TEACHING TOWARD EQUITY IN MATHEMATICS

By

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ABSTRACT

This research is a qualitative case study examining changes in urban Canadian elementary teachers' conceptualizations of equity and approaches to pedagogy in their mathematics teaching in relation to their involvement in multiple professional learning contexts. The study focuses on four major professional development (PD) efforts in which five focal teachers participated over a school year. Data sources include researcher observations, field notes, video-recordings of PD sessions and classroom mathematics teaching, as well as a series of one-on-one interviews. Data analysis revealed three main ideas related to equity that were adopted by focal teachers: 1) the importance of developing awareness of students and their communities; 2) teaching strategies to scaffold students' development of mathematical proficiency; and 3) strategies for structuring student-driven, inquiry-based learning for mathematics. The multiple contexts of professional learning presented contradictory messages. Thus, teachers took up some ideas and left others behind and sometimes took up ideas that served conflicting goals of education. Future studies of teacher PD should focus on the teacher's perspective and the role of any individual PD within the multiple contexts of professional learning in which teachers participate.

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DEDICATION

This dissertation is dedicated to my loving parents, Mary and Brian Caswell who because of life circumstances were not able to complete high school degrees but were able to instill in their children a lifelong love of learning and a commitment to social justice.

The dedication would not be complete without a tribute to my husband, Gilbert Goldstein, who urged me to pursue my dream and whose unwavering love, support, encouragement, and positive energy (not to mention the groceries, dinners and laundry) carried me through the ups and downs of the dissertation process.

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Finally, the dissertation is dedicated to elementary school children and their teachers -with the commitment of developing quality mathematics education as a right and responsibility. And a special tribute to teachers like Rita Carlson who made such a difference in my life.

CHAPTER 1: TEACHING TOWARD EQUITY IN MATHEMATICS

"Knowledge is power, and mathematical literacy opens the door of opportunity" (Leonard, 2008, p. 160).

Since 1989, mathematics education in Canada has been influenced by the standards-based changes proposed by the (American) National Council of Teachers of Mathematics (NCTM, 2000). This reform movement aimed to make high quality mathematics equitably accessible to all students, characterized in part by the promotion of constructivist (Palincsar, 1998) experiences over rote learning. This pedagogical shift generated new teaching approaches designed to improve students' conceptual understanding, procedural fluency and strategic competence in mathematics (Donovan & Bransford, 2005). With it came the goal of high expectations and strong support for all students and the creation of a coherent curriculum rather than disconnected sets of activities in the more 'traditional' curriculum. However, twenty years later, it has become clear that the reform approach has not resulted in educational equity for many students of colour and those living in poverty (Dixson & Rousseau, 2005; Ladson-Billings, 2006; Martin, 2003). These equity issues are also a concern in Canada. What reform mathematics does not take into account is the need for curriculum that builds on the cultural and linguistic knowledge that a child brings to school. Neither does it explicitly work with students to examine issues of power so that mathematics can be used as a tool to understand the world in which students live and to promote social change.

Students' lack of success in mathematics can be seen as a form of exclusion from further involvement in mathematics in school and beyond. Doing well in mathematics has frequently been required "as a passport to gain entry into practices that enjoy a different

status in the wider society" (De Abreau & Cline, 2007, p. 125). Conversely, doing poorly in mathematics has precluded entry into many sought-after university programs and professions. When achievement in mathematics becomes a form of *gatekeeping* (Leonard, 2008; Nasir, 2007; Mason, 2006) as a barrier to higher learning and to earning potential and participation in society (Gutiérrez & Rogoff, 2003), this clearly becomes an equity issue, with equitable access to mathematics learning critical for all students.

Disparities in school achievement demonstrate the need for systemic change in the way we think about teaching mathematics. Traditional and reform methods of teaching mathematics need to be revisited, reconstructed and reinvented to ensure increased engagement and participation by students typically underserved by the educational system. In response to this realization, mathematics education is changing to promote equity. But what does equity in mathematics mean and what would a mathematics program look like with equity as its focus? A growing body of research in the United States is examining culturally relevant teaching (Leonard, 2008, Demmert &Towner, 2003; Howard, 2003; Lipka & Adams, 2002; Ladson-Billings, 1995) and teaching for social justice and equity in mathematics (Lubienski, 2008, 2000; Moses & Cobb, 2001, Gutstein, 2006, 1997; Gutiérrez & Rogoff, 2003; Gutiérrez, 2007, 2008). There is further work being done in professional development related to issues of equity in education in general (Cochran-Smith, 2004) and in mathematics in particular (Leonard, 2008, Kitchen, 2007) to support change in teachers' practice.

In order to transform teacher practice, change needs to occur within schools and within professional development (PD) programs in order to prepare teachers to meet the needs of a diverse student population. In the literature, there have been many studies

focusing on the implementation and impact of single PD efforts, but surprisingly few if any have examined the multiple contexts of professional learning in which teachers are involved. Because many teachers participate in multiple PD efforts during a single school year, individual PD programs cannot be considered as separate from the rest of a teacher's professional life.

My research addresses this problem. I draw on grounded theory and ethnographic methods to study elementary teachers who are working collaboratively toward a pedagogy of equity in their mathematics teaching in an urban inner city context. The purpose of my study is to reveal how mathematics and equity are conceptualized and practiced as teachers learn to teach for equity through their participation in professional learning communities. This study also targets a gap in the field of culturally relevant mathematics teaching and equity-focused teacher education, namely that in Canada, less research is being conducted in this area and what has been done focuses mainly on relatively homogenous, Aboriginal and rural (Nicol & Brown, 2008; Nicol, Archibald, Kelleher, Brown, Hutchingson, Nielsen, & Owuor, 2007; Mason, 2006) rather than diverse urban communities.

My research questions include:

1. *How do teachers conceptualize equity in mathematics education, in a Canadian urban multicultural context? How do they achieve equity through their instructional practices in their mathematics teaching?*
2. *How do these conceptualizations change over time when teachers are involved in a variety of professional learning communities that focus on mathematics education, student achievement, curriculum development, and culturally relevant*

and responsive pedagogy?

3. *In the multiple contexts of professional learning, what ideas do participants take up, and which ideas do they reject as they participate in the various PD opportunities?*

This doctoral research is grounded in my work as a classroom teacher and mathematics education reformer for ten years and as a teacher educator for the past four years focusing on exploring issues of social justice, equity, anti-oppression, poverty and the integration of research-based theory and practice on behalf of change for students traditionally underserved by the educational system. I am interested in what equity in mathematics might look like for teachers in diverse, urban classrooms, and how teachers work towards equity in the context of the demands on teachers from the system at the institutional, programmatic, and classroom level. As well, I want this research to inform my own practice as a mathematics education instructor in teacher education and professional development by raising my awareness of what actually happens in schools and classrooms so that I can find practical applications of equitable pedagogies and curriculum development. As Cochran-Smith (2004) points out, "the language and critique of school-based reforming teachers are as essential as are those of university-based educators and research; and in the end, the power to reinvent teaching, learning, and schooling is located in neither the university nor the school but in the collaborative work of the two" (p. 27).

CHAPTER 2: LITERATURE REVIEW

This chapter consists of three subsections. I begin with a review of the literature around teaching for equity in mathematics. Four main themes emerge from the literature and are illustrated with a number of classroom models and research-based approaches in mathematics education that have been designed to serve the needs of marginalized youth. In the second section, I discuss the sociocultural theoretical framework used in my research. The third section examines literature around professional development in mathematics education and professional development with an equity focus.

Teaching for Equity in Mathematics: Four Themes

Four main themes emerge in the literature related to teaching for equity in mathematics and will be addressed in this section of the chapter. It is important to note that I could find no studies in Canada relating to equity and mathematics in urban, multicultural and multilingual classroom contexts. Consequently, I draw mainly on literature from the United States, which focuses on equity issues and mathematics in multicultural classrooms. This literature is important because by studying the way equity has been defined in current research, I can compare and connect teacher ideas in my study to the literature. The first theme is around the need to develop approaches to raise the *achievement* levels of marginalized students; the second theme is around providing *access* to high levels of mathematics for students who have been historically underrepresented in this area. Although a focus on access also has to do with achievement, it is different than a strict focus on raising achievement levels. For example, providing access to high levels of mathematics can mean creating opportunities for students to access language used in mathematics and also in changing the content of the

curriculum to make it more inclusive and accessible. The third theme examines the use of issues of *social justice* to provide access to mathematical ideas. The fourth theme explores the development of a *culturally relevant pedagogy* in order to reach students and to make the curriculum more inclusive. The themes will be illustrated with examples of classroom models and research-based approaches in order to examine what happens in mathematics instruction when equity is the focus.

Theme 1: Examining the achievement gap.

Much of the research in equity in mathematics grew from a response to the disparities in academic achievement among African American, Aboriginal and Latina/o students as compared to their Anglo counterparts. *Multicultural education* (Banks, 1995) advocated for teaching that cultivated "the intellectual capabilities of children from a variety of marginalized sociocultural groups" (Sleeter, 1997, p. 680). I am indebted to Rochelle Gutiérrez (2003, 2007, 2008) whose work builds a strong foundation for conceptualizing equity in mathematics. For example, one of her definitions of *equity* means not being able to predict a student's achievement based on their race, class, gender, etc. (Gutiérrez, 2007).

Examining the gaps in achievement between groups of students has raised awareness for equity in education, but caution is needed when focusing on achievement gaps. First, there can be a tendency toward 'gap-gazing' (Gutiérrez, 2008, p. 358), or looking at marginalized groups of students as somehow deficient in mathematical skills, instead of looking at what conditions led to the outcomes (Gay, 2000; Leonard, 2008) and what changes might be needed to make mathematics more accessible to marginalized students. In a deficit model of thinking, students who don't do well on standardized tests

are seen as lacking the ability or skills to succeed in school, sometimes motivating educators to give up on trying to adjust their teaching methods to reach those students. Instead, the emphasis is placed on students to conform to the curriculum rather than on teachers (and other curriculum makers) to rethink their curriculum and teaching choices.

Secondly, framing equity problems with an achievement gap lens sends "an unintended message that marginalized students are not worth studying in their own right – that a comparison group is necessary" (Gutiérrez, 2008, p. 359). The achievement gap perspective reinforces the view of "whiteness and middle-to-upper income as a norm" (Gutiérrez, 2008, p. 359), placing students other than the norm as deviant in some way. This also normalizes "the 'low achievement'… without acknowledging racism in society or the racialization of students in schools" (Gutiérrez, 2008, p.359). As McMurtry and Curling (2008) point out, "the significant new investments in education are not reaching many of the children who need the most help because long-identified barriers to learning are not being addressed" (p. 3).

Thirdly, implicit in the achievement gap analyses is the view that tests used to measure achievement are valid measures of what students know and can do. Statements equating student achievement with ability are "false on premise because performance does not equate to intelligence" (Leonard , 2008, p. 130). Even a 'good' test only tests what a student has done, not what a student *can* do. As well, it would be worthwhile to study the inherent biases in standardized tests used to create mathematics achievement scores. Gutiérrez (2008) suggests alternative forms of assessment for a clearer picture of learning as a process rather than as a static phenomenon.

Theme 2: Providing access to high levels of mathematics.

Mathematics, as a gatekeeper subject, can be seen as a border that students need to learn how to negotiate in order to access the series of codes needed to acquire power. These often inaccessible codes can keep marginalized groups out of math-related careers. Teachers of diverse student populations need to develop a pedagogy that will motivate and engage their students while teaching them what they need to know to gain access to academic and economic opportunities (Delpit, 1995; Gay, 2000; Martin, 2003; Moses & Cobb, 2001; Nieto, 2002; Sheets, 2005; Leonard, 2008). Most programs that have found substantial gains in marginalized students' learning have come from a drive for excellence, "not parity with Whites" (Gutiérrez, 2008, p. 359).

Moses developed the Algebra Project (Moses & Cobb, 2001), a form of political organizing, in response to there being no advanced algebra courses offered at his daughter's school (and in many of the high schools in marginalized communities throughout the United States). The Algebra Project bridges from students' everyday mathematical thinking to more formal algebraic thinking. Its three foundational principles include: involving families in the work of organizing local projects, organizing in the community where one lives, and empowering youth to become advocates for their own education. Moses uses creative and non-traditional methods in his curriculum planning to let students in on the 'code' or rules of the game of mathematics. For example, in a thematic unit for African American students in a Grade 4 & 5 classroom, African drums are used to explore the mathematical concepts of fractions, rate, ratio and the development of students' proportional reasoning (even though students are probably not

all African drum enthusiasts). For Moses, access also means building on students' cultural competencies. This approach reflects Delpit's (1988) argument that students must learn the rules of the codes of academic subjects through "linguistic style, communication strategies and presentation of self" (p. 283). For mathematics, this means developing conjectures and being able to communicate mathematical ideas.

The Algebra Project has raised student enrollment levels in college mathematics. Mathematics is represented as worthy of everyone's attention and helps marginalized students to see themselves as competent in mathematics and to develop the language of mathematics that mathematicians use. Delpit and Moses don't ask that curriculum itself fundamentally change, but ask how to make it accessible to more students.

Theme 3: Exploring issues of social justice through mathematics.

An area that is lacking in reform mathematics is that it "does not position students to consider power issues in society" (Gutiérrez, 2007, p. 39). This is a key component in making mathematics more equitable and accessible for students typically marginalized by the school system. Gutstein (2007) writes about the need to teach the three C's in mathematics: *classical mathematics*, which refers to formal, in-school, abstract knowledge; *community mathematics*, which refers to the knowledge people bring to school with them (includes cultural knowledge, ways of knowing, and languages,); and *critical mathematics* which is knowledge about the sociopolitical conditions of one's life, or what Freire (1970) referred to as reading the world. He changes the *content* of the curriculum and conceptualizes mathematics as a vehicle for students to "read the world" (Gutstein, 2007, p. 4) in order to understand the sociopolitical, cultural-historical conditions of their lives, communities, societies and world; and to "write the world" (*ibid*,

p. 4) in order to effect change in it. He incorporates a "problem-posing pedagogy" (Freire, 1970) and a "pedagogy of questioning" (Gutstein, 2006, p. 132) that gives students multiple ways to access the curriculum. This becomes what Gutstein calls a pedagogy of access for students.

In Gutstein's classroom, students (most of whom are Mexican American) explored issues of social justice related to their lives and are given specific mathematical tools to come to an understanding of power imbalances in society. Themes in his mathematics program include having students explore a simulation of the global distribution of wealth, a project to investigate racial profiling through concepts of randomness and probability, and assessing whether racism is a factor in the difficulties African Americans and Latina/os have in obtaining mortgages in Chicago (Gutstein, 2006). His work connects students' exploration of social justice issues, culturally relevant pedagogy and developing mathematical skills and concepts.

Theme 4: Culturally relevant pedagogy and student identity

The term *culturally relevant teaching* grew from Gloria Ladson-Billings' (1995; 1992, 1991, 1990) work in developing a theory to examine ways of confronting and alleviating "the growing disparity between the racial, ethnic, and cultural characteristics of teachers and students along with the continued academic failure of African-America, Native American and Latino students" (1995, p. 483). Her work doesn't just point to gaps, it theorizes why the gaps exist and does something to narrow them. She argues that:

> "culturally relevant teaching must meet three criteria: an ability to develop students academically, a willingness to nurture and support cultural competence,

and the development of a sociopolitical or critical consciousness" (Ladson-Billings, 1995, p. 483).

In this way, Gutstein's (2006) work reflects one of the main facets of culturally relevant teaching (CRT) which is to develop learning environments where students are able to maintain their cultural integrity and explore power dynamics so that they understand barriers to accessibility of learning (Gutstein, 2006). Gutiérrez' (2007) definition of equity includes the goal that diverse students would become increasingly able to participate democratically in society. Gutiérrez argues that culturally responsive mathematics pedagogy would build on students' cultural knowledge (which includes their language and ways of seeing the world) and connect to students' lived experiences. Such pedagogical approaches and supports in mathematics instruction (developed with and for teachers and students) would support and develop students' identities as "doers of mathematics" (Nasir, 2007, p. 132).

The development of students' classroom *identities* is intimately related to the development of their mathematical reasoning (Nasir, 2007). "According to D'Ambrosio [1999], matheracy is the first step in the students' development of an intellectual and critical posture" (Guiterrez, 2007, p.42) in which students come to see themselves and be seen as legitimate participants in the math community. Schools often reflect the culture of white, middle-class society which can lead to a disconnect between students who come from different cultures and family conditions and traditional school structure and expectations.

In the *Funds of Knowledge* research (Gonzalez, Andrade, Civil, & Moll, 2001), teachers and researchers develop and draw on knowledge of students and their communities to help students see themselves reflected in school activities. Added to this goal of community and culture is the goal to develop students' academic skills (including mathematics) in order to provide them with opportunities to have a voice in society. This access to mathematics begins with teachers interviewing parents of students and collecting ethnographic data to 'mathematize' working-class household practices into school-based mathematical skills. The emphasis on creating a link between schools, teachers, families and communities helps to validate the experiences of households where 'funds of knowledge' can be extracted, where "lived experiences can become validated as a source of knowledge", and where parents can come to "authenticate their skills as worthy of pedagogical notice" (Gonzalez, *et al*, 2005, p. 42). Funds of knowledge teachers recognize the cultural and cognitive resources that families can bring to the mathematics classroom. This approach, as well as providing access to mathematics, offers an antidote to viewing marginalized communities through a deficit lens.

