Collaborative Teacher Inquiry in Elementary and Secondary School Mathematics

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1. What have you learned about teaching/learning in your research?

I have been in education for over 33 years, teaching at the elementary, secondary and tertiary school levels in mathematics. For the past 16 years at the University of Toronto, I have focused my scholarship, teaching, and creative professional activity program on mathematics teaching and learning, collaborative teacher inquiry, the professional learning of teachers, and technology-supported learning.

The Ten Dimensions of Mathematics Education Framework

My most recent work has focused on the use of a conceptual framework for improvement in mathematics called the Ten Dimensions of Mathematics Education. The Ten Dimensions of Mathematics Education is a framework that breaks down the essential components of a successful mathematics education program (McDougall, 2004; Ross et al., 2003). The dimensions overlap and together constitute an orientation to instruction that differs from traditional practice. The Ten 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; many of these problems do not afford a single solution. Skill and procedural work can be engaging and meaningful; (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 reformed classes with the aid of manipulatives and with ready access to mathematical tools - calculators and computers; (8) Students' Mathematics Communication: Instruction in reformed 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 towards mathematics and comfort with the subject matter affects student learning.

The Collaborative Teacher Inquiry Project – Grade 9 (2008-2012) focused on the improvement of instructional strategies in Grade 9 Applied level mathematics, with the goal of improving student achievement and student engagement in mathematics. A partnership between the University and four urban school districts in the Greater Toronto Area, the Learning Consortium consisted of 12 participating schools in December 2008 to June 2010. Five additional schools, along with five of the initial 12 schools, continued their participation from December 2010 to June 2012. The purposes of this project were to: 1) improve the teaching and learning of Grade 9 Applied mathematics and 2) investigate collaborative inquiry as professional development strategy.

The participating schools created an implementation team of administrators and teachers. This team met to discuss mathematics improvement in their school as part of the Learning Consortium's project. The participants attended three in-service professional learning sessions for

each of the four school years. These sessions focused on assessment, technology, teaching strategies, school improvement, student tasks, collaborative learning and data analysis.

The University research team interviewed teachers and department heads/curriculum leaders in the schools to gain more information about their understanding of mathematics improvement, mathematics teaching and learning, and school success. A self-assessment survey (Ross et al., 2003), which consists of 20 Likert (agree-disagree) items, was also used as a practical starting point for collecting information about teacher's current attitudes and practices surrounding the Ten Dimensions.

The five schools that participated in the project for four years had an average increase of 110% in their EQAO scores. The five schools that participated in the project for two years had an average increase of 113%. One school increased by 256% over two years while two other schools increased by over 150% over the project. These schools were selected due to their low EQAO scores; therefore, it was a significant positive result that five of the ten schools more than doubled the percentage of students at the provincial standard during their time in this project.

The following is a summary of our research findings from the Collaborative Teacher Inquiry Project. The findings are organized by dimensions:

<u>Dimension 1: Program Scope and Planning</u>

- Start with measurement, splitting up strands so that they are not taught as distinct units
- Schedule courses so that teachers have common planning and discussion time
- Class length should allow for opportunities for engaging student activities
- Organize EQAO questions by unit/chapter so that they can be integrated into topics
- Resources - Edugains, TIPS, course packages are all excellent resources
- Continue these practices into the Grade 10 Applied level classrooms

<u>Dimension 2: Meeting Individual Needs</u>

- Use a variety of instruction approaches – skill, conceptual, constructivist
- Strategies for differentiating instruction should be presented and practiced as part of the professional development program
- After school numeracy classes are valuable additions to the regular classroom

Dimension 3: Learning Environment

- Classroom organization should encourage mathematics learning - cluster of tables
- Word walls help students remember important concepts and skills
- Peer tutoring provides additional support for students
- Scheduled the same room for all sections of Grade 9 Applied to maximize limited resources and technology

Dimension 4: Student Tasks

- Integration of TIPS resources enhances student motivation to complete tasks
- Integrate EQAO questions into introductory activity, unit tests, investigations
- Meaningful and engaging practice builds student confidence
- Meaningful contexts encourages student engagement with the activities
- Class should be long enough for students to complete tasks

Dimension 5: Constructing Knowledge

- Use of appropriate instructional approaches builds on different learning styles
- Use of effective questions builds understanding of concepts
- Understanding how students construct knowledge helps teachers to identify student misconceptions

Dimension 6: Communicating with Parents

- Communication should focus on student progress and mathematics program
- A variety of ways are necessary to engage parental support

