

A Forum for Action – Effective Practices in Mathematics Education
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Background

My research into mathematics education has a teacher practice focus. The goal is that through understanding teacher practice from the time of preservice learning into, and throughout, inservice learning improvements to teaching can be pursued ultimately benefiting student learning of mathematics. Three particular questions guide my study and inquiry into teacher practice. The first two questions represent my own individual research efforts; the third question has become a collaborative research effort with education colleagues.

1. What is the nature of teacher efficacy and its sources, and the potential influences such as locus of control, teacher concerns, and teacher orientation, and how do these work together and impact teacher learning and hence teacher practice?
2. What is the nature of the mathematics discourse teachers bring to their learning, and use in their practice, and what does this mean for preservice and inservice teacher practice (e.g., improving student learning in classroom contexts)?
3. With respect to current trends in professional learning models, such as instructional rounds, and collaborative inquiry, how are teachers negotiating these professional learning models, e.g., for contexts such as learning about Assessment for Learning?

In the background, underpinning the first two questions is an inquiry into the mathematics used for the purpose of teaching mathematics, i.e., what is the impact of a larger conceptualization of teacher efficacy, and of teachers' mathematics discourse when we think of the mathematics teachers learn and use in their classroom practice. The sense of importance to learning a particular content area appropriate for teaching in the secondary school classroom was developed from Shulman's (1986, 1987) work on pedagogical content knowledge. This work became focused on mathematics using Deborah Ball's (for example Ball & Hill, 2008; Ball & Sleep, 2007) development of mathematics knowledge for teaching (MKFT), which is currently being refined as *mathematics for teaching* (Adler & Davis, 2006; Davis & Simmt, 2006; Simmt, 2011). *Mathematics for teaching* incorporates a contextual sense to pedagogical content knowledge and mathematics knowledge for teaching by situating the concept into mathematics classroom practices.

When thinking about teacher efficacy, I have found that a larger conceptualization is needed for me to explore the richness of this teacher belief and its influences on teacher practice. This larger conceptualization of teacher efficacy incorporates teacher efficacy, a sense of control over outcomes, what teachers are concerned about, and their orientation or perspective to their teaching practice. "Teacher efficacy has been defined as the extent to which the teacher believes he or she has the capacity to affect student performance" (Berman, McLaughlin, Bass, Pauly, & Zellman, 1977, p. 137) and

was often envisioned through some combination of two prominent psychological theories; social learning theory (Rotter, 1966), and social cognitive theory (Bandura, 1977). Social learning theory and locus of control suggests a sense of cause, that teachers hold beliefs that their ability to affect and/or influence student outcomes is attributed to an internal locus of control, that is, to one's own actions and efforts, or to an external locus of control, that is, to influences outside of one's control. Comparatively, social cognitive theory considers one's actions to exercise some sense of outcome as cognitively and socially motivated, and that there is a network of reciprocal interactions that exert influence. Social cognitive theory suggests there are four sources to self-efficacy, mastery experiences, verbal persuasion, vicarious experience, and physiological and affective states. Fuller (1969) suggested teachers move through stages of concerns which may be conceptualized as a progression (Borich & Tombai, 1997; Fuller & Bown, 1975) of self-concerns (about survival) to task-concerns (about teaching strategies) to impact-concerns (about student learning). Feimen-Nemser (1990) proposed a schema of five particular orientations to one's sense of professional knowledge and practice: Practical, Technological, Academic, Personal, and Critical-Social.

Instructional Rounds in Education (IR) comes from the traditional practice of medical rounds in the field of Medicine. IR emerges from various attempts over time to improve teaching and learning, such as 'learning walks' (see Lauren Resnick and colleagues work from the Institute for Teaching at the University of Pittsburgh) and Instructional "walk-throughs" (for example see Downey, Steffy, English, Frase, & Poston, 2004; Protheroe, 2009), providing quick snapshots of teaching and what classrooms look like. On the other end of what could be considered a continuum of methods used to improve classroom teaching and learning, one could consider Japanese 'lesson study' -- a teaching and learning method for improving a particular pedagogical practice (for example, design and refine a lesson on finding algebraic solutions to a system of two linear equations). Growing out of these efforts (positioned somewhere in the middle of such a continuum) is a current trend of collaborative inquiry within professional learning communities (for example Byrne-Jimenez & Orr, 2007; Talbert, 2010, November). The importance of Instruction Rounds (IR) is its potential to build and sustain a professional culture of analysing, understanding, and improving the work of education. City et al (2009) viewed the field of medicine and its medical rounds as a "most powerful social practice for analyzing and understanding its own work" (p. 32).