In Canada, Nicol and colleagues (2007) developed a collaborative, community based participatory action research project that focused on developing relationships between the university, the Haida Gwaii Nation and school district, the Nisga'a' Nation and school district, and the Vancouver School board. In the project, teachers, researchers, elders and other community members worked collaboratively to adapt and develop materials and approaches to teaching to meaningfully incorporate Nisga'a cultural values, experiences and practices into the school curriculum. The research addresses Aboriginal

cultural ownership over the initiation, representation, and legitimacy of the research process. Projects included the collaborative creation of mapping activities.

This *pedagogy of place* or *place-based education,* which is based on the right 'to live well in the places he or she inhabits" (Gruenewald, 2003, p. 8), is rooted in relationship and place. However, place-based education does not necessarily promote involvement with socio-historical or political discussions in the community, called for in Ladson-Billings' (1995) culturally relevant teaching. There is certainly an opportunity to link the two. For example, Nicol *et al* (2007, 2008) could work with students to use mathematics to explore land claim issues that are currently in dispute in British Columbia where the work is situated.

The *"Benjamin Banneker project"* (Leonard 2008, p. 49) addresses themes of cultural relevance (e.g., the Underground Railroad, African American music, Black aviation) through children's literature and technology to engage African American students in "culturally rich problems" (p. 84) in mathematics and science. The pedagogical focus is on developing students' vocabulary in these subject areas. For example, Leonard explores the development of mathematics and science vocabulary that emerges during students' discussion of the Underground Railroad, and classroom teachers in her study help students to build mathematical and science understanding through these discussions. The teacher leads a discussion in which she clarifies or inserts mathematics and science terms into the children's conversations. Although she is building on students' background knowledge, she does not have students building their own knowledge through actually working with mathematical ideas or building on their interests to design curriculum.

In another classroom example, Leonard reports that much classroom time was spent on discussing equity issues, and on students' invented strategies and algorithms. The latter are a standards-based reform to encourage mathematical thinking and communication. However, she reports that the students didn't seem to be deepening their understanding of mathematical concepts. A number of reasons for this are possible: for example, teachers' lack of mathematical content knowledge and understanding may have caused them to have students to share strategies without linking or building on students' strategies to deepen their understanding (Shulman, 1987, 1987; Ball & Bass, 2003); or perhaps it reflects the large amount of time needed to develop deep understanding; or perhaps these teachers were mistaking the constructivist approach for a laissez-faire approach to teaching.

A common critique within the mathematics education community when equity is the focus of the mathematics classroom is, "Where's the math?" Although social justice and culturally relevant topics may be engaging for students, the criticism is that mathematical concepts may become watered down when themes of equity are the focus. Gutiérrez (2007) asserts that equity should not be trivialized in the mathematics curriculum and feels that both worlds are possible (rich mathematical content and equity). This raises the issue that professional development needs to be more explicit in combining teacher content knowledge with equity-based pedagogies.

Theoretical Framework

This research is built on sociocultural theories of learning and development, as a way to understand how teachers learn through participation in teaching and in various PD efforts. In this section, I will briefly clarify terms and theories regarding culture and

learning. Different from a developmental model of in-the-head cognition (Piaget, 1965) in which individuals learn concepts on a developmental trajectory, a *sociocultural* or *cultural-historical perspective* understands learning as inevitably embedded in cultural settings (Vygotsky, 1932, 1978). Vygotsky's theory states that human cognitive development is a socially mediated process. According to Vygotsky, social interactions, especially cooperative dialogues with more knowledgeable others, are necessary for children to acquire ways of thinking and behaving that make up a community's culture. *Culture* means ways of thinking and behaving and seeing the world. Culture, according to cultural anthropologists Bates and Plog (1990) is "the system of shared beliefs, values, customs, behaviours, and artifacts that the members of society use to cope with their world and with one another, and that are transmitted from generation to generation through learning (p7). Culture is socially constructed and changes and relates to "the multiple dimensions of the lived experiences of students" (Gonzalez, Andrade, Civil, & Moll, 2001). Because individuals participate in multiple cultural communities, culture is not static. McCarthy (1995) argues that a person's culture cannot be reduced to characteristics that are static because individual identities are constantly being constructed through the intersection of racial, class, gender, ethnic and other experiences.

Vygotsky argued that such social interactions are more than simple influences on cognitive development – they actually create people's cognitive structures and thinking processes. Therefore it is important for curriculum to build on students' lived experiences to create cognitive learning pathways. There are always variations *within* groups, as well as *between* groups (Nasir & Cobb, 2007). This is why it is important in research to study the "shifting and relational nature of culture" (Boaler, 2007, p. 27).

One way to understand 'culture' and the relationship between culture and learning is based on the concept of communities of practice (Wenger, 1998). Communities of practice are at the center of *situated learning theory*, a social learning theory built upon trying to understand how people negotiate meaning. In this theory, learning is a process that involves active social participation in the varied communities of practice in which people have membership and through which they develop practice-linked identities. Communities of practice are "groups of people who share a concern, a set of problems, a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger, McDermott, & Snyder, 2002, p. 4). Teachers at a particular school form a community of practice because they share an interest in teaching children (i.e., a shared learning enterprise) and they "engage in discussion and activities, helping each other and sharing information" and are "commonly focused on a particular topic" (Buysse, Sparkman, & Wesley, 2003, p. 266).

In this study, equity served as a point of focus around which to organize meaning. Teachers shared three dimensions of practice which according to Wenger make up a community of practice: "mutual engagement, joint enterprise, and a shared repertoire" (Wenger, p. 73). Mutual engagement refers to the development of relationships among the teachers in this community and the ways they engaged in developing their conceptions of equity. Joint enterprise refers to their struggle to understand what equity in mathematics might mean and look like. Developing a shared repertoire refers to how teachers produced artifacts and tools or invented new terms relating to equity and how they took up or dropped ideas as they tried to achieve equity in their teaching practices.

This study examines the process of teacher learning that occurs through shared practices that emerge and evolve when teachers strive toward the common goal to teach more equitably in mathematics. As a community of practice, the teachers developed a shared set of instructional practices and pedagogical knowledge around equity and mathematics teaching, and learning comes through experience and interaction within the context of their community of practice.

Situated learning (Lave & Wenger, 1991) is a powerful framework that recognizes that learning is often reflected in the renewal and production of useful knowledge, rather than the internalization of a set and pre-existing "truth." From a sociocultural perspective, the practice of teaching abides in a complex system that is historically, politically, and socially situated. Participation in multiple contexts shapes what teachers teach, how they see themselves and how they make meaning of their work. A community of practice develops routines, artifacts, practices, symbols, slogans, histories and stories. In this way, the theory moves us away from thinking of teaching as an individual act. The community of practice makes available for teachers certain ways of talking about and doing things.

An understanding of learning as situated in communities of practice allows the researcher to consider both explicit knowledge – what teachers verbalize about their teaching practice – and the tacit knowledge that undergirds their day-to-day action in the classroom. Both what teachers say, and what they do, reflect their learning. As Little (2003) points out in her study of teachers learning communities: "The ongoing talk both conveys and constructs what it means to teach and to be a teacher, and to do so in this school, with these students and among these colleagues" (p. 937).

Professional Development (PD)

In this section, I review professional development in two separate areas: in mathematics education and PD related to equity.

PD in mathematics education.

In recent research on teacher professional development (PD), there has been an emphasis on supporting the development of a school community (Westheimer, 2008), engaging with artifacts from practicing teachers' classrooms (Borko, Jacobs, Eiteljorg, & Pittman, 2008), and supporting an inquiry stance toward teaching rather than specific training in a particular approach (Sherin, 2007). Also important is for teachers to work collaboratively to find ways to make students' mathematical thinking visible, to draw on their lived experiences, and to explore how teaching and learning play out in local contexts (Foote, 2010).

In professional development sessions in a follow-up to *Funds of Knowledge* research, teachers met to explore how to integrate different content areas and required curriculum, assess children's learning, and how to bring mathematical knowledge from the home to the classroom(Civil, 2007). Instructional units were grounded in students' interests and experiences, emphasizing inquiry based learning and a participatory approach to include children's sharing of ideas. Civil examines the tension between preserving the purity of the Funds of Knowledge (FoK) approach when it is implemented in the classroom context. Civil found that a focus on students' interests and themes in the FoK approach could at times water down the mathematical concepts because they were only touched on superficially. Again, this highlights the tension between mathematics

concepts and equity and raises the issue of what teachers and researchers view as what counts as mathematics.

Compared to other curriculum areas such as language arts and social studies which are often integrated, mathematics remains typically a stand-alone subject in many classrooms. This approach to mathematics teaching is difficult to change, as demonstrated in a study of the effects of professional development around multicultural education (Sleeter, 1997). In this study, teachers had a very difficult time thinking about mathematics as anything but a stand-alone subject.[1] This could have to do with mathematics being placed in the 19th century at the top of the curriculum hierarchy by August Comte[2] where it was seen as elite knowledge.

PD with an equity focus.

Professional development and teacher education that help teachers develop critical perspectives about their identities and that allow them to reflect and develop their own cultural awareness often result in equitable classroom practices (Nieto, 2002; Delpit, 1995; Gay, 2000, Leonard, 2007). Although these new approaches have been documented in the literature, what usually happens in PD is that teachers are expected to *adopt* how-to strategies rather than work collaboratively to *build* pedagogical knowledge, curriculum, and effective instructional strategies (Schwartz & Fischer, 2003). As well, any PD that works with issues of equity needs leadership in schools that encourages and supports collaborative discussions of difficult issues in teaching and to build trust

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[1] Sleeter found that it took teachers two years to begin to incorporate strategies such as cooperative learning into their mathematics teaching. Even though cooperative learning doesn't mean integrating subject areas, it does provide a structure that has been used to integrate other subject areas.

[2] A founder of sociology.

amongst participants through long-term commitment and the message that issues are not cut-and-dried (Pollock, 2004).

In this chapter, I described accounts of classroom practices and teachers who are working toward (and in some cases successfully) helping marginalized students gain access to mathematics. Rather than having effective instruction happen sporadically in a handful of progressive teachers' classrooms, it is important to make a concerted effort to identify what is needed in professional development. Because few studies on mathematics education in schools move beyond access and achievement (Gutiérrez, 2008), my research includes an examination of professional development with a focus on effective teaching interventions and provides rich descriptions of learning environments for marginalized students (Atweh, 2004; Skovsmose & Borba, 2004; Gutiérrez, 2008).

Many of the research-based examples and approaches outlined in the previous sections take place in classrooms that were not as culturally diverse as those in Toronto's inner city schools. My study addresses this gap. I want to examine how supportive learning communities arise and are nurtured and how teacher change for equity is supported through collaboration (Cohen, 2004). Most studies of PD look at one specific PD only while I am focusing on experiences of teachers as they went through multiple different PD programs in the same academic year. I will be looking at how the multiple contexts of professional learning communities engage teachers in tasks that are both meaningful to the participants and accessible to their current understandings (Stein and Brown, 1997). Teachers need to be encouraged to see themselves "as researchers, reformers, and reflective practitioners responsible for critiquing and creating curriculum,

instruction, forms of assessment, and the institutional arrangements of schooling" (Cochran-Smith, 2004, p 29).

CHAPTER 3: RESEARCH METHODOLOGY

The focus of my research is a qualitative case study of elementary teachers who were working collaboratively toward a pedagogy of equity in their mathematics teaching. I investigated the major forms of professional development at their school and considered teachers' opportunities to learn in and across all of the various PD contexts. The purpose of my study was to reveal the process and implementation of what it means to teach for equity in mathematics. My research questions included:

1. *How do teachers conceptualize equity in mathematics education, in a Canadian urban multicultural context? How do they achieve equity through their instructional practices in their mathematics teaching?*
2. *How do these conceptualizations change over time when teachers are involved in a variety of professional learning communities that focus on mathematics education, student achievement, curriculum development, and culturally relevant and responsive pedagogy?*
3. *In the multiple contexts of professional learning, what ideas do participants take up, and which ideas do they reject?*

Rationale

I chose case study research methodology to study the issue of how a group of teachers in a "bounded system" (i.e., the professional learning community and classroom context) took up the idea of equity in their mathematics teaching. Because my study was guided by a Communities of Practice framework, the unit of analysis was the group of

teachers in this community of practice rather than individual teachers (although I refer to specific teachers to highlight my findings). The group of teachers is the unit of analysis because I was interested in learning how the community developed – how their discussions about equity and their teaching changed – over the year. My research studied teachers' practice in order to create a case study or "cultural portrait" (Creswell, 2007, p. 72) of what it means to try to teach more equitably in mathematics.

Neuman and Kreuger (2003) define qualitative research as "the systematic analysis of socially meaningful action in order to arrive at understandings and interpretations of how people create and maintain their social worlds" (Strega, 2005, p.78). The strength of qualitative research is to create a more complex picture of what is going on within "culture-sharing groups" (Creswell, 2007, p. 71) and in "participant settings" (Goodwin and Horowitz, 2002, p.44). Qualitative methodologies or *interpretivism* (Strega, 2005, p. 206) search(es) for understandings rather than facts about the social world and social beings. This was important in my study because at present, there is a scarcity of research around teaching for equity in mathematics in Canadian classrooms.

I also drew on grounded theory (Strauss & Corbin, 1994; Charmaz, 2003) because it is about making discoveries about the world one studies, and about "pursuing these discoveries to construct an analysis" (Charmaz, 2003, p. 48). This worked well because equity in mathematics education is a relatively new concept that has received little attention in elementary school classroom research in Canada. In grounded theory, "researchers are part of what they study, not separate from it" (Charmaz, 2006, p. 178)

which allows for learning from the participants in the study and from their interpretations as well as the interpretations made by the researcher.

I report on the teachers' involvement in the various learning contexts (both the PD and their classroom mathematics teaching). This long-term involvement is an element of qualitative research that allows access to the rich details and components of social life (Goodwin and Horowitz, 2002). This methodology fits well with my study because I was able to become immersed in the context of teaching which provided a sense of place allowing me to "inscribe the detailed, context-sensitive, and locally informed field notes with which to begin to study patterns and emerging themes and meanings through social interactions" (Geertz, 1973, in Emerson *et al*, 1995, p. 8).

Developing a reflexive stance

Qualitative research is mediated by the researcher's experiences and points of view and theoretical perspectives but these are also shaped by the relationships formed with the people whose social world one is trying to understand (Denzin & Lincoln, 2000; Creswell, 2007). Emerson, Fretz, & Shaw (1998) describe the importance of working alongside and getting to know the participants involved and the setting. My past experience as a teacher helped me acknowledge the complexity of the life of a teacher and the multiple demands placed on them, and this helped build rapport with teachers in my study. I noticed that because I was somewhat of an 'insider' (Glaser & Strauss, 1967), teachers seemed comfortable in speaking with someone they felt understood the system.

I draw on ethnography because it creates rich and detailed data or thick descriptions (Geertz, 1973; Emerson, *et al*, 1995; Denzin, 1989; Cresswell, 2007), which

include written descriptions by researchers, personal experiences or accounts, and participant observers' transcriptions. This is an appropriate methodology for this context because I wanted to reveal teachers' philosophical and pedagogical stances. "The key idea behind qualitative research is to learn about the problem or issue from participants and to address the research to obtain that information" (Cresswell, 2007, p. 39). Since the goal of qualitative research is not directed at establishing a definitive "truth" (Charmaz, 2003, p.28) about an external world, but at the continual improvement of existing theory, I used both the interview protocol as well as open-ended questions with teachers to get at the complexity of the choices and actions that they made as well as their thoughts and feelings that may not be clear in regular conversation.

However, as an 'insider,' there is the potential to bias the findings. I tried to be mindful throughout each part of the process, trying to consciously remain open to what the data was saying rather than what I wanted it to say or shaping and shading it by my own experiences as a teacher. It was important to recognize the hierarchies of power in the research site and to admit that as a researcher I brought an agenda to the research and that my involvement had an influence the research (Cotterill, 1992; Burowoy, 1998). One of the challenges was to hear "the voices of participants" (Creswell, 2007, p. 37).

Charmaz (2003) discusses how the interaction between researcher and the researched *produces* the data. It was important in my study to become self aware about how and why I was gathering data and how I interpreted teachers' actions and words. I tried to take a self-critical, "reflexive science" (Burowoy, 1998, p. 5) stance and to address "the reflexivity of the research" (Creswell, 2007, p.37), by noticing and

acknowledging my own biases and values and "bracketing" (Strega, 2005, p. 207; Creswell, 2007, p.59) these to keep them separate from the information being gathered in order to try to correctly interpret the research. I constantly went back to the data to confirm and potentially disprove my findings.

