Efficacy, Professional Learning, Content Precision, and Future Directions

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

I have been studying the teaching and learning of mathematics for about 25 years now. Fourteen of these were more informal, as a classroom teacher. And 11 of these have been formal – through an intensive research program at Trent University. One of the central features of this research work is the construct of teacher and student efficacy, which stems from the work of Canadian-born psychologist Albert Bandura. Teacher efficacy in mathematics is the teacher's belief that he or she can help students learn mathematics despite possibly difficult working conditions or environments and despite the circumstances of the students (home life, prior experiences, learning challenges) that he or she is teaching. Student efficacy in mathematics is the student's belief that he or she has the ability to learn. When students believe they can learn math and teachers believe they can help students learn math, the result is that students DO learn math; teacher and student efficacy are predictive of, and strongly correlated to student achievement. My research program has continued to further our understandings in this area (Bruce & Flynn, 2013; Bruce et al., 2010) and illustrate the relationship between high quality professional learning opportunities, teacher efficacy and student achievement. The most persuasive type of experiences that influence efficacy is what we call *mastery experiences*. When a student learns something in mathematics that is challenging, and feels a boost of confidence because of this experience, that student has a mastery experience. He or she thinks, "I can do this! I am capable of learning math! And when I try hard, it pays off." When the teacher see's this student having a mastery experience, the teacher thinks, "I just set that student up for success. I gave her/him a challenging task and the student persisted through to success. That student now understands the math concept we are learning about. I am a great teacher!" It is this cycle of mastery experiences, occurring over a sustained period of time, that increases both student and teacher efficacy.

In my research program, we are learning: (i) that children are far more capable than we give them credit for in terms of their mathematics thinking, and (ii) that spatial reasoning and visual affordances in low and high tech environments are key to unlocking mathematics ideas for students, including in difficult to teach/difficult to learn content areas such as algebra and fractions (see Math for Young Children project at www.tmerc.ca; Fractions project at www.mathgains.ca; Beatty & Bruce, 2012).

2. How are teachers supported through professional learning to make a more substantive difference for student learning? Please give an example that touches on the importance of teaching fractions and how teachers can be supported in this area of professional learning.

I have been evaluating a range of models of teacher professional learning (PL) since 2006, continually asking two questions: What are the characteristics of high quality mathematics professional learning? And how do we know they work/have a positive impact? To summarize findings from the first question,

Table 1 (adapted from Bruce, Flynn & Stagg-Peterson, 2011) helps to characterize models of professional learning that have proven to be more effective in supporting that golden combination of teacher *and* student learning.

Generally Less Effective	**Generally More Effective**
Expert or leader directed, with imposed goals and expectations	Collaborative in nature, with shared goals and expectations (alignment and agreement)
Learning environments that are primarily outside the classroom and require translation by educators to the classroom	Classroom-embedded learning where the primary site of inquiry is the classroom context (requires an opening of doors, and shared risk-taking)
Short, workshop oriented session(s) or meeting(s) that gloss over the mathematics content	Cyclical: Iterative and sustained inquiry that focuses on key mathematics ideas and content
Deficit orientations toward educators and/or students ("fix-up" models)	Constructive: Asset orientations toward educators and/or students (What *can* students do? And what more can they learn?)
Disengagement, mistrust and resistance to evidence are high amongst members of the group	Committed: Trust, ethic of care and accountability are high amongst members of the group

Table 1. Characteristics of less and more effective professional learning models

To answer the second question, "How do we know that the PL model is working?," we examine student outcomes and teacher learning. As an example, I will turn to the fractions research that I have been doing with my Trent Mathematics Education Research Collaborative (TMERC) staff, in collaboration with the Ontario Ministry of Education (and funded by SSHRC for digital data collection and analysis innovations). This project involves engaging in cycles of collaborative action research with teachers and researchers who share a mutual interest in improving student understanding of fractions (their meaning and their use). Teachers in the project select an area of particular concern or challenge in the content area of fractions learning and we dwell on that area for a sustained period of time (at least 6 months), using an asset orientation to student learning. As part of this process, the teachers on the team are punctuating the learning of fractions throughout the school year, rather than treating fractions as a 'unit of study'. This decelerated and cyclical approach enables teachers to think about fractions with their students in a deep, integrated and on-going manner. This is important given the central role that fractions and proportions understanding plays in administration of medications, engineering design, construction, arts-based and chemistry careers, for example. Teachers in the project report that their own content learning has been high, and particular gains have been made in the types of representations being featured by these teachers – to elicit engagement of students in problem-based tasks – that have proven to be of greatest value in helping students understand fractions ideas. For example, the use of linear and set models to think about fractional situations has increased dramatically in these teachers' programs. But the students have also demonstrated strong gains in their understanding using reliable pre-post measures that are carefully controlled for difficulty (parallel items of the same difficulty).

The graphic on the left (Figure 1) illustrates one sample data set of pre-post results for students over a six-month period. The graphic on the right (Figure 2) illustrates a DRAFT summary of a tentative learning pathway based on an extensive literature review and team learning in this on-going study. The pathway is now in field-test stage in Ontario classrooms through continued cycles of *collaborative inquiry*, so that we can better understand how students might increase the depth, breadth and long-term retention of fractions ideas.