Methodologies and Methods

For research into a larger conceptualization of teacher efficacy, I predominantly use a mixed methods approach. Qualitative methodologies often provide the dominant methods, and quantitative methods act simultaneously and/or sequentially. Rich and diverse data offers opportunities for deep and insightful understanding. Short answer questions and interviews provide the bulk of the data. For quantitative data two particular scales are used, one to gather the sense of locus of control (internal and/or external) that influences teacher efficacy, the Teacher Efficacy Scale (TES) (Guskey & Passaro, 1994), and a second to gather the sense of teacher efficacy as a classroom context construct, the Teachers' Sense of Efficacy Scale (TSES) (Tschannen-Moran & Woolfolk Hoy, 2001). The Guskey and Passaro (1994) scale reliably measures a teachers' sense of self efficacy from a locus of control perspective, that may more concisely be called internal efficacy and external efficacy. The TSES (Tschannen-Moran & Woolfolk Hoy, 2001) contains three subscales, efficacy for student engagement, efficacy for instructional strategies, and efficacy for classroom management, reliably measured in a short form of twelve items. The results of this scale present a classroom contextualized teachers' sense of self-efficacy that may more concisely be identified as 'teacher efficacy'. These two scales provide two lenses with which to examine and discuss a teacher's sense of self-efficacy in his/her classroom practice.

Mathematics discourse research is approached with a discursive analysis framework of linguistic, semiotic, and mathematical discourse analysis. For example, lexical chains (Herbel-Eisenmann & Otten, 2011; O'Halloran, 2005) group similar texts together and allow me the opportunity to follow a specific idea as it moves through the entire conversation. This procedure generates a set of themes for thematic analysis, which create a global insight into the nature of the discussion. The semantic elements of language (e.g., entity, extent, meronym, and holonym) are explored through the creation of thematic maps (Halliday, 2004; Herbel-Eisenmann & Otten, 2011). This illustrates relationships amongst mathematical terms as understood, and used by mathematics teachers. Finally, the nature of intertextuality (Lemke, 1992) through a mathematical activity trace (Reid, 1995) explores the mathematical actions, objects, metaphors, analogies and explanations, as well as mathematics teachers' descriptions of other texts such as math text books and other resources. This analysis provides a sense of how mathematics teachers give meaning to the mathematical ideas they discuss.

Research into professional learning models such as collaborative inquiry and instructional rounds is currently being performed through developmental program evaluations using both qualitative and quantitative methods. Methods such as web-based surveys of quantitative and qualitative data collection, interviews and focus groups, observations of classroom practice and professional learning days, and artifacts such as teacher and student products and school board and Ministry of Education policy and practice documents provide diverse and rich data.

Results

Thinking of teacher efficacy, my results have begun to show that teacher concern appears to be a nested construct, and appears related to teacher efficacy. Low teacher efficacy may relate to expressions that consist mostly of self-concerns while high teacher efficacy may relate to expressions of impact concern. Higher Internal efficacy may also be related to expressions of impact concern. As teacher efficacy increases, teacher concerns appear to change from a single concern to a pair of concerns, such as self and task, and then to combinations of all three concerns (see Figure 1 below). Teacher orientation appears to be a complex construct that correlates with teacher efficacy more so than time itself. Low teacher efficacy appears to align with expressions of single orientations, more often the Technical and Academic orientations, and high teacher efficacy appears to align with combinations of orientations, more often including the Critical Social and/or Personal (see Figure 2 below).

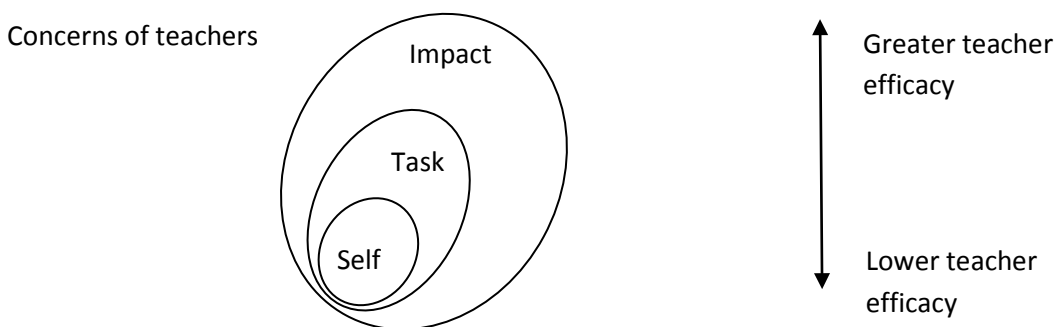


Figure 1. Teacher concerns and teacher efficacy.