The School

The school is located in a large, urban Canadian city in what is referred to by the city's mayor as one of the city's high-needs neighbourhoods. During the year of the study, the school had 450 students in kindergarten to Grade 5. Within the school and family population, there were 30 languages spoken and 35 countries represented. The school received extra funding from the school board because it was identified as underperforming in provincial literacy and numeracy scores. As well, the school was one of seven schools in the board that was provided with extra funding for professional development programs to help provide academic and social support to the families and communities. Further support was included for early years, after-school programs for recreation, tutoring and homework, mental and physical health needs, newcomer settlement support, parent outreach and education, and community partnerships.

Participants

Prior to this project, I had been involved with teachers at the school in a one-year PD pilot project called the Radical Math Study Group. Once a month, I worked with a university professor and another graduate student along with the teachers in the school to develop and implement inquiry projects in which they investigated issues of equity in their mathematics teaching. This earlier work provided a foundation of rapport with the

principal and the teachers in the school. I had planned to continue this PD with the group of teachers the next year as the major part of my dissertation research, but there were three new PD sessions implemented in which teachers were expected to attend: a school-university partnership pilot seminar project that focused on culturally relevant and responsive pedagogy (CRRP), an Ontario Ministry of Education mandated Teaching-Learning Critical Pathways (T-LCP) model, and the Junior Undiscovered Math Prodigies (JUMP) PD. Because of the additional responsibilities of participation in so many PD opportunities, the teachers requested that I support them in these other PD programs rather than adding another PD to their already full schedules.

Five classroom teachers from Grades 1 to Grade 5 volunteered to take part in my study. Their teaching experiences ranged from three-and-a-half years to fourteen years and they ranged in age from thirty to forty-five years of age. Three of the teachers were female, the other two were male; one teacher was Southeast Asian (raised in Canada) and the other four teachers were White (raised in Canada). Two of the five teachers held leadership positions within the school. Because of the theoretical framework of situated learning that frames this study, the unit of analysis was the group of teachers rather than individuals.

Tracey, Grade 1 Teacher.

Tracey, a White female, taught Grade 1 and had 19 students. She taught mathematics four to five afternoons a week for 45-minute periods. Although she had seven students with identified special needs, Tracey had no assistant during her mathematics teaching time. She had been teaching for ten years, all at this particular

school. She started her career teaching in special education, then moved to Grade 3 This was her first year teaching Grade 1. Previous to becoming a teacher she worked for a tour company and then taught English in Korea.

Stan, Grade 2/3 Teacher.

Stan, a White male, taught Grade 2/3 and had 21 students (six Grade 3s and fifteen Grade 2s). He taught mathematics five times a week for 50-minute periods. He has been teaching on a permanent contract for three and half years and previously took on a succession of long-term occasional teaching positions. He began his teaching path at 30 years of age and was 43 years of age at the time of the study.

Leah, Grade 2/3 Teacher.

Leah, a Southeast Asian female, taught Grade 2/3 and had twenty-one students (eight Grade 2s and thirteen Grade 3s, three of whom receive special support in mathematics from the resource teacher). She and Stan shared the teaching of mathematics – she taught all of the Grade 2 students, and he taught the Grade 3s. She was in her seventh year of teaching and her second year at this particular school. She had taught a range of grade levels. She came to teaching later than she planned because she couldn't afford to take a year off work to attend teacher's college, and at that time there weren't many teaching jobs.

Sally, Grade 4 Teacher.

Sally, a White female, taught Grade 4 and was in her fifth year of teaching and her first year at this school. The political climate toward teachers in the late 1980's early 1990's prevented her from pursuing a teaching degree, so there were ten years between

her undergraduate degree and her entry into teacher's college. She worked in an environmental education not-for-profit organization, then became an office administrator at a private school for boys before earning a teaching degree. She was a parent and began teaching when her daughter started high school. There were 20 students in her classroom and mathematics was a 50-minute period. This year was the first time she had English language learners in her class. Sally held Part I of additional qualifications in mathematics teaching.

Stewart, Grade 5 Teacher.

Stewart, a White male, taught Grade 5 and had twenty-nine students. He had been teaching for fourteen years, all at the particular school in the study. He taught a variety of grade levels including special education. His school responsibilities for the year included being a member of the School Improvement Committee, lead literacy teacher, the Information Technology go-to person in the school, and on the organizing team for the board's new teacher mentor cadre. Stewart was trained as an art therapist and worked in the youth justice system, then as an educational assistant in a self-contained classroom before becoming a teacher at the age of twenty-nine. He dropped mathematics in Grade 10 and described himself as having been "math phobic" until he became a teacher and began to understand underlying concepts in mathematics. He taught mathematics for 50 minutes each day.

Data Collection

The study drew on ethnographic methods of participant observation, document collection, and interviews. Over the year, I observed nineteen PD sessions in four

different PD efforts and documented these sessions through video recordings and/or field notes. I visited each participating teacher's classroom approximately six times between September and June, which totalled 30 hours of observations. I also conducted three interviews with each teacher (at the beginning, middle and end of the year) to learn more about how they conceptualized equity in their classrooms, how they achieved equity in their teaching, and how the PD supported their learning to teach more equitably.

The dissertation draws primarily on teacher interview data, which is triangulated with the data on the PD efforts themselves, and data from the classroom mathematics teaching sessions. Primary data sources included: transcripts of three sets of interviews for each participant, videotapes, observations, and fieldnotes for each PD session, videotapes, video content logs, and observations of each of the classroom teaching sessions. Table 1 describes the data collection schedule.

Table 1: Data Collection Schedule

Data Collection Schedule			
Time	**Classroom visits/observations conducted**	**PD Session observations conducted**	**Interviews conducted**
September/October 2009	1 visit/teacher x 1hr = 1 hour x 5 visits = 5 hours	CRRP/PAR 12 hrs T-LCP 5 hrs	5 X 30 minutes = 150 minutes
November/December 2009	1 visit/teacher x1hr = 1 hour x 5 visits = 5 hours	CRRP/PAR 3 hrs JUMP 1 hr T-LCP 2.5 hrs	
January/February/March 2010	2 visits/teacher x1hr = 1 hours x 10 visits = 10 hours	CRRP/PAR 9 hrs T-LCP 5.5 hrs JUMP 2 hrs	5 X 30 minutes = 150 minutes
April/May/June 2010	2 visits/teacher x1hr = 1 hour x 10 visits = 10 hours	CRRP/PAR 6 hrs JUMP 6 hrs ICS 3.5 hrs T-LCP 1 hr	5 X 30 minutes = 150 minutes
TOTAL HOURS	6 visits/teachers = 30 hours	PD 46.5 hrs	7.5 hours

Interviews.

Over the course of the school year I conducted three interviews with each of five teachers in my study: an initial, mid-year and end-of-year interview, each of which lasted approximately 30 minutes in duration, producing a total of 7.5 hours of interview data. These interviews were video- and/or audiotaped and then transcribed. The interviews were conducted using a standard protocol as well as open-ended questions to investigate teachers' conceptualizations of equity in mathematics, how they achieved equity in their mathematics teaching (their goals and instructional practices), and challenges they found in doing so. In the final interview, an additional question was asked which related to teachers' experiences to the PD. The interview protocol (See Appendix A) allowed for consistency over the course of the year but also allowed me to pursue questions related to issues I may have observed during the classroom teaching sessions. Questions related to what challenges teachers faced in mathematics teaching, what equity and social justice meant to them and how they achieved equity in their teaching. In the end-of-year interview, I asked about which issues in the PD were most helpful to them and whether they had made any changes to their teaching as a result of activities and discussions in the PD.

The first interview took place before the PD sessions began in order to get a sense of teachers' initial conceptualizations of equity and a beginning picture of the classroom context.

The second interview, a Stimulated Recall Interview, took place after videotaping a mathematics lesson in each of the five teachers' classrooms. Teachers viewed the

videotapes of their teaching session as a catalyst to discuss the pedagogical decisions they made concerning equity in their teaching (see description of each lesson and teachers' responses in the next section). This allowed me to look more closely at how teachers tried to achieve equity. The Stimulated Recall Interview (SRI) allowed teachers the opportunity to further develop their conceptualizations of equity and to comment on specific pedagogical choices. This process was invaluable because it allowed me to view teachers' enactment of equity in their practice. In this way, the Stimulated Recall Interview acted as a bridge between their principles of equity and their equity pedagogies as they faced the rewards, challenges, complexities, and contradictions in teaching with these principles in mind. In this interview it was difficult to keep separate teachers' conceptualizations, pedagogical goals and instructional practices. Each informed the other. As teachers spoke about their conceptualizations, they often simultaneously highlighted strategies they used to achieve equity. In turn, as they spoke about instructional practices they highlighted challenges to achieving equity in their teaching and this led back to further refinement of their conceptualizations. Thus, the analysis of teacher conceptualizations of equity drew on the definitions of equity that they gave, and their description of their teaching practices.

The final interview took place later in the school year, after all PD sessions had been completed. This interview repeated the questions asked in the first interview, and had an additional question that elicited teachers' reflections on each of the different PD efforts and on what they learned through their participation. The main purpose of this interview was to document any changes in the teachers' conceptualizations of equity and

to examine their reflections on the PD sessions. The final interview allowed me to delve more deeply into the kinds of affordances or pivotal moments the PD offered teachers and how the PD supported, confirmed, or developed teachers' conceptualizations of equity.

Description of mathematics lessons for stimulated recall interviews.

In this section I include a description of each teacher's videotaped mathematics lesson and a brief overview of teacher talk during each of the stimulated recall interviews. This is to give more context for later interpretation of the SRI data. More detailed analysis will be presented later.

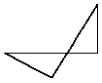
Tracey: Grade 1 - Measurement and estimation using non-standard units (02-02-10).

In this lesson, Tracey sat in a rocking chair beside an easel holding chart paper. The children were seated around the perimeter of the carpet in front of her. She began to tell a story of "Mr. Nobody", a paper figure approximately the height of the teacher. She held up a coloured marker and asked students to estimate how many markers it would take to measure the height of the figure. She accepted students' answers and used think-alouds as she recorded students' responses on chart paper. Tracey then gave instructions for the activity, telling students that they would be choosing from a variety of materials on a table to measure their assigned partners. She asked students to choose their materials and read the list of partners. She gave each pair of students a worksheet to record their findings. Pairs of students then moved to various locations around the classroom and estimated then measured their partner's height (as the partner to be measured lay on the

floor). Tracey worked with pairs of students on the carpet, asking probing questions to assess understanding, using mathematical vocabulary, and helping students where necessary (e.g., providing a number line to help them count; showing students how to use a tally to keep track of data). At times, she carried a clipboard, recording students' ideas and her own observations of their work. At the end of the lesson, she gathered students on the carpet, praising their work, asking groups to present their findings, and modeling how she 'talks' in her head to estimate measurement. She drew students' attention to the different answers they came up with, and asked them to think about why the numbers might be different.

During the Stimulated Recall Interview, Tracey focused on how she tried to 'get students to pay attention' by using a prop such as Mr. Nobody. She spoke about how most of the students made good estimates. Tracey then noted how much of her job in Grade 1 had to do with socializing students. She talked about students' reactions to groupings or children not always wanting to use the structured worksheet or placemat that she prepared for them. She focused on a section of the video where a student with autism became upset, reacting to the token economy reward system in the classroom when he didn't receive a reward. She commented on using the clipboard to keep track of students' understanding. She also commented on how she felt she had to rush through mathematics to "get it covered…I still have to get geometry in time for report cards." She also talked about getting the idea for the lesson from a PD group that was not part of the school's roster of PD opportunities, but was organized by a group of primary grade teachers from surrounding schools and was called 'Wondernet'.

Leah: Grade 2 - Polygons (02-02-10).

As children came into the classroom from recess, Leah asked them to take a seat on the carpet. There were twenty-three students in the class. Leah began the lesson by introducing a number of two-dimensional shapes which she had drawn on the white board at the front of the room. She began by asking children, "Who can tell me what a polygon is?" Students offered answers such as, "It's a shape" and one student said, "It's a shape with more than three sides." Leah reminded students that they could find examples in their JUMP workbooks. She then drew shapes on the whiteboard that were not polygons and asked children to give reasons why they would not be polygons. Students did not offer answers. When Leah called on a student, he said, "I forget." She then explained why certain shapes would not be considered a polygon (not composed of straight line segments or not a closed figure). She consulted a mathematics dictionary to find why the following figure would not be a polygon:  (because its sides do not intersect in exactly two places each). Leah then asked students for the number of sides of certain shapes such as quadrilateral, pentagon, and hexagon, moving on when children gave the correct answer. Leah then gave instructions for a geoboard activity which included an activity sheet with the names of certain shapes above images of geoboards. Students seemed excited to use the geoboards. She sent students to work at their desks which were placed together in groups. Throughout the activity, she used a variety of classroom management techniques when students were considered noisy (e.g., asking students to "Sit on your hands," raising her hand to indicate quiet, or using a musical

wand). In general, she gave students a chance to try out the activity before helping them. As the students were working, Leah remained at the front of room until students raised their hands to ask for help. Occasionally, she asked for the whole group's attention in order to check for understanding or to clarify instructions.

During the stimulated recall interview, Leah reported that her goal was for students to understand the names of shapes. She prepared for the lesson using the teacher guide that came with the mathematics textbook. She mentioned that she wanted to use the JUMP teacher's manual but had difficulty downloading it from the website. Leah focused on shapes as a way for students to access curriculum because it was something they had known and experienced throughout their lives, thus building on their background knowledge. As she taught the lesson, she realized that the worksheet had the word *quadrilateral* on it and commented that she needed to give all of the students in her class the background knowledge to understand the word because she wanted all of her students to have the same starting place. As she viewed the lesson, she commented that she wished she had made an anchor chart that listed vocabulary. She commented that she would have liked to have made observational assessments to "get in expectations for the report card." She also spoke about challenges with group work (e.g., she referred to four students in her class who were not able to sit together due to behaviour issues). She said that her equity goal was to reach all students and to make sure every student started at the same place, that the vocabulary on the page was explained, and to provide lesson extensions for those who finished early.

Stan: Grade 3 - Attributes of two-dimensional shapes (02-18-10).

As students arrived in the classroom in the afternoon from the lunch recess, Stan instructed them to sit on the carpet. He stood at the front of the room and drew their attention to a large piece of chart paper on the board that showed a number of two-dimensional shapes. He reviewed the shapes with students, asking them to name each shape and state the attributes that they learned from the previous day's lesson. Many students' hands were raised, and Stan called on a variety of students, acknowledging and building on their answers, embedding mathematical vocabulary as they responded. He gave a definition of parallel lines and demonstrated with a ruler to measure the distance between the lines. He asked students what a polygon was and students responded with answers such as "It's a two-dimensional shape with all straight sides." Students participated in choral reading from a chart that he had prepared that listed the attributes of different shapes. He then asked students to show him how to use a book to find a right angle, and called on students to come to the board to find shapes with right angles. He told students, "We're becoming right angle experts!" He kept the pace of the lesson moving quickly, calling on a variety of students by name and asking questions such as "How many right angles in a rectangle?" and "Do a line-up and see if they're right angles." He acknowledged students' answers and asked the class if everyone agreed. He occasionally reminded students to please raise their hands to answer so that it wouldn't get confusing. He seemed very aware of students who were not participating verbally and called on them for answers and to explain their thinking. He occasionally incorporated humour into the lesson to keep students' attention. For instance, he reviewed the

instructions for the game (which included names and attributes of shapes) in the style of a game show host, using a robot voice. He acknowledged student input, and extended their thinking with probing questions.

He let students know that they would be given attribute clues, and they were to act as detectives to reveal shapes. He modelled the game by saying, "My shape has three vertices" and then covered the shapes on the chart that would be eliminated by that clue. As the students eliminated shapes, Stan asked them why they made those choices (in this way assessing their understanding). At times, he pointed to shapes and asked why they wouldn't be polygons. He then instructed students to choose a shape and create their own clues. As students begin to work, Stan moved down to the carpet with them, working with individual students.

During the stimulated recall interview, Stan reported that his goals for the lesson were for students to have fun with the shapes in order to increase their participation levels and to have them develop mathematical vocabulary. He discussed how he created materials for students to work with that were "user friendly" (e.g., creating large shapes for each child to work with). He focused on students who were struggling and helped them create clues so that they could be part of the game.

Sally: Grade 4 - Data Management (02/04/2010).

Sally began the lesson by telling students how impressed she was with their work on the PAR recess graphs. She explained that the next step of the data management process was to try to make sense of the data so that they could communicate the results in the upcoming town hall meeting with the principal and vice principal. She called on

students to help her create a list of items to remember when writing up results or conclusions. She asked students to work in pairs to think about and write up their results. Sally then spent time with each group of students as they tried to make sense of the data they had collected and the graphs they had designed. For instance, she worked with a pair of boys who tried to design a question to find out "why boys didn't play with girls" or "why girls didn't play with boys." Sally guided the students to first ask how often boys played with girls, then they could do follow-up data to answer the more complicated question of why.