Dimension 7: Manipulatives and Technology

- Appropriate use of a variety of manipulatives assists in student understanding
- Use of technology software such as Gizmos and CLIPS enhances student motivation and understanding
- Various technologies enhance teaching (Docucamera, Interactive White Board)
- Technology Infrastructure must be stable to encourage consistent use of technology

Dimension 8: Students' Mathematical Communication

- Four types of communication are necessary (Oral, Written, Graphic/Pictorial and Physical)
- Encouraging students to share their understanding of mathematics helps to identify student misconceptions

Dimension 9: Assessment

- Diagnostic tests help to identify areas for instruction
- A variety of assessment strategies/tools should be used
- Moderated marking encourages professional discussion and growth
- Common evaluation and assessment tasks should be used regularly

Dimension 10: Teacher's Attitude and Comfort with Mathematics

- Modelling a positive attitude through professional development and with students
- Increased comfort comes with increased mathematics content knowledge
- Professional development workshops are necessary to build teacher understanding and comfort
- Teachers planning together creates an environment of support and encouragement
- Collaboration is key to a change in teacher attitudes, beliefs and comfort with mathematics

2. In your work with elementary and secondary school teachers, how has the integration of math content knowledge in to professional learning helped support student learning?

There have been a number of areas where the integration of mathematics content knowledge in professional learning has helped support student learning. The most noticeable change was the extent to which teachers took responsibility for student learning in their classroom by the end of the project. Many of the teachers found that their students experienced more success and developed confidence in their math studies as the teachers changed the teaching-learning dynamic in the classroom. They found that increased student engagement and better achievement led to improved attendance and participation in class. Teachers reported that the non-traditional delivery of the curriculum made the most positive difference for the students as well as for themselves.

The Grade 9 teachers find that their students are more eager to learn after experiencing increased success. There is a positive tone to the learning environment, with active student participation. There is a decrease in “math phobia”, and students are more willing to approach their teacher for help and clarification. This is partly the result of increased access and use of technology and manipulatives by all grade 9 applied math teachers.

Students have had more opportunities to become more engaged, to interact with their teachers and to get constructive feedback in the course. The students were more engaged through SMART board activities, BANSHO presentations and the use of clickers to respond to math

questions. Each student is engaged in doing mathematics as a result of the teacher assigning individual tasks to be completed in cooperative learning groups. As teachers experimented with a variety of groupings in the classroom, there was more interaction among students and between students and the teacher.

Through the increased knowledge of mathematics concepts, the teachers felt more engaged, more confident and more likely to increase EQAO scores with Grade 9 Applied level students. The collaborative inquiry approach assisted in changing teacher beliefs and teaching practices in the schools that we observed.

3. What further questions about mathematics teaching and learning are you now beginning to examine?

In regards to professional development, one of the most significant challenges is understanding how to sustain new pedagogical practices once the formal portion of a professional development program is completed. Numerous studies have linked student academic success to the knowledge and pedagogical skills of teachers (Darling-Hammond & Sykes, 1999; Fullan, Hill & Crevola, 2006; Glazerman, McKie & Carey, 2009; Slavin & Lake, 2008; Wilson, Floden & Ferrini-Mundy, 2001). Teaching is an extraordinarily complex profession, requiring a mastery of foundational content knowledge, a sophisticated repertoire of instructional strategies, and the ability to flexibly tailor practices to particular situations and the needs of individual learners (Bransford, Darling-Hammond & LePage, 2005; Cole & Knowles, 2000; Darling-Hammond, 1998; Turner-Bisset, 2001). It is perhaps not surprising therefore, that teacher professional development is the focus of a great deal of research. Much has been learned over the past few decades; traditional “one shot” sessions, delivered primarily through lecture or other transmission-oriented methods, have been found to be largely ineffective (Little, 1999).

Successful interventions typically employ a combination of some or all of the following elements: job-embedded learning, collaborative (peer) inquiry, and attention to student performance, institutional and administrative support, the provision of time and other resources, and a commitment to continuous long-term engagement in professional development initiatives (Guskey, 2000; Hawley & Valli, 1999; Suurtamm & Vezina, 2010). While there is a lack of agreement regarding the relative merits and efficacy of particular methods (e.g., action research vs. lesson study), there does appear to be a growing consensus that effective professional development requires a skilful interweaving of many or all of above-mentioned factors (Berliner, 2005; Fullan, 2001, 2005; Guskey, 1995, 2000, 2003; Hawley & Valli, 1999). As such, conducting an in-depth exploration on the sustainability and long-term effects of a professional development initiative may provide a better understanding of this issue.