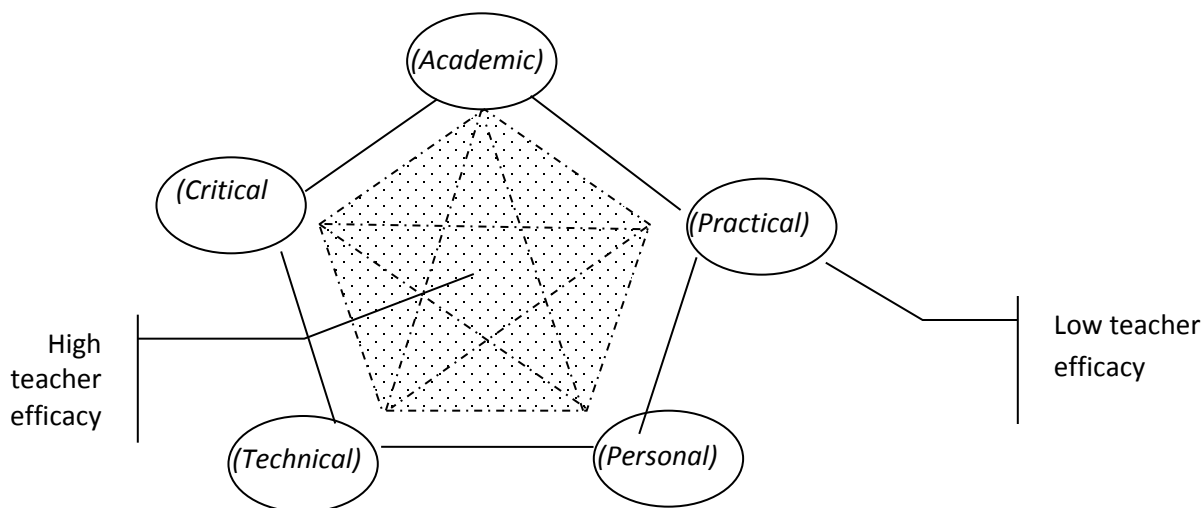


Figure 2. Teacher orientations and teacher efficacy.

Thinking of mathematics discourse, the linguistic terms used to explore and understand what teachers say and mean are presented in the following table.

Linguistic Terms		Example
Hypernym (a large set)	Hyponym (a subset)	A rectangular prism is an element of the set of prisms.
Holonym (a whole)	Meronym (a part)	A base, height, slant height are parts of the prism.
Entity (an object)	Extent (the value of measurement)	The height is the distance from the apex to the base. The height is 10cm .
Location	Located	A point inside a circle.
Process (mathematical action)		Calculating. Drawing.
Repetition		A point inside a circle, the point is at its origin.
Synonym		It is inside the circle.

The figures below show a portion of the *Rates of Change* thematic mapping space (Figure 3), and the *Rate of Change* (Figure 4) thematic mapping space from one particular study with preservice teachers. Reading these mapping spaces one can see similarities and differences. For example, from the central point of each map, identified with the pentagon, both show entities of *math* and *amount*, and both show a third entity, one of *slope*, the other of *pure math*. A sense of sets and subsets appears in the bottom left quadrant of the maps, about courses, Functions, Computer Science, or Applied and College courses. Linguistically, in the upper quadrants of the mapping spaces, the *Rates of Change* thematic map shows a distinct sense of sets and subsets with a predominance of hypernyms and hyponym, while the *Rate of Change* thematic mapping space shows a distinct sense of wholes and parts with a predominance of holonyms and meronyms.