With another pair of students, she tried to extend their thinking so that they were articulating the results of the graphs clearly. She helped one group wrap up their findings, then moved on to the next group who had difficulty with how they were to do the conclusion piece that Sally had outlined. In this case, Sally drew on the work of students who had completed this section to use as an example. In some cases, as the students explained their results, they realized (often with Sally's help) that they needed to refine their questions and collect more data. For example, one pair of students was interested in fair use of the playground in relation to the rules for junior level students and primary level students in different areas of the yard.

During the stimulated recall interview, Sally discussed various challenges she faced during the lesson. She highlighted group work as an issue and pointed out particularly three groups of students who had difficulty focusing or understanding the instructions. Sally also spoke about how she gave students a choice in who they would work with. She wondered how best to integrate students who were absent

the previous week or missed parts of mathematics class because they received special education or English as a Second Language support. She also commented on a student whose graph was meticulous but who was having difficulty in writing up his interpretations. She also talked about high achieving students (e.g., each had a double bar graph and were able to combine data into a quadruple bar graph). She spoke about students whose graphs were ready to take to the principal and how important it was to make the graphs look 'professional'. She talked about how the goal of the project was to have students become empowered and she would be displaying the graphs in the hallway outside of the Grade 4 classroom. She also spoke about forward planning, inviting the principal into the class and talked about the possibility of having the students decide which issue they would like to pursue as a class.

Stewart: Grade 5- Introduction to Data Management and PAR projects (01/27/10).

Twenty-six students were seated at their desks. Stewart stood at the blackboard at the front of the room and introduced the unit on data management by having students "skim through pages 135 to 149 in your JUMP books." Students spent approximately seven minutes skimming, then Stewart asked students to come to the carpet in front of the blackboard. Stewart asked for input on what students found in their workbooks that related to data management. Students offered ideas such as tally charts, pictographs, and bar graphs. Stewart then walked students through how to make a graph and used chart paper on an easel to record each step.

He began with talking about the importance of labeling the graph, then reviewed parts of the graph. A student mentioned the circle graph, and Stewart responded by teaching about that graph. He asked students the difference between the circle and bar graph, and students raised their hands and offered answers such as, "It uses fractions." Stewart tried to guide students toward the use of percents but students then offered decimals as an answer. He then told students that decimals were "something as a percent" and wrote *50%* on the chart paper. Children continued to search through their JUMP books to find other examples of graphs. One student offered "a broken line graph" as an example, and Stewart read aloud a definition from the mathematics dictionary. Stewart continued to ask questions about types of graphs, and children offered answers.

He then asked what he might do to find out the students' food preferences, and as the students responded, Stewart recorded their ideas on a new piece of chart paper, writing them as steps to review for data management (1. Question 2. Gather data 3. Record data). Students asked if they could make a tally chart.

Stewart then introduced the idea of creating surveys about how "to make recess more safe." He discussed with students what made a good question and gave examples of how certain questions were biased and others more open-ended. He let students know that good survey questions offered many choices and should include the category *Other.* He put students in pairs and they began creating survey questions. Stewart guided the students in their question formulation, making suggestions and giving advice.

During the stimulated recall interview, Stewart emphasized the importance of helping students figure out what questions to ask and what some possible solutions might be to create a safer playground. He also spoke about trying to foster a classroom environment where students were able to help each other. He watched on the video to see if he was giving everyone a chance to speak and stimulating students' thinking through questioning. He also raised difficulties he had about teaching students the relationships between percents, fractions and decimals and the use of the integer line to represent decimals. As well, he reported that he was unsure how to mathematically explain certain procedures such as multiplication of decimal numbers.

Classroom Observations

Since the study focused not only on teacher perspectives about equity in mathematics, but also on how equity was achieved in their teaching practice, classroom observation was part of data collection as well. I made 30 classroom visits during the school year (6 visits to each of the five participants' classrooms), all of which were videotaped. Each video was uploaded and stored on a CD and backed up to an external hard-drive. As well, I created a video content log for each visit which involved viewing the video and creating a minute-by-minute summary of its content. This produced a total of approximately 25 hours of video of classroom mathematics teaching and 5 hours of videotaped interviews with students. I kept a journal to document the visits and to record fieldnotes. As well, I collected artifacts from these visits (samples of student work, teacher lesson plans, photographs of work in the classroom or on the blackboard, provincial test samples, etc.) to represent different aspects of mathematics teaching. The

classroom observations allowed me to refer to certain situations or to flesh out pedagogical decisions teachers had made during teaching that related to what they were saying about equity during the interviews. Because I was in the classroom, it allowed me to ask questions that made some of the tacit part of teaching more explicit. I could refer to some of these classroom conversations during the interviews in order to gain more insight and seek clarification of teachers' ideas. As well, I began to see first-hand how teachers managed the daily demands of their job.

Professional development (PD) sessions

I also attended and videotaped each PD session (except for the T-LCP in which I only videotaped one session because they involved teachers with whom I did not have permission to videotape). This produced a total of 48.5 hours of observations. Video content logs and fieldnotes were created for each session. In this section, I present descriptions of the four major PD efforts that teachers participated in during the year of the study. Table 2 outlines the major PD efforts that the teachers participated in over the course of the school year. Tables 3, 4, 5, and 6 focus on the goals and the major activities of each PD to set the context for the teachers' comments about what they had learned in and across all of the various PD contexts. Within each PD description, I include a table that summarizes the goals and activities of the PD. The summary of goals was generated from the artifacts from the PD and from review of the video of PD sessions. Some of the information in Table 2 is repeated in Tables 3, 4, 5, and 6 to provide clarity for the reader.

Table 2: Teachers' PD experiences across the school year

PD experiences	September	October	November	December	January	February	March	April	May
Teaching-Learning Critical Pathway (T-LCP)[3]	Sept. 3: Reviewed Canadian Achievement Tests' scores/Inquiry units worksheet *3 hours*	Oct. 13: Moderated marking *2 hours* (each grade team)	Nov. 2: Reviewed Education Quality and Accountability Office (EQAO) scores Post-task *2.5 hours*			Feb. 8: Pre-task planning *2 hours*	March 10 & 25:Moderated marking, part one and two *3.5 hours*	April 15 and 16: Evidence of Level 4 thinking *1 hour*	
Culturally Relevant and Responsive Pedagogy Seminar Series (CRRP and PAR)	Sept. 2: Equity Summer Institute[4] Sept. 16: CRRP: systems of oppression in society/school *3 hours*	Oct. 16: PAR training *6 hours*	Nov. 2: PAR - Mapping Recess plan with teacher candidates *1 hour*	Dec. 9: Lesson planning/social justice theme: Africville *3 hours*	Jan. 21: Exploring issues of social justice through math *3 hours*	Feb. 26: Follow-up with PAR facilitator *3 hours*	March 24: Examining school board's demographic data *3 hours*	April 21: Systems of power + *Brown eyes, blue eyes* documentary *3 hours*	May 19: School groups share PAR projects *3 hours*
Junior Undiscovered Math Prodigies (JUMP[5])				Dec. 7: JUMP intro *1 hour*	Jan. 14: JUMP training *2 hours*			April 8: JUMP demo lessons *1 hour/session*	
Institute of Child Study Laboratory School									May 19: Inquiry-based teaching/Classroom observations

[3] T-LCP – teachers met in grade level groups for approximately 2 hours/session. In-school release time was provided. The first session began in the week prior to the beginning of school and focused on the "Inquiry units worksheet" and "Questioning Circles."

[4] The Equity Summer Institute was affiliated with but not officially part of the CRRP series. Presented by the school board in conjunction with university CRRP facilitators (in the week prior to beginning of school)

[5] Junior Undiscovered Math Prodigies (JUMP) - JUMP sessions were held during lunch hour or after school except for the session in April in which teachers were given release time to observe the founder teaching in various classrooms in the school. Tracey, the Grade 1 teacher was absent for the JUMP sessions. Stewart and Stan had attended JUMP workshops in previous year.

Teaching-Learning Critical Pathways (T-LCP).[6]

Table 3: Teaching-Learning Critical Pathways (T-LCP).

Teaching-Learning Critical Pathways **PD Goals:** • Closing the achievement gap/improving students' scores on standardized tests • Develop students' "enduring understandings" through focus on "big ideas" in curriculum as well as specific expectations in official curriculum documents. • Collaborative planning amongst teacher grade level groups to create assessment rubrics, evaluation strategies based on student work samples. • Collaborative planning of lessons to guide students to higher achievement levels. **Mathematics goals:**			
	Date	PD Activity	Duration
	Sept. 3, 2009	Reviewing school's standardized test scores (Canadian Achievement Test); introduction to inquiry units; filling out inquiry worksheets; grade level teams plan initial units – decide on 'enduring understanding' for unit. Create pre-task lesson.	3 hours
	Oct. 13, 2009	Moderated marking – creating rubric to assess students' work in pre-task. Create post-task.	2 hours
	Nov. 2, 2009	Review of school's provincial standardized test scores; Bring samples of students' work in post-task to mark.	2.5 hours
	Feb. 8, 2010	Pre-task planning	2 hours
	March 10, 2010	Moderated marking, part one	1.5 hours
	March 25, 2010	Moderated marking, part two + planning post-task	2 hours
	April 15/16	Reviewer visits each classroom to look for evidence of Level 4 thinking in students	1 hour/classroom
TOTAL HOURS OF T-LCP PD			**14 hours**

The T-LCP process was a ministry-mandated collaborative professional development process in which school staff examined the school's provincial standardized test result data for literacy and numeracy, focusing on areas of growth and choosing specific expectations from the curriculum with the goal to improve overall student and school performance in those curriculum areas. The T-LCP was designed as a professional

[6] The T-LCP was inspired by the work of Carmel Crevola, Peter Hill and Michael Fullan in their book *Breakthrough* with the idea that classroom practice can be organized in a "practical, precise and highly personalized manner with the outcome being increased student achievement" (Hine & Maika, 2008, p. 16).

learning community and involved three meetings per term for each grade level group of teachers. At meetings, teachers examined evidence of student growth by using a scoring rubric to assign an achievement level score to student work. The goal of this PD was to generate professional dialogue, to develop common language among teachers for assessment of student work and to focus on curriculum development to improve student achievement.

In this study, T-LCP sessions were led by the principal in conjunction with lead teachers in the school. There were three T-LCP's during the course of the school year each involving three (and occasionally four) separate one-to-three hour meetings for each grade level group of teachers. Each T-LCP was comprised of three stages: a) setting up the T-LCP, b) checking in and grade team planning, and c) moderated marking with a review of student progress within the unit.

A. Stage One: Grade Teams set up the T-LCP

The principal established the specific curriculum expectations or clusters of expectations to be addressed based on the school's standardized test results. Teachers used a Backwards Design Template to develop common curricular content. They looked at cross-curricular expectations (in Science and/or Social Studies) to integrate subject areas into the unit and to think about which expectations might work with thematic ideas such as Environmental Sustainability or Stewardship. Teachers were required to outline the '*Essential Question'* or *'Big Idea'* for the unit that would engage students and the '*Enduring Understanding'* that they expected the students to gain. They developed criteria to form a rubric that would reflect what successful student work looked like. They

then designed the culminating activity[7] and a set of six or eight sub-tasks that would teach the skills required for the culminating activity, as well as a pre-assessment, mid-assessment and post-assessment activity[8]. Teachers then built a 'data wall' to indicate students' actual performance in relation to the curriculum expectations and to predict students' expected outcomes at the end of the T-LCP.

B. Checking In

Teachers gathered together in grade level groups (usually for three hours) to discuss results of the pre-assessment and to plan a six-week teaching block focusing on the "Big Idea' that students would be learning about. A variety of texts were chosen at this time to use with the unit. Teachers shared what they called 'high yield teaching strategies' to promote student growth (Hine and Maika, 2008) and discuss how the unit was proceeding.

C. Moderated Marking

Teachers brought student work to examine evidence of student growth and used a scoring rubric for '*moderated marking*,' assigning an achievement level score to the students' work. The goal of *moderated marking* was to generate professional dialogue and to develop continuity and common language among teachers in terms of assessment of student work and "to calibrate teachers and give a focus on student evidence in relation

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[7] "Culminating activity: this assessment will involve an authentic application of the enduring understanding inherent in the content area; and should incorporate thinking skills (reading expectations)" (TDSB document).

[8] Post-assessment: the final assessment for each TLCP involved the application of the enduring understanding in the content area to a reading task (e.g., make a connection, evaluate, give an opinion, etc.) Teachers in the study usually duplicated the pre-assessment task.

to the scoring guide, to take away their [teacher's] subjectivity" (personal conversation with school board's Achievement Officer). In this session, teacher teams (referred to as the PLC, or professional learning community) examined and 'moderated' three to five pieces of student work. Teachers placed individual student data on the data wall. They discussed next steps or possible instructional strategies for students who were not meeting curriculum expectations.

The initial T-LCP meeting (September 3, 2009) was led by the school principal and focused on an introduction of the process of inquiry using a structured process of "questioning circles" (a board-wide initiative) that included having teachers choose a specific text and identify seven key "inquiry" questions to use with students in conjunction with the text. Teachers were given a template with examples related to: text questions, reader questions, world questions, text-reader questions, text-to-world questions, reader-to-world questions, and dense questions.

The principal highlighted that the questions should be related back to the 'Enduring Understandings' that teachers had chosen as goals for student learning. Teachers reported difficulty in choosing a text that related to the enduring understandings they had chosen in science such as systems and interdependence. Each grade level group was to complete a form to be submitted to the local superintendent that included their enduring understandings (the moral issue, plus a different area for curriculum expectations), the texts they would use, and how these texts would be used. The teachers were somewhat confused by this form (Fieldnotes, September 3, 2009).

Teachers used terms such as "the moral imperative" and "enduring understandings" which were the foundation of the school's T-LCP work. In the planning

stage, the focus of conversation was on creating a statement that reflected the "enduring understanding" that they wanted the students to gain over the course of the T-LCP. Teachers spent a good deal of time tossing ideas back and forth and discussing how to incorporate literacy techniques such as questioning circles, text-to-text comparisons, etc. There was a lot of discussion around how to fill out the form/framework. Stewart, the Grade 5 teacher suggested integrating science and social studies, but another teacher in the group (not from my study) said that it would be too difficult to integrate both subject areas and the idea of integration was laid to rest. Stewart added that if they removed science from the T-LCP planning, "that isn't going to get us the science mark [for report cards]. I want the T-LCP to be a catch-all" (T-LCP meeting, October 3, 2009).

In other T-LCP meetings teachers were reminded that pre-tasks should evaluate whether or not students identified the "Big Idea" and to use supporting details to connect to this enduring understanding. "Questioning Circles" were offered again by the principal as an example of getting at the "big idea." Teachers worked to complete the form with its structured framework, adding in words and revising their questions and asking for direction as to where to insert key concepts for the proposed unit. They focused on specific curriculum expectations and Stewart suggested integrating. Teachers seemed to try to fit the curriculum into the framework of the T-LCP. The conversation moved to the study of human rights, but one teacher said, "We've done rights." They focused on other themes. Stewart talked about lack of information on Islamic cultures for the Grade 5 Social Studies unit on Ancient Civilizations. Although teachers tried to incorporate culturally relevant themes, they ended up settling on Greek and Roman civilizations because they had books related to that in the library. Looking at the

template, Stewart said, “We’ve got the essential question, now we have to get the enduring understanding.” Teachers revisited the definition of enduring understanding : “A statement that has a moral component – you’re going to have one enduring understanding but you might have a number of questions” and helped Stewart revise the form.

In other T-LCP planning meetings, teachers spent the first 30 minutes or more deciding what the enduring understanding or mission statement should be (e.g., “You reap what you sow”). As teachers planned the unit of study, they shared theme ideas which ranged from studying water, to three-dimensional shapes in structures such as bridges. Teachers also talked about trying to make the unit authentic and having students actually build bridges in the playground but this ended up not fitting into the time frame for the T-LCP. Teachers also discussed separating science and social studies so that they weren’t “putting too much in.”

Culturally Relevant and Responsive Pedagogy (CRRP) Seminar Series and Participatory Action Research (PAR) Projects.