A direct follow-up of the Collaborative Teacher Inquiry Project, my research would focus on how teachers work in collaborative inquiry teams and integrate their new experiences and learning into existing knowledge structures. We need to have a better understanding of long-term sustainability, which has remained relatively unexplored in the academic literature. The future research questions are:

1. What innovative pedagogical practices were sustained and/or lost in the years following the project?
2. What factors contributed to the persistence or loss of these practices?
3. To what extent did teachers personally pursue their own ongoing, self-directed professional development in the years following the project?
4. To what extent did these initiatives involve consultation and sharing with peers?
5. What components of the professional development program enhance sustainability?

References

Berliner, D. C. (2005). The Near Impossibility of Testing for Teacher Quality. *Journal of Teacher Education, 56*(3), 205-13.

Bransford, J., Darling-Hammond, L., & LePage, P. (2005). Introduction. In Darling-Hammond, L. & Bransford, J. (Eds.), *Preparing Teachers for a Changing World: What Teachers Should Learn and Be Able To Do*. Jossey-Bass.

Cole, A. & Knowles, G. (2000). *Researching Teaching: Exploring Teacher Development Through Reflexive Inquiry*. Toronto: Allyn and Bacon.

Darling-Hammond, L. (1998). Teachers and teaching: Testing hypotheses from a National Commission Report, *Educational Researcher, 27*(1), 5-15.

Darling-Hammond, L. & Sykes, G. (Eds.) (1999). *Teaching as the Learning Profession.* San Francisco: Jossey-Bass.

Fullan, M. (2001). *The New Meaning of Educational Change* 3rd. Ed. New York: Teachers College Press.

Fullan, M. (2005). *Leadership and Sustainability: Systems thinkers in action*. Corwin Press.

Fullan, M., Hill, P., & Crevola, C. (2006). *Breakthrough*. Corwin Press.

Glazerman, S. McKie, A. & Carey, N. (2009). An evaluation of the teacher advancement program (TAP) in Chicago: Year one impact report. Washington, D.C.: Mathematica Policy Research.

Guskey, T. (1995). Professional Development in Education: In Search of the Optimal Mix. *In Professional Development in Education: New Paradigms and Practices*. (Guskey, T. & Huberman, M. Eds.) New York: Teachers College Press. pp 114 – 132.

Guskey, T. (2000). Does it make a difference? Evaluating professional development. *Educational Leadership, 59*(6), 45 – 51.

Guskey, T. (2003). What makes professional development effective? *Phi Delta Kappan, 84*(10), 748-750.

Hawley, W. & Valli, L. (1999). The essentials of effective professional development: A new consensus. In *Teaching as the Learning Profession: Handbook of Policy and Practice*. Darling-Hammond, L. & Sykes, G. (Eds.). San Francisco: Jossey-Bass.

McDougall, D. E. (2004). *School Mathematics Improvement Leadership Handbook.* (pp. 88). Toronto: Thomson Nelson.

Ross, J. A., Hogaboam-Gray, A., McDougall, D., & Le Sage, A. (2003). A survey measuring implementation of mathematics education reform by elementary teachers. *Journal of Research in Mathematics Education, 34*(4), 344-363.

Slavin, R.E. & Lake, C. (2008). Effective programs in elementary mathematics: A best-evidence synthesis. *Review of Educational Research, 78*(3), 427-515.

Suurtamm, C. & Vezina, N. (2010). Transforming pedagogical practice in mathematics: Moving from telling to listening. *International Journal for Mathematics Teaching and Learning.* http://www.cimt.plymouth.ac.uk/journal/default.htm

Turner-Bisset, R. (2001). *Expert Teaching: Knowledge and Pedagogy to Lead the Profession*. London: David Fulton Publishers.

Little, J.W. (1999). Organizing schools for teacher learning. In L. Darling-Hammond and G. Sykes (eds.), *Teaching as the learning profession: Handbook of teaching and policy.*, pp. 233-262. San Francisco: Jossey Bass.

Wilson, S.M., Floden, R.E., & Ferrini-Mundy, J. (2001). Teacher Preparation Research: Current Knowledge, Gaps, and Recommendations. A Research Report Prepared for the U.S. Department of Education. Seattle, WA: Center for the Study of Teaching and Policy. (February).