The mathematical trace activity provided an overview of how preservice teachers were thinking of mathematical ideas and concepts. For example, in one instance, a trace followed a mathematical action of *finding a rate of change*, to the object of a *derivative*, and then to a metaphor of rate of change as the acronym *r.o.c.*, but described as *The ROCK* alluding to the athlete and actor, Dwayne Johnson, with explanations of its relevance to student learning. Another mathematical trace delineated a large section of the conversation concerning the geometry of right prisms. A third mathematical trace consisted of a teacher candidate using his practicum experience to illustrate how procedural knowledge was often a class's focus instead of an overall understanding of the concept.

Thinking of professional learning models and concepts such as Assessment for Learning (AfL), studies are currently ongoing and data collection continues. Results are not available at the moment.

Next Steps

The significance of research into teacher efficacy is the potential to connect the three constructs of teacher efficacy, teacher concern, and teacher orientation in preservice mathematics teacher preparation, and the potential for transferability of this theoretical framework and enhanced understanding of mathematics preservice teacher efficacy (see Hoy & Woolfolk, 1990) to educator efforts in the design and implementation of mathematics teacher professional learning.

For example, results suggest that teacher concern and teacher orientation align with teacher efficacy, and attention to the nature of teacher concern and teacher orientation may increase preservice mathematics teacher efficacy. Continuous assessments of teacher orientation, teacher concerns, and teacher efficacy might provide feedback for curricular and instructional decisions by professional learning providers. For example, mathematics education learning activities may be selected to appeal to the teachers' initial need for survival, content knowledge, and classroom management knowledge given common initial teacher concern, self-concerns (Fuller & Bown, 1975; Veenman, 1984), and common initial teacher orientations, Academic and Technical. An initial focus on the Technical orientation may help professional learning facilitators give teachers a set of steps or procedures for teaching activities such as graphing curves on a graphing calculator, or provide classroom context samples of definitions and meanings of terminology, or scripting lesson transitions or professional learning interactions. My initial results showed few mathematics preservice teachers, and then only those with high teacher efficacy, expressed a Critical Social orientation. What might this mean for social justice issues development and awareness with mathematics teacher professional learning programs?

Further research should be completed to more strongly articulate the relationships amongst teacher efficacy and teacher concern and teacher orientation and how teacher concern and teacher orientation act as influences to teacher efficacy (Klassen, Tze, Shea, & Gordon, 2010). For example, attention in mathematics teacher professional learning for further self-reflection and professional reflection—in action, and —on action (Schon, 1983) may improve and enhance mathematics teachers' learning of the teaching and learning of secondary school mathematics.

The lexical chains, thematic maps, and mathematical traces provided an understanding of the complexity of preservice teachers' knowledge and use of mathematics for classroom practice. In addition, this analysis provided insights into preservice teachers' misunderstandings, misinterpretations, and misconceptions of mathematics. This type of information about preservice teachers' understanding and choices of expression of mathematical concepts is important for teacher educators to appreciate in order to respond to student needs with improved program design. Furthermore, this study contributes to the growing body of knowledge and understanding of the nature of current mathematical pedagogical-content knowledge; more specifically, how it aligns with the contextual sense of *mathematics for teaching*. Many questions emerged from this study. Additionally, with further study

such as the linguistic and semiotic sense of teachers' mathematics discourse, and with consideration of other factors that influence the outcomes of teacher professional learning it is hoped that future research will begin to converge with an impact on undergraduate mathematics and undergraduate education courses and programs.

Berliner (1994) suggested that preservice teachers might not travel very far along their learning curve within the time frame of a preservice program, relative to their career as an inservice teacher. Erikson (1993) suggests there exists a continuum on which beliefs and classroom practice change, which suggests potential value of an inquiry into the changes in teacher efficacy, teacher concern, and teacher orientation over the duration of a preservice program and throughout inservice teaching. Some research has shown that teachers' perceptions of themselves, such as their concerns and orientations, does not match classroom practice (Bramald, Hardman, & Leat, 1995; Bullough & Stokes, 1994; Fung & Chow, 2002) and other research has shown teachers' perceptions of themselves does match classroom practice (Doolittle, Dodds, & Placek, 1993; Johnson, 1994; McDiarmid, 1990). As teachers' careers progress, they participate in new initiatives brought forth for the improvement of teaching and learning. Teachers experiencing continual professional learning may feel a cyclical nature to their teacher efficacy and teacher concern. These cyclical effects might also be reflected in their language use and the nature of a changing professional discourse. Such issues may be valuable to consider when selecting professional development models for teacher learning.

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