Table 4: PD activities and goals - CRRP

Culturally Relevant and Responsive Pedagogy (CRRP) and Participatory Action Research (PAR) PD ACTIVITIES **PD Goals:** See communities as funds of knowledge, understand issues in the community, examine how positions of power and privilege and bias affect teachers’ pedagogical and curriculum choices, and how that affects students and families.			
	Date	Activity	Duration
	09/16/09	Overview of social injustices and systems of oppression in society and schools/highlighting racialized achievement gap and promoting culturally	1pm – 4pm

		relevant pedagogy to alleviate issue PowerPoint presentations and large group discussion	
	10/16/09	Initial Participatory Action Research (PAR) training	9 pm – 3pm
	10/28/09	Focus on White privilege (teachers participated in simulations such as Privilege Walk) Tim Wise YouTube video Small and large group discussion of article:	
	12/09/09	School groups shared their initial PAR projects: "mapping recess." Introduction to James Banks framework for lesson design to build social justice issues into the curriculum. Presenters used the story of Africville to design integrated unit – teachers participated in various activities – gallery walk of photos from Africville, small and large group discussions of curriculum content and systems of oppression.	1pm – 4pm
	01/21/10	Teacher candidates who were placed in the teachers' classrooms shared their equity-focused mathematics lesson plans. PowerPoint presentations and discussion	1pm – 4pm
	02/26/09	Teachers in study met with PAR trainer for follow up session. Teachers shared student work (students' surveys and graphs of recess issues) PAR trainer suggested possible next steps and mathematics extensions	1pm – 4pm
	03/24/10	Teachers worked in mixed groups to examine school board demographic data and to compare general data to their family of schools Small group and large group discussion of the implications of the data Time was given to groups to think begin to prepare end-of-year PAR presentations	1pm – 4pm
	04/21/10	Examining the language and culture of power – teachers discussed article Watched the video *Brown Eyes Blue Eyes* followed by	1pm – 4pm

		full group discussion	
	05/19/10	School groups' PAR presentations (six school groups)	1pm – 4pm
TOTAL HOURS OF CRRP/PAR PD			**24 hours**

Teachers in the study were part of a larger group of thirty teachers from six schools who participated in a seminar series on Culturally Relevant and Responsive Pedagogy (CRRP). These sessions took place approximately once a month over the course of the school year for a total of nine sessions (including those dedicated to PAR which will be discussed in the next section). The CRRP Seminar series provide a forum to: create and implement culturally relevant curriculum and resources that reflected the lived experiences of students in the school, examine participants' social identities, raise awareness of power imbalances in schools and society, investigate schools' demographic data and levels of social injustices, develop an anti-oppression framework, and to strengthen school-family partnerships. The term 'white privilege' was defined and teachers generated examples from lived experiences as well as from literature provided.

The CRRP workshops structured opportunities for teachers to develop pedagogical conversations based on dilemmas they faced in their classrooms. The seminar series provided illustrations of differentiated instruction for all social identities in classrooms, working toward an end result of improved student achievement and success. The focus was not on best practices or teaching strategies but on examining this particular community of educators' identities and beliefs as a way to provide a foundation for better understanding the lived experiences of their students. Ultimately, it was hoped that these experiences would help the teachers build connections with students' lives and value the knowledge and experience that students bring to the classroom.

PAR PD Sessions.

The CRRP Seminar series also included training in Participatory Action Research (PAR). PAR is a framework for creating knowledge where the guiding principle is that the people most affected by an issue are involved directly with the design and process of research (Fine, & Torre, 2006). The PAR process involves participants identifying issues of concern and collaborating on how to study the issue in order to raise awareness or develop critical consciousness, to improve the lives of those most affected by the issue(s) by empowering them to work toward social change and to transform underlying societal structures that are inequitable. Thus, PAR is a form of knowledge building inquiry with a focus on democratic empowerment for social change which combines forms of community building, social activism and critical analysis (Rutman, Hubberstey, Barlow, & Brown, 2005). PAR projects are situated in a variety of communities (e.g., oppressed and elite) and with a variety of participants (e.g., youth, parents, elders) from a variety of cultural backgrounds.

The initial 6-hour session provided training in the PAR process (provided by María Elena Torre[9] and Mayida Zaal[10]) and included a brainstorming session to discuss areas of concern at schools. Three follow-up PD sessions included: a) a 3-hour meeting with the larger group of teachers to share their initial work with students, b) a 3-hour meeting with the PAR facilitator to review how the project was evolving in their school, and c) a final 3-hour meeting with other school groups to share each school's PAR projects.

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[9] The Public Science Project: Participatory Action Research and Design for a Just World
[10] Montclair State University

In the initial PAR session, the presenters conveyed the idea that PAR involved a trust in students' competencies and ability to formulate questions and ideas that would then structure and support their inquiry into issues of importance in their lives. The focus of the PAR PD session was to show how youth were capable of generating, designing, analyzing and creating products that aided in changing their lived experiences. There was an emphasis on inquiry through *giving students ownership* over the design of the project which leads to *student voice* and *participation*.

In the initial one-day PAR training session, the presenters gave examples of PAR to show how a children's club in Nepal used social mapping to critically analyze the structures and decision-making process in the organization, to explore how power was exercised, and to discuss patterns of membership and exclusion and to highlight the capacity of children to come together, make decisions and enable change in their communities. The presenters emphasized "if children are allowed to do it in their own way" (PD presenters, Fine & Torre, October, 2009) their research methods often went beyond what was typically expected of children. As well, teachers were encouraged to think about their relationship to the community and to ask questions, to complicate everyday teaching practices considered "normal," and as one presenter said, "to take what is normal and disrupt it" (Fine, October, 2009).

In this initial PD session, school groups worked together to think about their own school contexts and were asked by the presenters "to think with your students about questions whose study would be important and useful work" (Torre, October 2009). Teachers in my study identified issues around recess as an area of concern. Issues included an increased number of incidents with students involved in fighting, bullying or

being hurt in the playground, or students not participating or being included in playground activities. The presenters supported the idea and encouraged teachers to work with students to generate data that could be used as a springboard to talk about issues of power and privilege. The school principal, who also attended the PD, supported the teachers' ideas of working with students to 'map recess,' with a view to explore patterns and issues around gender, participation levels by grade or how new a student was to the school or whether the student was an ELL. The teachers reacted positively and with enthusiasm about the PD and about the process of PAR with comments such as "I'm very excited that this process will empower kids" (Leah, Grade 2/3 teacher).

The second PAR PD session involved time for school groups to share the work done in the classrooms based on the initial training and to plan further projects based on the initial implementation. The third PAR PD session involved a progress meeting with one of the PAR trainers to review the research projects that were taking place in the school and to gain further insights into PAR principles. The final PAR session involved school teams presenting the work of their students in each of the projects within the larger group of teachers.

PAR was enacted in the classrooms in two ways: a) first through the introduction of a social mapping activity led by teacher candidates who were placed in the classrooms at the time of the first PAR training session, and b) secondly, PAR was enacted three months later when two of the five teachers adopted PAR's inquiry-based approach in their mathematics pedagogy through a data management unit. The data includes classroom observations and the teachers' interviews.

Junior Undiscovered Math Prodigies (JUMP).

Table 5: PD activities and goals - JUMP

Junior Undiscovered Math Prodigies (JUMP)			
PD Goals: Break mathematics down into do-able steps so that students are included in mathematics. Reach students who are typically underserved in mathematics. Close achievement gap.			
	Date	PD Activity	Duration
	12/7/09	JUMP philosophy and teaching approach was introduced by founder, John Mighton. He used Smartboard to demonstrate strategies to help students learn multiplication (e.g., patterns in the nine times table) and invited teachers to answer mathematical questions that he poses.	11:45am – 12:45pm
	01/14/10	More on JUMP philosophy and teaching: JUMP founder showed video of his classroom teaching. Provided examples of mathematical concepts that students found difficult on annual standardized test and offered techniques to scaffold students. Activities: JUMP founder presented mathematics questions and tasks and invited teachers to answer; increased participation by breaking the concept down into do-able pieces.	4:00pm – 6:00pm (dinner provided)
	04/8/10	Teachers observed JUMP founder teaching mathematics to children in various classrooms in the school Lunch hour debrief with JUMP founder. Teachers asked questions and shared some of their experiences with the application of JUMP in their classrooms.	9:00am – 10:20am 10:25am - 11:45am* 11:45am – 12:45pm
TOTAL HOURS OF JUMP PD			*6 hours 45 minutes*
TOTAL HOURS OF JUMP PD FOR PARTICIPATING TEACHERS			**5 hours 20 minutes**

* Teachers viewed one classroom session (lasting 1 hour 20 minutes)

The JUMP math program is based on the belief that every student is capable of learning math and of reaching high levels of mathematical proficiency through an abundance of practice and praise. The JUMP approach breaks mathematical concepts into manageable steps that children practice and master before going on to the next concept. Lessons are delivered to the whole class, and students are given mini successes to build

their confidence and conceptual understanding. The JUMP approach differs from a 'reform' mathematics teaching approach in that there is not an emphasis on students explaining their thinking or inventing/sharing strategies, or working collaboratively to solve problems. Instead the program uses a combination of conceptual and procedural teaching with the teacher directing students to think about patterns, teaching students tricks and shortcuts, and teaching mnemonic devices to develop computational fluency.

JUMP initially came to the school via the interest of a small group of teachers who were convinced that the improvement in the school's Grade 3 standardized test scores were due to implementing JUMP. The principal supported their interest and offered the PD to the whole school. The JUMP workshops included: a) two one-hour lunchtime sessions which gave an overview of the JUMP philosophy and provided a series of examples of math teaching using the JUMP method; b) one after school workshop, with a demonstration of how mathematical concepts could be broken down into a series of small, sequential steps, and c) an opportunity to see JUMP's founder teach students in four separate classrooms in the school. The school provided release time for each teacher to visit one classroom JUMP session.

Through the demonstration lessons with students, teachers observed a skilled educator build almost immediate rapport with students through a variety of instructional strategies to build student confidence and engagement in numeracy activities, engagement and participation, and providing continuous assessment. Teachers commented on the increased participation levels of students who were typically less involved in mathematics lessons. During the JUMP presentation, students interacted with the presenter, responding to questions posed. During this time, students did not speak

with or interact with each other. Following the presentation students commented enthusiastically about the lessons (e.g., "this was the best math class ever!").

Institute of Child Study (ICS).

Table 6: PD activities and goals - ICS

<table>
<tr><td colspan="4">Institute of Child Study Laboratory School (ICS)
PD Goals:
Provide examples of inquiry-based learning (curriculum development based on student interest and ideas) and integration of mathematics with other subject areas; to make students' thinking visible; focus on students' conceptual understanding in tandem with development of their procedural fluency.
Equity goals: Inquiry as a form of equity
Mathematics goals:
• Focus on developing students' conceptual understanding in mathematics and computational fluency
• Curriculum development that builds on student interest and ideas (idea-centred)
• Importance of making student thinking visible
• Mathematics as a stand-alone AND integrating mathematics with other subject areas such as science and language arts</td></tr>
<tr><td></td><td>Date</td><td>PD Activity</td><td>Duration</td></tr>
<tr><td></td><td>05/19/10</td><td>Teachers were introduced to ICS's principles of inquiry-based learning
Teachers visited classrooms at ICS to observe inquiry-based pedagogy in mathematics in practice</td><td>9:00 am – 12:00pm</td></tr>
<tr><td colspan="3">TOTAL HOURS OF ICS PD</td><td>3 hours</td></tr>
</table>

Teachers in the study attended a half-day PD session at the Institute of Child Study (ICS), a laboratory school affiliated with OISE. ICS's tripartite mission is to bring together graduate teacher education, exemplary educational practices, and multidisciplinary research in child development. The PD focused on ICS's inquiry-based philosophy of teaching and learning with its integration of mathematics, science, social studies and language arts to create high expectations for students. The focus of teaching is on making students' thinking visible and to make students' ideas as the focus of teaching.

This meant creating a progressive curriculum built on students' ideas and interests. The teachers were given the opportunity to visit classrooms and to observe inquiry-based teaching in action. They had the opportunity to speak with classroom teachers, to clarify pedagogical choices teachers made and to examine student work and other artifacts of practice.

Data Analysis

My goal was to gain insight and "knowledge from the inside" (Kobayashi, 2001, p. 64) about teachers' conceptualizations of equity and how the different PD made space for various conceptions. As well, I wanted to examine closely the decisions and choices they made as they tried to achieve equity in their mathematics teaching. The words and actions of the participants provided a starting place to look at how they talked about equity and made meaning of the multiple contexts of professional learning and classroom practice. Because of the theoretical framework of situated learning that frames this study, I looked for overall themes that emerged during each interview with the unit of analysis as the group of teachers rather than individuals teachers. I analyzed the data in two sections as discussed in the next sections: a) first, with regards to the interview questions related to teachers' conceptualizations of equity and mathematics teaching (what they were and how they changed over time); b) and second, with regards to the ideas taken up within each of the PD experiences. In this way, I traced the trajectory of teachers' "coconstructions within and across episodes, groups, and time" to "link the general normative disposition of a teacher community" (Little, 2003, p. 939).

A. Analyzing the interviews.

The interview transcriptions became the primary source of data for the first two research questions because they elicited teachers' reflections on equity, teaching goals, instructional practices used to achieve equity, and the challenges they faced in teaching. I used a constant comparative method (Glaser & Strauss, 1967; Strauss & Corbin, 1990, 1998; Charmaz, 2003) to code each of the three sets (initial, mid- and end-of year) of five interviews, for a total of fifteen interviews. I included relevant quotes to reflect the teachers' voice and to limit my own preconceived ideas. The research questions acted as an anchor throughout when analyzing the data. I first looked at themes that emerged in each interview *within participant and within interview*. I then compared conceptualizations of equity *between* participants to form a broader picture of what it might mean to teach for equity in a diverse urban classroom. Next, I looked for patterns of change over time *across participants and across interviews*. The conceptualizations that were shared by teachers were examined to tease out deeper details. As well, I was able to identify 'outlier' themes that were reported.

Patterns and themes identified within teachers, across teachers, within interviews and across interviews were compared and categories were narrowed, merged, or redefined. Like Kitchen (2007), I developed a working hypothesis by keeping track of similar patterns across data from all of the teachers. For each of the research questions, I used an analysis process that consisted of the following four phases, repeating the process for each interview, sifting through the data and frequently moving back and forth across participants and across interviews.

Phase One: The process of *transcribing* each interview not only immersed me in the data but alerted me to initial thoughts about potential themes which I included as observer's comments in a separate column in the margins of the text during the transcription process. As each set of interviews was transcribed I made a first broad sweep, reading the interview texts through twice to examine each of the participants' responses within the interview transcripts in relation to the first two research questions. By reading and re-reading the interview transcripts, I began to notice common themes repeated by teachers within and across interviews. I read the transcripts in their entirety, highlighting passages with similar themes.

Phase Two: Taking a grounded theory approach, I began analyzing each interview more systematically using an open-coding approach (Emerson, Fretz, Shaw, 1995; Charmaz, 2007). I created a set of codes by using line-by-line coding, searching for themes that related to equity, social justice, how it was achieved and the challenges teachers faced. This process of line-by-line coding was useful because it allowed me to look for "actions in each segment of data rather than applying preexisting categories to the data" (Charmaz, 2009, p. 47) and kept me open to possibilities and to discover ideas and subtle nuances that may otherwise have escaped me. I chose words, phrases and sentences to create initial codes to anchor my reflections. This allowed me to examine more closely what participants said and to pay attention to ideas they struggled with.

In this phase, I paid attention to *in vivo* codes, or specialized terms, "general terms everyone 'knows' that flag condensed but significant meanings" (Charmaz, 2006, p. 55). It was sometimes difficult to understand or distinguish what teachers' conceptualizations meant about equity because teachers tended to speak in generalizations, using aphorisms,

(e.g., "meeting students' needs").that allowed me to look for implicit meanings and also problematize these terms to unpack generalizations that represented mainstream interpretations of equity. These kinds of codes reflect assumptions, and "such codes anchor your analysis in your research participants' worlds" (Charmaz, 2006, p. 57). By making comparisons about how they were used, I was able to further develop how they fit or linked up with emerging categories. During this 'messy' stage, I generated a list of approximately thirty 'codes' (see Appendix B). The openness of the initial coding provided the opportunity for ideas to emerge and to spark my thinking.

The Stimulated Recall Interview was particularly useful in disentangling or teasing out these differences, and it was informative because it allowed teachers the opportunity to further develop their conceptualizations of equity while viewing a videotaped session of their mathematics teaching and commenting on pedagogical choices they made in relation to their equity goals as well as their goals for developing students' understanding of mathematical concepts.

Phase Three: The next step involved *memo-writing* and *clustering* to reduce the codes into sub-categories of concepts, or *themes*, and to generate a list of headings to compare across data contexts. I compared the lists generated for each teacher in the interviews and in the memos and began to identify concerns and ideas that were common and contradictory amongst teachers. In this phase, I had to decide which initial codes made most sense for categorizing data. Because there were a wide variety of themes that emerged, I had to decide which to use for this dissertation. For each major interview, I wrote a memo for each participant, creating an overall picture of their ideas of equity. I then went back to the data to chunk and categorize it under headings that addressed the

specific research questions, focusing on what teachers said and comparing and coding similar events and dissimilar responses. In this way the initial codes moved closer to becoming categories or themes that 'fit' with the research questions. This *focused coding* allowed me to analyze patterns in the data and to further develop common/different themes across the five participants for each of three interviews.

In selecting themes, I gave priority to what seemed important to teachers, such as ideas they repeated throughout the interviews, ideas that sparked their interest, or recurring issues or challenges that remained throughout the course of the school year. Memos allowed me to crystallize ideas in order to separate the chaff from the grain, so to speak. In this way, I identified a core set of themes and sorted the data into those themes. These consistent threads helped me identify concepts shared amongst participants and prompted me to delve more deeply into the meanings teachers negotiated in their everyday routines of teaching. In all, I reread the interview data approximately twenty times.

