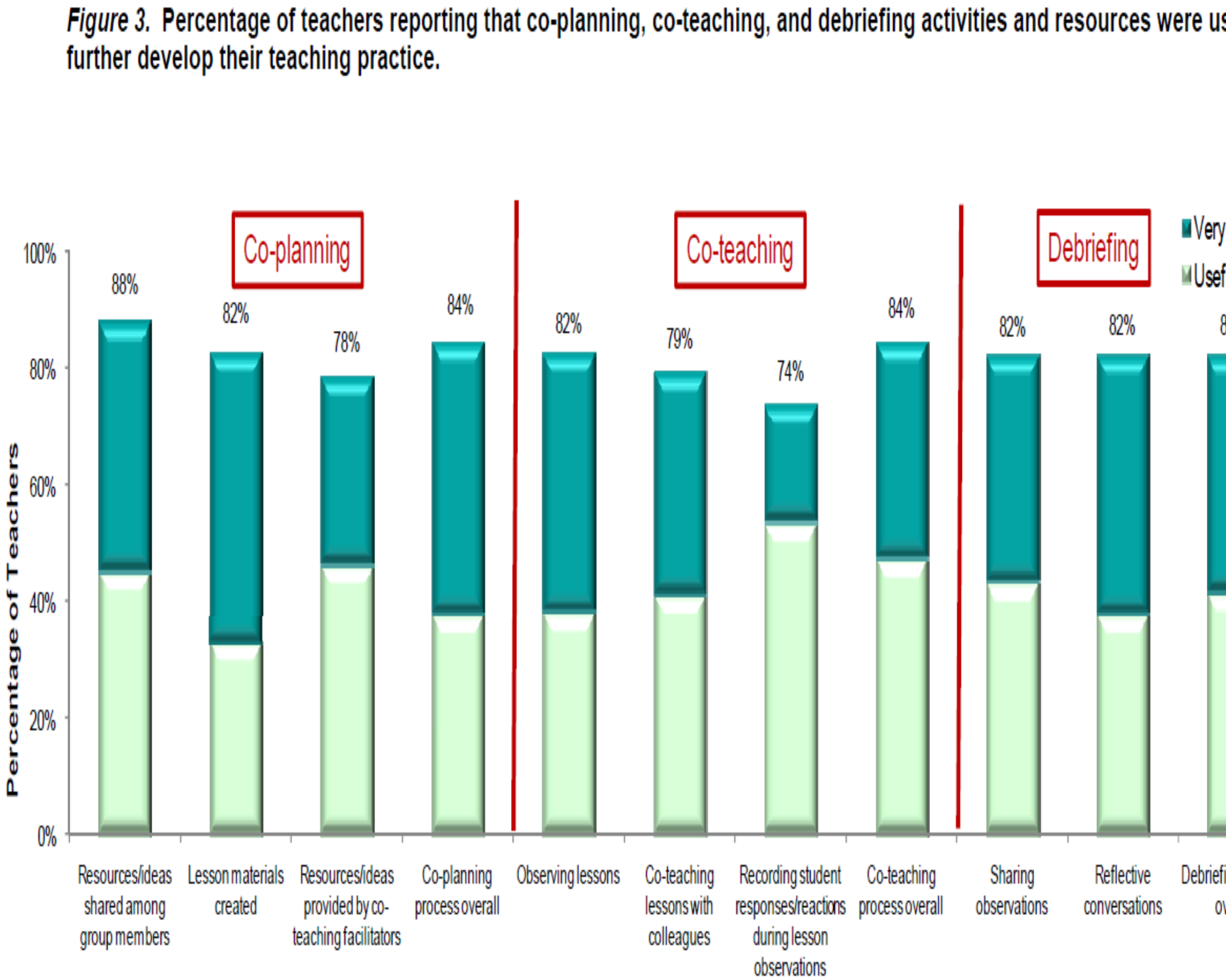

Figure 3. From Gray, 2011, p.7. Reproduced with permission.