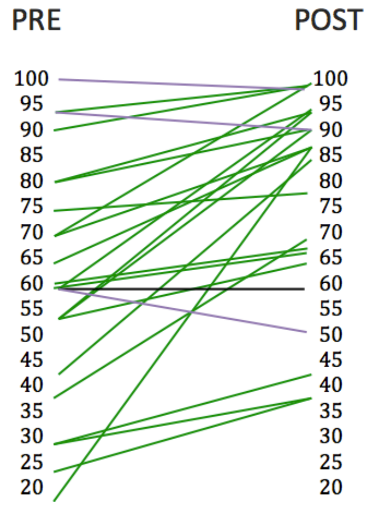

Figure 1. Pre-Post Fractions Results
Positive change
Negative change
No change

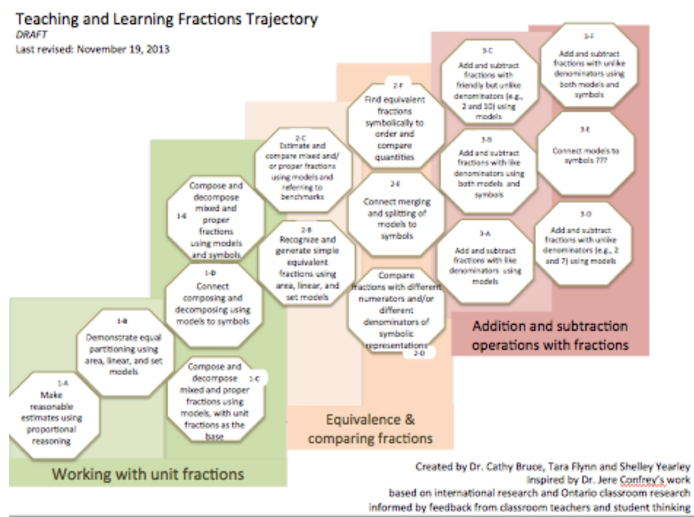

Figure 2. *Draft* fractions learning pathway, Bruce, Flynn, Yearley (2013)

During a recent PL session with teachers and math leads, I asked to interview the mathematics teachers of School A and the Grade 7 & 8 teachers of the feeder schools to School A because they seemed so passionate about their mathematics programs. In the interview, this teacher team summarized their shared goal: "Our goal is to set students up for success." Some of their professional learning strategies include: 5 years of sustained collaboration spanning Grades 7-9; self-directed and teacher-initiated professional learning goals established by the Grade 7-9 mathematics teachers; strong support from their principals; Grade 7-9 teachers meet regularly to develop continua of learning (lesson trajectories); content specific PL with a larger group and but also as a small team; Grade 8 teachers go to the secondary school to participate in Grade 9 academic classes and Grade 9 applied classes; and, finally, Grade 9 teachers come to the Grade 8 classes and teach 2 lessons to students in the feeder schools. The overlap between the teacher list and the characteristics of effective professional learning described in Table 1 are fairly well matched.

Interestingly, at School A, there has been a steady incline in EQAO scores for Grade 9 academic course students (92% at levels 3-4, 2013) and applied course students (76% at levels 3-4, 2013) over the past 5 years. EQAO is only one metric to consider, but this type of "good news story" provides further insights into the potential benefits of authentic collaborative models of professional learning. School B shares the same geographic region (only blocks away) with School A, and draws on the same community (statistical neighbours). However, in School B, EQAO scores have declined for applied courses (28% for 2013) while academic scores are relatively stable, matching those of the province (mid-80's).

When I asked the teachers of School A what they attributed student success to, they listed the following 7 features of their work:

1. A culture of collaboration (planning, communication, co-teaching, and mirroring: "It is expected: we collaborate to ensure student success…");
2. Positive attitudes about academic and applied learning (with case-by-case analysis);
3. Consistency (same team of Grade 7-9 teachers for 5 years);
4. Vested interest and *passion* for this age group;
5. A cyclical approach to the curriculum (with bi-weekly reviews and explicit circling back through strands and concepts regularly);
6. Professional pride and accountability to one another and to the students;
7. Customized, personalized, and focused instruction.

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

I am currently extending my focus on mathematics for young children (JK-Gr 2), because of its importance in closing learning gaps as early as possible, and because these students are so amazing! The Trent research team, in collaboration with the research team from the University of Toronto (Jackman ICS) are engaged in a multi-year mixed-methods tracking study to learn more about the malleability and predictive powers of spatial reasoning, as well as developing high quality and field-tested math activities that embody playful pedagogies using a design research methodology. For middle grades, I am engaged in a 3-year mixed methods study of fractions learning in order to validate and enrich a robust fractions learning pathway from unit fractions through to fractions operations. At the Bachelor of Education level, much energy will be required over these next several years to reconfigure the program, and along with that – to enhance the learning opportunities for mathematics, including specialization courses for primary/junior teacher candidates that focus on financial mathematics and statistics, mathematics for early years learners, and the integration of mathematics, science and technology to enhance learning. My continued fascination with technology-based learning affordances and knowledge mobilization strategies, including visual data displays, will no doubt play a large role in all of this work.

References

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Trent Mathematics Education Research Collaborative: go to www.tmerc.ca