Phase Four: In this phase, I compared and coded similar/different themes across participants and across interviews in order to begin to define patterns and pivotal ideas in the interviews. I used *axial coding* to move from general categories to more detailed subcategories trying to reassemble the data into some form of coherence. I revisited the transcripts to see how well matched the themes were to the words. For example, the axial coding stage of the Stimulated Recall Interview helped me to abstract from the general statements teachers made during the initial interview and to tease out conceptions of equity through their teaching of mathematics with children in the classroom. I tried to tell an "analytic story" (Charmaz, 2006, p. 63) with a focus on changes/similarities over time

for each teacher, between teachers and across interviews. I continued to create analytic memos that made links between common themes and looked at outlier themes across participants and interviews.

As well, I drew on fieldnotes and video content logs to compare data contexts. I began to identify ideas that were implicit in the interviews as well as examine the explicit statements made in an attempt to make the daily routine of teaching "unfamiliar and new" (Thomas, 1993). I compared what teachers said in the interview to ideas that emerged in my fieldnotes of the classroom observations to find similar and different ideas. In grounded theory, this is seen as "the pivotal intermediate step between data collection and writing drafts of papers" (Charmaz, 2006, p. 73). As well, it allowed me to integrate themes. "By making frequent comparisons across the data, the researcher can develop, modify, and extend theoretical propositions so they fit the data" (Emerson, Fretz, Shaw, 1995, p. 143).

Coding and recoding allowed me to interact with ideas for a sustained period which was a fascinating process in which I felt immersed in the data day and night. In fact, I often awoke at night with an idea for a theme that better encapsulated the teacher talk in the interviews and in the classroom teaching data. My supervisor's suggestion of keeping a bedside research journal ensured that these ideas were not lost. Memo-writing gave me the opportunity to ask questions when reviewing and analyzing fieldnotes, sparking my memory of links between the PD sessions, classroom teaching sessions what was said in the interviews.

B. Analyzing the PD.

To analyze the PD sessions, I reviewed fieldnotes and documents to ascertain the major goals of each PD context and the major activities for teachers. I primarily drew on interview data and examined teachers' responses to following questions in the final interview:

Of the issues that have come up in the PD sessions, which are most important to you and your teaching?

Have you made any changes to your teaching because of discussions or activities in the PD sessions?

Anything you would suggest to change the PD sessions? How could they be more relevant and effective?

Using the constant comparative method described earlier, I first examined transcripts of the final interview and chunked together all responses having to do with each PD context first *within* then *across* teachers. I then looked for patterns that emerged *within each* PD and *across teachers.* This process was repeated for each PD. Through memo-writing and focused coding, I examined what ideas were taken up by teachers for each of the PD and what contradictions arose within each of the PDs. I then compared data *across PD.* I first collected all comments related to teachers' perspectives on a single PD effort into a single group; I then looked across groups to search for themes – similarities and differences in the ways the teachers talked about the various PD efforts. I selected statements that highlighted the most common assertions teachers made about what they had learned in the PD.

In order to triangulate the data, I examined video-tapes, content logs and fieldnotes of each of the PD sessions to compare the messages teachers received in the PD and what they said about the PD in the final interview. I searched for pivotal moments *within PD* for each participant in terms of ideas taken up, and how those ideas added to their developing conceptualizations of equity or mathematics teaching, especially those that had changed over time. I then examined ideas taken up that were common and those that demonstrated a contradiction or tension *across PD.* Working from the premise that dialogue is the social act of creating meaning (Vygotsky, 1978; Kobayashi, 2001) the discussions in the PD study group were important in analyzing the research.

Phase One: The interviews, fieldnotes and content logs were reviewed to constitute an initial broad level of analysis. This allowed me to form tentative ideas about emerging themes. I reviewed pivotal moments in the PD that I intuitively believed to have meaning. Rather than using preconceived codes, I constantly went back to the interview data to confirm intuitions because I wanted to ensure that they earned their way into the analysis (Charmaz, 2007, p. 68).

Phase Two: In this phase, there was a more in-depth process, working back and forth between the data, the research questions and the theoretical underpinnings of Communities of Practice (Wenger, 1998). I looked for shared ideas amongst the teachers both in the school classroom and in their professional learning context to consider their meaning within specific contexts.

As I worked on the analysis I also had the opportunity to meet with my supervisor and our research team to discuss findings that were confusing or that I found difficult to fully formulate into theoretical categories or to analyze the conceptual implications of

those understandings (Josselson, 2007). I am indebted to the conversations with my supervisor that helped me clarify both the process and the emerging themes and helped me constantly go back to the research questions and to the literature review as a way to make sense of the overwhelming amount of data to sift through.

Phase Three: I clustered the data into essential patterns and relationships amongst codes and contexts (Charmaz, 2006). I revisited understandings from previous steps and created visual images to capture the connections between the ideas that were emerging from the PD data and the teacher talk around equity, always checking back with the data set for confirmation.

Overview of Findings and Discussion

In the next chapters, I analyze the PD experiences in which teachers were involved over the course of the school year and map out teachers' conceptualizations of equity and how they changed over time (Time 1, Time 2, and Time 3 interviews) in relation to the PD.

In Chapter 4, I examined the ideas that teachers took up and rejected in the PD sessions, and the challenges they reported in trying to teach mathematics more equitably.

In Chapter 5, I described the conceptions of equity that remained constant over time as well as emerging conceptions that teachers describe. Within the chapter, I linked their reported PD experiences with the conceptions of equity that they reported on in the interviews. As well, I examined the ways teachers conceptualized their practice in mathematics. Although in the literature, divisions between conceptions of equity seem clear cut, in my research, there was overlap between categories.

In Chapter 6, I used the Communities of Practice framework (Wenger, 1998) to discuss the tensions and possibilities that teachers reported on as they tried to use the ideas from PD in their teaching. I also discussed limitations of the research and implications for further research and professional development for teachers. As well, I provided a conclusion to summarize the study.

CHAPTER 4: FINDINGS FROM PD IDEAS TAKEN UP AND/OR REJECTED FROM THE MULTIPLE CONTEXTS OF PROFESSIONAL DEVELOPMENT

In this chapter, I analyze the ideas from the various PD experiences that were taken up or rejected by teachers in relation to their developing ideas about mathematics teaching and equity. I focus on the following research question: *In the multiple contexts of professional learning, what ideas do participants take up, and which ideas do they reject as they participate in the various PD opportunities?* I examine the ways that teachers selectively took up pieces of the PD and dropped others or in other words, "the ways in which the practices of the group open up some opportunities and constrain or close off others" (Little, 2003, p. 939). At times, even within a single type of PD, a teacher could describe the same idea as both positive and negative. As Wenger (1998) points out, "understanding in practice is the art of choosing what to know and what to ignore in order to proceed with our lives" (p. 41).

The data is mainly from the final interview when teachers discussed what each PD had taught them, although I also include data from fieldnotes taken during the PD sessions. Some of the ideas that teachers took up from the PD were related to conceptions of equity (and will be discussed further in the next chapter), while others were about general issues in mathematics teaching and learning.

For each of the PD contexts, I provide a table to review the equity goals and/or mathematics goals associated with each of the PD and as well as the ideas that teachers took up and/or rejected. I examine the research question: *In the multiple contexts of professional learning, which ideas did participants take up, and which ideas did they*

reject? The PD will be examined in the order in which it occurred over the school year.

Teaching-Learning Critical Pathways (T-LCP)

<table>
<tr><td colspan="2">NAME OF PD: Teaching-Learning Critical Pathways (T-LCP)

Equity goals of PD: Raising student achievement levels in relation to curriculum expectations; reaching all students; students as agents of change.
Math goals of PD: Although the year's focus was on literacy rather than numeracy, the PD emphasized inquiry into practice through the focus on specific curriculum expectations and developing instructional strategies to introduce students to 'big ideas' in content areas with the idea of developing their 'enduring understandings.'</td></tr>
<tr><td>Ideas taken up</td><td>Ideas rejected</td></tr>
<tr><td>Focusing on big ideas and enduring understandings in curriculum</td><td>Use of collective text</td></tr>
<tr><td>Examining specific curriculum expectations</td><td>Lock-step approach to inquiry</td></tr>
<tr><td>Examining student work samples to collectively create assessment and evaluation criteria</td><td></td></tr>
<tr><td>Moderated marking as a way to help in planning for student success</td><td></td></tr>
<tr><td>Students as agents of change</td><td></td></tr>
</table>

The T-LCP PD created collaborative structures for professional learning by providing teachers with time to collaborate in grade level teams. The focus was on raising student achievement levels by choosing specific curriculum expectations (related to low scores in standardized test results), and linking them with big ideas in subject areas in order to design instruction that would improve student learning. Teachers examined student work samples to use in their planning and to develop common assessment and evaluation rubrics.

Teachers were both enthused and constrained by this PD. The comment below was typical of teachers' praise of the PD:

> "The Pathways to me are amazing because it gets everybody using the same dialogue so if a student goes from one grade to the next, they can talk about making connections. It's a commonality of language that makes learning successful for all kids and I think it's invaluable and I think it's going to show in the performance of all students" (Stan, grade 2/3 teacher, final interview).

Despite this enthusiasm, teachers struggled with participating in this PD and implementing this form of teaching. At times, teachers seemed confused about how to fill out the structured framework for the T-LCP. Although they understood the purpose of the pre- and post-tasks - "the pre-task tells where the kids are and the post tells what they can do" (Stan, T-LCP PD, October 13, 2009) - and they demonstrated familiarity with curriculum expectations (e.g., they often used terms such as "1.7" and "1.4" to refer to specific curriculum expectations from the ministry documents), they often sought guidance from the principal to clarify specific details. For instance, they seemed to find it difficult to clarify the difference between a big idea and an enduring understanding and spent much of the PD discussing this. The principal reminded them that the enduring understanding related to a more global theme, such as "what the author is trying to tell you" and gave examples which included having students look at the text from the lens of writers to think about why the author chose certain characters or behaviours. Teachers were encouraged to be consistent in what activities they did and instructional practices they chose in each of the grade level classes so that they could compare results when it

came time for moderated marking. Teachers were also reminded by the principal that pre-tasks should evaluate whether or not students identified the "Big Idea" and used supporting details to connect to the enduring understanding that the grade level team had come up with. "Questioning Circles," too, were offered again by the principal as an example of getting at the "big idea."

The lock-step approach of the T-LCP caused some frustration for teachers during the PD. For instance, Stan, the Grade 2/3 teacher (at the T-LCP, September 3, 2009) seemed resistant to using 'Questioning Circles' because as he reported, he had worked over the summer preparing graphic organizers to use with his students. There was much talk about assessment and evaluation of children's work in relation to the Achievement Level Charts. Teachers spent time discussing the difference between a Level 2 response (students' opinion) and Level 4 response (at the idea level). Rehanna (Grade 2/3 teacher) pointed out that "the material we're getting from them [students] is more superficial than the sophistication on the board" (September 3, 2009), referring to examples of students' work at various levels. At the end of the session, the principal simplified the instructions to: "Read a book, find out the big idea, and explain your thinking" (Principal, Fieldnotes, T-LCP, October 13, 2009).

Although T-LCP was developed as a literacy *and* numeracy initiative, during this school year the focus was mainly on developing students' reading comprehension skills. Stewart, the Grade 5 teacher, described how he incorporated literacy initiatives into his mathematics teaching by "getting the kids to have critical literacy skills, so higher level thinking and knowing about 'Big Ideas' [from a ministry-mandated PD]. So what I'm

trying to think about with the math, too, is how to integrate that and how to get them thinking on a bigger idea level." (Final Interview) Looking toward practices they wanted to take up in the following school year, both Tracey and Leah reported that they would like to include literacy initiatives such as guided reading groups into their mathematics teaching.

On the one hand, teachers commented positively on the way the T-LCP helped everyone to develop a "commonality of language"(Stan, Grade 2/3 teacher, final interview) and how "moderated marking helps in our planning together" (Tracey, Grade 1 teacher, final interview). On the other hand, they expressed concern that they were "so constricted" (Sally, Grade 4 teacher, final interview) and "so limited in what you can really do" (Stan, Grade 2/3 teacher, final interview) in the T-LCP program because they had to use the same themes, tasks and assessments as all teachers in their grade level group. Although the goals of the PD were to create a collaborative professional learning community that focused on the development of instructional practices for the improvement of student learning, effective forms of PD according to the literature (Guskey, 1995, 2000; Lustick & Sykes, 2006), teachers reported both positively and negatively about the experience. For example, Sally, the Grade 4 teacher, described the amount of time the T-LCP process took as a hindrance to the intent of the PD:

> "Pathway [T-LCP] is literacy-based and takes a beginning point and end point, teaching between these points and looking for progress – sounds great on paper. But in the classroom, it is an unnatural fit to what's going on. It consumes a lot of time" (Final Interview).

Teachers noted that the Ministry-mandated T-LCP prevented them from following student interests because they had to do the same activities and use the same texts as the other teachers in their grade levels. Tracey, the Grade 1 teacher commented that "I don't think all of us should have to do the same – we're all as teachers individually unique and have our own ways, and the students are different [in each classroom]" (Final Interview). In other words, once the grade level team decided on certain texts to use with their students, there was no veering off that course. Teachers saw this as preventing them from being autonomous and creative in some of their pedagogical decision-making. Thus, although the T-LCP was mandatory for teachers to follow, their low opinion of the need to teach the same as other teachers in their grade level meant that they did not carry the T-LCP process further than required. Teachers expressed frustration at feeling "so constricted" by the demands of the T-LCP to implement a prescribed curriculum which meant that teachers were "still limited to what you can really do…The enduring understanding is *this*" (Sally, Grade 4, final interview). Tracey's comment below echoes a feeling shared by her peers:

> "I feel like I teach a very prescribed curriculum. They kind of want the lessons planned *there,* and I section it up as well too so it's very prescribed: we're going to do *this*, then this, then *this.* In *this* amount of time" (Final Interview).

Junior Undiscovered Math Prodigies (JUMP)

NAME OF PD: ***Junior Undiscovered Math Prodigies (JUMP)*** Equity goals of PD: Providing equitable access to curriculum; raising student achievement levels; leveling the playing field for students; increasing student participation and engagement. Math goals of PD: Breaking mathematics concepts into incremental steps and sequences; building students' confidence and increase student participation and engagement; meeting curriculum expectations; developing students' computational fluency as a prerequisite to conceptual understanding of mathematics; importance of scaffolding and practice; use of pictures and mental strategies rather than manipulatives (which are seen as potentially distracting for children).	
Ideas taken up	Ideas rejected/issues
Develop students' computational fluency as a prerequisite to higher level mathematics	Use of teacher's guide
Scaffolding and practice	Accepting the program uncritically
Breaking mathematics concepts into incremental steps and sequences – teaching mathematics and problem-solving in steps (top down)	Tried to adapt to incorporate inquiry
Use of praise	The belief that the workbooks would solve the language issue for students who struggled or ELLs
Minimizing use of manipulatives	

According to JUMP, practice and repetition are the key to developing students' procedural fluency, to increase their participation levels in class, and to improve their conceptual understanding and standardized test results. The message of the importance of *practice* for students in learning mathematics was taken up by teachers in the study and emphasized by Mighton who often referred to research in cognitive science to support his curricular approach. For example, he argued that this research showed that "ability can be trained, and to build up basic knowledge, concepts have to be built up rigorously" and "you've got to give them [students] practice – that's the biggest thing in cognitive science, they're saying" (JUMP PD, December, 2009). He used the example of expertise

in chess to argue that "ability isn't correlated with how much time you spend playing the game, it's correlated with how much guided practice you get, playing small sets of moves, studying the moves of master players, memorizing positions and out of that derivative work emerges a love of the game, a deep commitment, intuition and an ability to see things and so on…" (JUMP PD, January, 2010).

During the PD in January (2010), teachers speculated that students' low scores in automatic recall in both the national and provincial standardized tests was likely due to lack of *practice* in computational skills. In the final interview, Stan's comment echoed the JUMP perspective when he talked about how "the brain can learn just about anything if you work hard enough at it." This linked to one of the messages in the JUMP material handed out during the initial workshop which stated that "the brain is not static; it continues to change and develop throughout life. Steady, incremental learning based on guided practice can result in the emergence of new abilities" (December, 2009).

The JUMP approach does not include the use of manipulatives but instead encourages the use of pictures and the development of students' mental strategies. As well, one of JUMP's goals was to build students' confidence by strengthening their computational skills through practice, praise, and by breaking mathematical concepts into sequential steps that would help make concepts accessible for students. As demonstrated in classroom demonstration lessons, JUMP was not strictly procedural, despite the fact that this is a common criticism against the program by the local school board. Instead, the founder of JUMP provided lessons in which conceptual and procedural knowledge co-existed. For instance, he was able to provide a sequence of activities and representations

for students (and teachers) to help them understand why the invert-and-multiply algorithm for the division of fractions works. In the literature, this particular algorithm has been highlighted by Ball and Bass (2003) to illustrate the difficulty students have in understanding it and the need for "the special kind of teacher knowledge that links content and pedagogy" (p. 4). In this way, Mighton was able to demonstrate the mathematics behind the algorithm in a way that seemed to make sense to the teachers and students.

While teachers praised the JUMP approach, contradictions arose between the messages they received and how they were actually able to implement the approach. They did not uncritically take up all of the ideas associated with this approach. They described using aspects of JUMP that they found to be effective and dropping those that they felt would not work with their students. As a result, rather than JUMP being the focus of their mathematics program, it became a component of the teachers' varied toolkit of mathematics teaching ideas and approaches.

In an email after watching the founder of JUMP conduct his demonstration lessons, Stan, the Grade 2/3 teacher said that the performance aspect of JUMP appealed to him, but "it didn't give the kids a chance to demonstrate their learning in front of the class which would help concept understanding. The tasks were done in isolation and teacher driven, which I try and steer away from as much as possible. When I teach, I also like to introduce a variety of methods that children can use to support their thinking" (April 14, 2010). What this demonstrated is Stan's ability to critically consider elements of PD that worked for his teaching and his students and those he could leave behind.

Teachers reported that the approach was most effective when they used the teacher guides provided with the program because "it weaves strands of math that are usually taught as separate units" (Stan, Grade 2/3 teacher, Final Interview). In the PD, teachers heard that "it can take time to learn how to use JUMP" and that "it's not that hard if you put the time in" (Mighton in PD, January, 2010). However, in the final interviews, teachers reported having trouble navigating the website to download the guide, while another teacher reported that it was "six hundred pages, I don't have time to read that" (Leah, Grade 2/3 teacher). Stan, the Grade 2/3 teacher agreed that, "Yeah, the teacher guide's essential, but to be really honest I don't do it all the time." In the next sentence, though, he went on to say that, "The teacher guide for the JUMP books are great because it gives you three or four different ways that you can teach it [mathematics]." Even though teachers saw the benefits of the guide, which laid out pedagogical approaches and background content knowledge for the concepts, they did not use it on a regular basis. Instead, they often relied on using the JUMP workbooks to guide their practice, to introduce a concept, and to provide a structure for students to practice skills.

Teachers focused on students' needs as a priority for deciding when and how to use JUMP. For instance, Stan reported abandoning JUMP when it seemed to confuse students:

> "I don't think I ever will use it all because some of the way that it's broken down will confuse my children. And I've done it, and I've tried it, and if they get lost in certain areas they lose sight of the big picture" (Final Interview).

The above comment reflected how teachers took a critical stance while incorporating JUMP into their mathematics teaching practice. For example, Stan made pedagogical decisions as to how much the mathematics needed to be "broken down" in relation to his goal for students to see the "big picture."

Another goal of JUMP was to reduce the amount of language currently used in mathematics textbooks. This tied in with teachers' goals to reduce language barriers for ELLs. Sally, the Grade 4 teacher, reported that JUMP had the capability of "freeing them [the students] up from excessive writing" that can occur if a mathematics program relies solely on a textbook where students become "stuck in whole writing out the questions." However, Sally went on to report that she often needed to provide extra support for ELLs during a JUMP class and that language remained a main barrier to teaching equitably in mathematics. For example, she spoke about having to devote a large portion of a particular Grade 4 lesson on division with an ELL student in order to help him understand what a 'sailboat' was so that he could answer a series of division questions about in the JUMP workbook. As Sally tried to focus on individual needs (in this case, understanding vocabulary), the mathematics was put on the back burner while vocabulary development took the lead. This highlighted the complexity of trying to meet the needs of students in order to increase participation and access to the mathematics.

One of JUMP's goals was to minimize what students needed to write in the workbooks, "so there's no information overload there's only room in the JUMP books for the kids to put in that one number" (Mighton, 01/14/2010). For some of the teachers in the study, this was also a drawback of JUMP because it did not allow students to draw

pictures, add information, or make their thinking visible to the teacher. They also described the workbooks as putting a ceiling on students' thinking. Although Sally, (Grade 4 teacher, Final Interview) reported that she "liked how the fractions were scaffolded [in a JUMP unit], she reported that when she used the long division unit, "the students really struggled with it" because the lay-out of the lessons "would only really deal with the tens." This emphasis on building Grade 4 students' understanding of the base ten system as a step toward understanding long division became, in the teacher's opinion, a source of frustration for students who already had an understanding of base ten and were eager to solve a long division question beyond dealing only with tens. This example raises the issue of the complexity of how to meet students' needs in mathematics. While students who struggle with the Grade 4 curriculum likely need to develop a stronger foundation of the base-ten system, others need challenges that extend their thinking.

Culturally Relevant and Responsive Pedagogy (CRRP) Seminar Series and Participatory Action Research (PAR)

NAME OF PD: ***Culturally Relevant and Responsive Pedagogy (CRRP) Seminar Series and Participatory Action Research (PAR)***

Equity goals of CRRP: To view communities as funds of knowledge; to understand issues of social justice in the community, school and society; to examine how positions of power and privilege and bias affect teachers' pedagogical and curriculum choices and how that can affect students and families; to raise student achievement levels; to increase student participation and engagement; and to create inclusive curriculum that reflects and draws on the cultural and linguistic knowledge of students.

Equity goals of PAR – To empower students to democratically build knowledge around issues of concern in their lives with the purpose of promoting social change.

Math goals of PD: Change content of curriculum to create inclusive, student-driven curriculum that reflects the lived experiences as well as cultural and linguistic knowledge of students.	
Ideas taken up	Ideas rejected or revised
Changing content of curriculum to connect with students' lived experiences	Student-driven curriculum
Using social justice issues in mathematics to promote social change	
Redressing power imbalances	

Although two CRRP sessions dealt directly with using social justice issues as a springboard to engage students with equity issues and with mathematics, some teachers in the final interview reported that there was little concrete connection to actual teaching practices, especially for mathematics, so teachers struggled to make these ideas manifest in their mathematics teaching. A typical comment was, "I don't feel that I came away with very concrete ideas." (Sally, Grade 4). For some of the teachers, the CRRP discussions were "not directed towards the classroom – really there to support me in the classroom" (Sally, Grade 4 teacher, final interview). Tracey wanted to see "*real* examples…seeing it in action," and stating that "I need someone to show me" (Tracey, Grade 1 teacher, final interview).

Stewart (Grade 5 teacher) described CRRP as being "too touristy" (final interview) meaning that it didn't go into the depth that he would have liked. Because each of the CRRP sessions focused on a different 'ism', teachers didn't have the chance to bring issues of practice into the PD. Similarly, in Pollock's (2004) study of talk about race in an American high school, she found that "sufficient time was rarely allotted for such discussions" (p. 220) which prevented the building up of trust amongst PD

participants. She suggests that effective PD builds time in for deep discussions that are structured to build trust amongst participants.

As well, teachers wanted more guidance in how to process conflicting sets of values with respect for differences and to deal confidently with controversial issues with students and with parents:

> "They were saying to us that we need to have these discussions in our classroom but nobody ever really got to how to have those conversations in your classroom. How to initiate them, how to deal with some of the conflicts that come up, with the parents and with the students, some ideas that might be challenged" (Tracey, Grade 1, Final Interview).

Data from the final interview showed that CRRP supported teachers in seeing students as autonomous and individual. Leah, the Grade 2/3 teacher linked her experience in CRRP and PAR with "seeing them [her students] more as complete individuals that need some guidance to shine and not trying to make them all the same." Yet in the same breath, she described how difficult it was to address students' individual needs. For example, Leah reported that to assess her students "I'm giving them a quick geometry test with faces, vertices and points… And I have the same test for everybody because I didn't have the time to go and find a Grade 3 test." Thus, teachers acknowledged the value of addressing student needs but found it difficult to implement.

PAR enacted in classrooms: Using PAR to explore Recess Issues.

PAR was enacted in the classrooms in two ways: a) first through the introduction of a social mapping activity led by teacher candidates who were placed in the classrooms

at the time of the first PAR training session, and b) secondly, PAR was enacted three months later when two of the five teachers adopted PAR's inquiry-based approach in their mathematics teaching with students developing data management skills through conducting surveys and creating graphs based on questions and issues of concern about recess or the playground.

PAR and Social Mapping Activity in Grades 1 – 5.

Building on students' concerns, teachers were interested in introducing PAR through a social mapping activity. Although they were eager to begin PAR projects, teachers felt unable to devote their planning to an inquiry-based model of teaching because of time pressures with report cards that were due that month. As Sally, the Grade 4 teacher reported, they delayed implementation of PAR "because my job is to cover the curriculum." Teachers felt constrained by having to report on curriculum expectations for three strands of mathematics (after just six weeks into the school year) and felt they couldn't give the PAR project the time it deserved. As a result, the initial PAR project was given to the teacher candidates in their classrooms to create and implement as a requirement for one of their mathematics assignments ("Exploring Issues of Social Justice through Mathematics") from the university. In consultation with the teachers, the teacher candidates introduced PAR through a social mapping activity where they asked students to visualize the playground and to think about where they played, what they were playing, and what was happening around them. Students then 'mapped recess' (using digital maps of the playground projected on a SMART Board, or large hand-drawn maps of the playground) to indicate areas where they enjoyed playing and where they

didn't. The mapping activity provided a way for students to raise issues that teachers were previously unaware of. For example, the Grade 2/3 classroom teachers were surprised about the issues students raised during the mapping activity (e.g., the fact that they didn't play in certain parts of the playground because "that's where play torture happens" or "the Grade 5s own that part of the playground" (Grade 2/3 students). As Leah, the Grade 2/3 teacher pointed out in an interview, "I might not have even thought that the kids felt there was inequity in the playground. I might not have even thought of that. Well, I don't think I even did" (Fieldnotes, December 17, 2009).

This initial activity allowed students to express their concerns about recess issues in conjunction with developing mathematical concepts such as measurement and visual spatial awareness. For example, in the Grade 1 classroom, use of SMART Board technology to project the map had interesting implications for developing and assessing students' visual spatial abilities. Tracey, the Grade 1 classroom teacher, expressed surprise that her students were able to identify landmarks such as playground areas and equipment on the map, and were also able to locate their homes and apartments in the surrounding streets on the map projected onto a SMART Board. Since this was the first time the SMART Board had been used with Grade 1 students in her classroom, she had not expected that children of this age would have this kind of visual spatial awareness (Fieldnotes, classroom observation, November 23, 2009). First grade teachers wouldn't necessarily teach this skill or teach mapping because these were curriculum expectations typically reserved for higher grade levels. And yet, through the use of technology, there was an opportunity to build on students' visual spatial skills. As well, students were

fascinated with the map and the affordances the technology provided, such as being able to record their ideas as an overlay onto the map.

In the Grade 2/3 classrooms, teacher candidates (in collaboration with the classroom teachers) built on the mapping activity to investigate perimeter and area with students through the use of standard (e.g., trundle wheel) and non-standard measurement systems (e.g., counting 'giant steps', or working in partners to measure arm spans). The results were recorded, and students worked to make sense of the differing numbers recorded, comparing non-standard and standard results which led them to think about the need for precision in measurement.

PAR embedded in data management unit in mathematics.

Two months later, teachers embedded PAR further in their mathematics teaching with students developing data management skills through conducting surveys and creating graphs based on questions and issues of concern about recess or the playground. These projects ran for a four to six week period through January and February. Sally introduced the project by letting her Grade 4 students know that they would be "survey makers, researchers and graph makers" an idea they seemed excited about. Sally asked the children to generate and record their ideas on sticky notes, then categorize the ideas. She then reviewed what made good survey questions and students responded with answers such as "giving people choices" and creating various categories and if necessary, a category called "other." Survey questions that students generated included: the frequency of bullying, types of games preferred, use of library during recess, ways to decrease fighting during recess, etc. For example, one group of students used graphing to

represent their concern about the lack of inclusive games and activities in the playground especially for students new to the school. Teachers commented that through appealing to students' sense of fairness as well as their experiences in the schoolyard, their levels of engagement and participation in mathematics increased. A side benefit of this approach was that when students worked with authentic problems where mathematics was used to analyze issues of concern and where the results would be used to create change, this provided motivation for students to create graphs and products that looked "professional" in order "for them [the principal and vice principal] to take you seriously." In this way, students could clearly see mathematics being used as a tool for communication and change. Students presented their data to parents and to the school principal which, in some cases, led to changes in the playground and recess. For instance, the principal invited Right to Play[11] to the school to work with students and parent and caregiver volunteers to design and implement inclusive games during the lunch recess.

A focus of this work was on making students' ideas visible. Sally described how for some students this was difficult because they had to be able to take risks and to be able to express themselves both orally and in writing. In viewing the video of the lesson, she referred to a student who typically focused on the mechanics of writing (i.e., spelling) so that he found it difficult to get his ideas down on paper. The PAR project helped Sally emphasize a focus on ideas rather than mechanics: "So I really wanted him just to get his

[11] Right to Play is an organization devoted to improving the lives of children through the sport and play for development, health and peace.

ideas down, just to take risks in his writing." With her scaffolding, the student was able to share his ideas within the group.

Institute of Child Study – Inquiry PD

NAME OF PD: **Institute of Child Study (ICS)** Equity goals of PD: Inquiry as a form of equitable teaching. Math goals of PD: Use of idea-centred, inquiry-based approach to access higher level mathematics; computational fluency taught in conjunction with teaching for conceptual understanding; mathematics as a stand-alone subject and/or integrated with other curriculum areas such as science and language arts.	
Ideas taken up	Ideas rejected
Inquiry-based teaching and learning (but only when there was time in the school year depending on report cards…)	Student led inquiry-based (rejected because of feeling constricted by curriculum and demands of initiatives such as T-LCP)
Building integrated curriculum units around student interest/not pre-planned/building curriculum on student/collaborative approach to develop understanding of a topic collectively	
Examining big ideas in subject areas	
Accessing students' higher level thinking	
Seeing children in a holistic way	
Integrating mathematics with other subject areas	

The ICS PD provided a presentation of inquiry and gave teachers opportunities to see inquiry in practice at a laboratory school affiliated with the university. All but one of the teachers in the study reported enthusiastically about their experiences in this PD (May, 2010). Stewart, the Grade 5 teacher, was relatively unimpressed. He reported that "yeah, there was some really neat interesting stuff going on but there wasn't anything there that I kind of went 'Wow, I never thought about *that'"* (Final Interview). In contrast, Tracey, the Grade 1 teacher commented that she go more out of the ICS visit

than all of the PD experiences throughout the year. Four of the five teachers reported that the bird unit they saw in the kindergarten class made inquiry come to life for them. Stan, the Grade 2/3 teacher described the process of inquiry which is described in his reflection below:

> "Well it was the opportunity of walking in a classroom and yeah I looked up and saw that the children had created objects of flight – little airplanes or birds – that they thought would fly. I saw their first attempt at it and then she went through and explained to us how the unit started, which started from a book and a discussion where the kids seemed interested in flight, and so she started to ask them, you know, why do you think birds can fly or what is it about the shape of their wings, and that evolved into an experiment and talking about it, and dialogue and discussion and conversation and going through books, and what they knew about it, and logging all that information and recording all that data on a chart, doing their experiments with their plane and then having an expert come in. Someone came in who was familiar with gliders and what was that - propulsion and the other three concepts of flight, or whatever, and then the kids got a chance to change their planes, make a new one or alter their planes. And to me it was just – it was quite clear from the classroom and with the kids talking about it when they were talking about their planes they were just so excited. I mean that's something that those kids in kindergarten are going to remember their whole lives."

In the ICS PD, teachers observed that instruction was built on students' ideas and teachers were able to change the direction of study based on students' interests and contributions to the curriculum design. As Tracey, the Grade 1 teacher reflected on the ICS visit, "There, their thinking was that if the students show an interest, then go with that and change." The curriculum, in this way, was seen as a flexible roadmap.

As well, teachers saw examples of how mathematics was taught both as a stand-alone subject and integrated into other curriculum areas such as science (as in the bird unit). However, teachers also reflected on the perceived difficulty of implementing an inquiry-based approach while also meeting curriculum expectations. As they described it, an idea-centered curriculum (such as the one presented at ICS) was in conflict with an achievement-centered curriculum in their school. Stan, the Grade 2/3 teacher, reflected on his visit to ICS and asked how he could possibly fit inquiry into his teaching:

> "The amount of learning that happened with that is really great. So you walk into a classroom and you see that and you'd go, 'Oh, I'd like to try that but how can I fit that in? Like I mean realistically can you fit it in [to the curriculum expectations]? Yeah, but when do you actually have time to sit down and uh, ok what units will that be covered in?"

In this way, the constraints of curriculum held teachers back from enthusiastically taking up the ideas presented during the ICS visit.

CHAPTER 5: FINDINGS - TEACHERS' CONCEPTUALIZATIONS OF EQUITY IN MATHEMATICS ACROSS INTERVIEWS

In this chapter, I analyze the data in relation to the following research questions:

1. *How did teachers conceptualize equity in mathematics in a Canadian urban context? How did they achieve equity through their instructional practices in their mathematics teaching?*
2. *How did teachers' conceptualizations of equity change over time?*

Within each interview, I examined teachers' existing conceptualizations of equity and pedagogical goals as well as the instructional practices they used to achieve equity.

I begin the chapter with an examination of the conceptions that remained relatively constant over time. Within each conceptualization, I document changes over time across the initial interview (Time 1), the Stimulated Recall Interview (Time 2) and the final interview (Time 3). The interviews served as a reflection of teacher talk in the community of practice. Thus, I use participants' quotes to illustrate the meanings negotiated by the group of teachers and to describe details of the emerging conceptualizations. Because the unit of analysis for my study was the group of five teachers, I mainly discuss common patterns within the group. However, at the end of the chapter, I include a section on the differences in teachers' conceptions. As well, Appendix B provides an overview of each teacher's conceptions of equity across the three interviews. Table 7 gives an overview of the community's conceptions of equity over time as well as the various PD activities in which they were involved across the school year. Table 8 gives an overview of teachers' conceptions of equity in relation to the PD and in which interviews the teacher talk appeared.

Overview of teachers' conceptions of equity over time in relation to PD

Table 7: Teachers' conceptions of equity over time in relation to PD

Mapping Teachers' Conceptions of Equity across time with Professional Development (PD) across the school year									
	Time 1: Initial Interview (Sept/Oct)			**Time 2: Stimulated Recall Interview (Jan/Feb)**			**Time 3: Final Interview (May/June)**		
Teachers' conceptions of equity	***•Raising student achievement*** *Curriculum coverage* *Preparing students for standardized tests* ***• Equity does not mean equal treatment*** ***• Providing access to conceptual understanding*** *Computational fluency as a prerequisite for accessing higher level thinking in mathematics* ***• Providing access to language in mathematics for English Language Learners***			***•Raising student achievement*** *Curriculum coverage* *Preparing students for standardized tests* ***• Equity does not mean equal treatment*** ***• Providing access to conceptual understanding*** *Computational fluency as a prerequisite for accessing higher level thinking in mathematics* ***• Providing access to language in mathematics for English Language Learners*** - - - - - - - - - - - - - - - - ***• Drawing on social justice issues to promote positive social change*** ***• Inquiry as a form of equity***			***•Raising student achievement*** *Curriculum coverage* *Preparing students for standardized tests* ***• Equity does not mean equal treatment*** ***• Providing access to conceptual understanding*** *Computational fluency as a prerequisite for accessing higher level thinking in mathematics* - - - - - - - - - - - - - - - - ***• Drawing on social justice issues to promote positive social change*** ***• Inquiry as a form of equity*** ***• Becoming aware of students' lived experiences/building students' cultural and linguistic knowledge***		
PD experiences	**September**	**October**	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Teaching-Learning Critical Pathway (T-LCP)	Sept. 3: Reviewing CAT scores/Inquiry units worksheet *3 hours*	Oct. 13: Moderated marking *2 hours* (each grade team)	Nov. 2: Review EQAO scores Post-task *2.5 hours*			Feb. 8: Pre-task planning *2 hours*	March 10 & 25:Moderated marking, part one and two *3.5 hours*	April 15 and 16: evidence of Level 4 thinking *1 hour*	
Culturally Relevant and Responsive Pedagogy Seminar Series (CRRP &PAR)	Sept. 16: CRRP: systems of oppression in society/school *3 hours*	Oct. 16: PAR training *6 hours*	Nov. 2: PAR - Mapping Recess plan with teacher candidates *1 hour*	Dec. 9: Lesson planning/social justice theme: Africville *3 hours*	Jan. 21: Exploring issues of social justice through math *3 hours*	Feb. 26:Follow-up with PAR facilitator *3 hours*	March 24: Examining school board's demographic data *3 hours*	April 21: Systems of power + *Brown eyes, blue eyes* documentary *3 hours*	May 19: School groups share PAR projects *3 hours*
JUMP				Dec. 7: JUMP intro *1 hour*	Jan. 14: JUMP training *2 hours*			April 8: JUMP demo lessons *1 hour/session*	
Institute of Child Study Lab School									May 19: inquiry-based teaching/class-room observations

Teachers' conceptions of equity in relation to PD and interviews.

Table 8: Teachers' conceptions of equity in relation to PD and interviews

Teachers' Conceptions of equity and where they occurred in the interviews and PD		
Equity means:	Connection to PD	Interview
Raising student achievement levels	•Teaching-Learning Critical Pathway (T-LCP) •Junior Undiscovered Math Prodigies (JUMP) •Culturally Relevant and Responsive Pedagogy (CRRP)	Initial Interview Stimulated Recall Interview Final Interview
Equity does not mean equal treatment	CRRP	Initial Interview Stimulated Recall Interview Final Interview
Providing access to high levels of mathematics – equity as a drive for excellence	JUMP, ICS, CRRP, PAR, T-LCP	Initial Interview Stimulated Recall Interview Final Interview
Providing access to language for English Language Learners	JUMP, CRRP	Initial Interview Stimulated Recall Interview
Drawing on social justice issues to promote positive social change. By product: make mathematics relevant and engaging	CRRP/PAR, T-LCP	Stimulated Recall Final Interview
Inquiry as a form of equity	PAR, ICS, T-LCP	Stimulated Recall Interview Final Interview
Acknowledging, honouring and connecting to students' lived experiences	CRRP/PAR	Initial Interview (one teacher) Final Interview (all teachers

In each of the interviews, teachers were asked directly what equity and social justice meant in relation to their mathematics teaching. Across all three interviews, they often answered the equity question in general statements such as 'meeting the needs of students.' However, when teachers were asked to talk about instructional practices they

used to achieve equity in their teaching and what challenges they faced in teaching mathematics more equitably, their pedagogical goals and ideas of equity surfaced and became clearer and more fleshed out.

In the initial interview, conducted in September and early October, teacher talk revolved around four main conceptualizations of equity which included: a) raising student achievement levels with a focus on curriculum coverage and increasing student scores in standardized tests (especially for students with special needs and English Language Learners), b) ideas of treating students fairly (equity does not mean equal treatment), c) providing *access* to high quality mathematics, and d) providing access to language in mathematics for English Language Learners (ELLs). In this interview, the greatest challenge for teachers was to create an equitable learning environment that addressed the variety of needs of students in the classroom while meeting curriculum expectations. At this point, curriculum remained unchanged.

In the second interview, conducted in January and February, teacher talk continued around themes of achievement, access, and fair treatment but gave rise to a new conceptualization: *raising students' awareness of issues of social justice to promote positive social change* and to make mathematics relevant to students to increase student engagement. In this interview, teachers talked about changing the content of the curriculum to include social justice issues, and changing their pedagogy to include inquiry-based teaching and learning as a form of equitable teaching. A by-product of this approach was that teachers reported increased student participation and engagement in mathematics. Teachers also talked about treating students fairly, and meeting the socio-emotional *and* academic needs of students.

In the final interview, teachers continued to talk about meeting students' needs but began to articulate a new conceptualization of equity in relation to students' lived experiences. Embedded within their talk were ideas about how to acknowledge, honour, and connect with students' lived experiences, to examine issues of power in society and in the classroom, to use inquiry as a form of equity, and to bring student voice into the curriculum.

The following sections outline the findings as well as discussion of teachers' conceptualizations of equity that emerged through the data analysis. Each teacher described several different conceptions of equity at various interviews, but also within the same interview. Although I've articulated clear stances of conceptualizations of equity in the literature review, these didn't play out as clearly separated categories in my study. Many of their conceptions related to or overlapped with the four themes used in the literature review and reflected the complexity of the topic. But for the purposes of reporting the findings, I have reported on different conceptions in separate categories. Different conceptions of equity reflected different ideological stances but within the findings, the five teachers in my study demonstrated how these stances could co-exist. Although certain conceptions remained across time, there was a recognized shift in conceptions of equity over time, as shown by how teachers moved from the conception of closing the achievement gap and curriculum coverage to talking about designing curriculum to promote social change and developing an awareness of students, their families and communities.

Teachers' Conceptualizations of Equity that Remained Constant Across Interviews

Below, I report on three conceptions of equity that remained relatively constant over the three interviews: a) equity as raising student achievement levels, b) equity as fair treatment (rather than equal treatment) and c) equity as access to conceptual understanding of mathematics. I also talk about the changes in meaning that developed within these conceptualizations as the school year progressed. By drawing on interview data from the final interview, when teachers were asked which of the PD sessions brought about changes to their ideas of teaching equitably, in some instances I was able to link their conceptions of equity with PD experiences. In other instances, the reasons for changes were unclear.

Equity means: Raising student achievement levels.

Across the three interviews, teachers often reflected a sense of feeling ill-equipped to both deliver and meet the many expectations laid out in the official curriculum documents. Teachers' conceptualizations of equity included a concern for raising achievement levels for students whose mathematics skills did not match the grade level curriculum expectations. The most common explanation of equity across interviews was in terms of "meeting the needs of students," and "making sure they get what they need" in relation to the goal of meeting curriculum expectations. Teacher talk in the initial interview focused specifically on helping students with special needs access the curriculum:

> "There are lots of children who need special support in those areas. And that's right down from the language to working with manipulatives, to understanding the concepts, with getting a lot of scaffolding, almost continuous scaffolding one-

on-one. There's a huge equity issue when it comes to children who have exceptionalities" (Stan, Grade 2/3 teacher, Initial Interview).

This conceptualization of equity had to do with a commitment of practice that was difficult to meet, namely the goal of helping students efficiently "get through the curriculum" (Leah, Grade 2/3 teacher, initial interview) as it was laid out in the standards documents or mathematics textbooks. When they expressed these goals, teachers also articulated several concerns and challenges that made achieving the goal of meeting students' needs difficult. These concerns included uncertainty about whether high expectations were appropriate for all students (especially ELLs or those they referred to as having 'special needs'), and a concern that if they spent substantial amounts of time with students who were struggling, the high-achieving students would not receive the attention that they, too, deserved.

Curriculum coverage.

A dilemma that arose for teachers was the time it took to ensure students' understanding of concepts versus moving efficiently through the curriculum to meet expectations in a time frame that matched due dates for report cards. For instance, although teachers were enthused by the PAR PD, they didn't feel they could devote the time needed to do it justice because the timing coincided with report cards being due. Since they were required to report on three strands of mathematics, they needed to "get through the curriculum" in the most efficient way possible. This led to a treatment of the curriculum as a checklist, and a focus on what teachers taught, rather than what children learned.

In general, in the *initial interview* teachers did not problematize or suggest changing the curriculum but instead tried to fit children into it. They found that they needed to provide "almost continuous one-to-one scaffolding" for students who struggled to meet those expectations. Goals for equity had more to do with meeting the needs of individual students in relation to raising student test scores, and teachers did not describe problematizing curriculum content - a practice that has been beneficial to student success in marginalized communities (Moses & Cobb, 2001;Ladson-Billings, 1995; Delpit, 1988). Neither did teachers problematize classroom structures to redress power imbalances. This reflects Apple's (2004) argument that power remains in the hands of those who already have it through what is taught and how it is taught (both content and implementation), thus maintaining the status quo. In other words, schools (by implementing a curriculum produced by those in power in society) can reproduce inequalities of society because a certain view of knowledge is legitimized which can provide opportunities for some and barriers for others. In the initial interview, only Tracey, the Grade 1 teacher, alluded to the possibility of changing her practice as a way to support students who struggled with mathematics: "In Grade 1, I'm finding that some [students] need constant attention and direction and refocusing…and that's probably me. I think if I readjust what I'm doing with them, that might change."

By the *stimulated recall interview* (January/February, 2010), the teachers had participated in two sessions of PD in JUMP (December and January). JUMP's goal of serving the needs of students who are typically underserved in mathematics seemed aligned with teachers' sense of the importance of teaching equitably. Perhaps because the PD acknowledged the curriculum demands on teachers and offered a specific set of

classroom activities as a way to meet grade level demands for all students, there seemed to be teacher buy-in from the first PD session.

During this interview, teachers described the disconnect between where some of their students were in their mathematical understanding and where they were expected to be in terms of curriculum expectations. For example, Stan (Grade 2/3 teacher) discussed the challenge in planning a lesson to reach all students when there were some "who probably didn't even understand how to count sides on shapes" (Stimulated Recall Interview). By this interview, teacher talk included the goal of having *all* students meet curriculum expectations and the pedagogical goal to move students along a learning continuum, or as Sally, the Grade 4 teacher explained, "to push them along the continuum" (Stimulated Recall Interview).

In the *final interview,* curriculum coverage remained a primary goal for teachers, and they continued to talk about the time pressure they felt to cover the numerous curriculum expectations. The comment below is typical of those that teachers shared:

> "Well we *have* to report on all strands of the curriculum, the math curriculum. So there's five strands. Within each strand there are very different parts of the unit and the expectations. So I strive to hit them as best I can. Um, and I find that there just isn't enough time. I could teach math all day long every day for a hundred and ninety-five teaching days and I don't think I would do it justice…I don't think I reached everybody." (Leah, Grade 2/3, Final Interview)

Ontario's current mathematics curriculum (Ontario Ministry of Education, 2005) consists of a weighty series of curriculum objectives, reminiscent of the Tyler Rationale (1949), an educational philosophy of social efficiency designed to develop human capital.

Success in learning is evaluated in relation to how well each learner meets the curriculum planners' stated objectives (Kliebard, 1975), assuming the assessment is perfectly accurate. The sheer number of expectations in the Ontario curriculum (e.g., in Grade 1, for math alone, there are 67 expectations to be met in one year) illustrates a factory model of curriculum planning where curriculum becomes a checklist of tasks or products for students to churn out. For example, the official curriculum guidelines for mathematics talk about using teaching strategies that will meet the "…productivity needs of any group of students" (Ontario Ministry of Education, 2005). This begs the question: Whose needs are these expectations serving? And what barriers to learning are created when the curriculum becomes a checklist?

When the curriculum is seen as a set number of skills to be taught and student success is measured in terms of how well they meet the curriculum planners' stated objectives (Kliebard, 1975), the focus in the mathematics teaching is on learning skills and concepts mostly at a factual level with very little application of concepts and skills to problems outside the textbook (except if application and problem-solving are part of the stated objectives). As teachers described what it was like to try to achieve equity in practice, the competing goals of meeting students' needs and meeting curriculum expectations were at times incommensurable.

Although one of the biggest challenges for teachers remained curriculum coverage, by the final interview, teachers also discussed *adapting* the curriculum to begin to meet the needs of students. Tracey, the Grade 1 teacher gave a clear example of this: "Some are still struggling with adding to ten so that I wouldn't give them a problem that expects something beyond that." Rather than this being an example of watering down the

curriculum, through my classroom observations, Tracey took the time to build up the student's understanding of base ten before moving directly to the grade level curriculum expectation. Many of the teachers included "extensions on the expectations for those kids that can get it right away" (Sally, Grade 4 teacher, final interview) or gave extra time for students to process concepts. Similarly, Stewart, the Grade 5 teacher, drew on the idea of curriculum as a learning continuum when he linked equity with a variation on the common term in teaching of 'differentiated instruction':

> "The big buzz word now is differentiated learning, but I mean to me that's equity and it just means that my job as a teacher is to help each child move from where they're at to where they need to go or to where they *can* go. I would say even more because that means the kids that are below expectations are moved to as far as they can, hopefully beyond the expectations and then those kids that are, you know, your solid *B* students or maybe even your *A* students move beyond what the curriculum expectations are."

With a view of curriculum as a continuum of learning, teachers' goals were to provide all students with opportunities to be moved forward in their understanding (through providing extra time and support or providing extra challenges). This goal of moving students along a continuum of learning highlighted the teachers' focus on meeting the needs of individual students and reflected the messages in the T-LCP of moving students to higher achievement levels.

The influence of standardized tests on teachers' pedagogical goals.

Although all of the teachers in the study had to administer a national standardized test for their students, only Leah and Stan, whose students were involved in the provincial

standardized assessment (EQAO[12]), reported feeling pressured to prepare students to do well in them. For instance, Stan, the Grade 2/3 teacher reported early in the school year that "the pressure right now is to increase student scores, and it's not about creating equitable lessons for kids." He was referring to the school's goal to improve student scores which was also the focus of the T-LCP PD. Leah and Stan, the Grade 2/3 teachers, made a decision early in the school year that Stan would teach mathematics to all of the Grade 3 students, and Leah would teach the Grade 2 students. The advantages of this idea were that the teachers would only have to focus on one set of curriculum expectations as opposed to teaching two sets of expectations for the split-grade class. In this way, they felt they had a better chance of covering the grade level expectations and preparing the Grade 3 students who would be writing the standardized test at the end of the school year. While she appreciated that Stan had taken on test preparation for her Grade 3 students, in January Leah commented that it was inequitable that she had to teach twenty-three Grade 2 students while Stan had only sixteen Grade 3 students. In March, they switched back to teaching their own students in mathematics.

In the initial interview, Stan discussed that his goal in mathematics planning was to prepare English Learners for the standardized test and involved "looking down the road at what language is used on the EQAO test…and trying to incorporate that into your lesson. So it's just understanding all the same terms which seem to change from year to year on EQAO." Stan in particular described the lack of "continuity of language" in the

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[12] The Education Quality and Accountability Office (EQAO) develops, administers, and evaluates province-wide standardized tests annually for students in Grades 3, 6, and 10 and reports on plans for improvement goals for schools in order to "change conditions for learners to ensure improved achievement" (EQAO, 2011, p. 1).

mathematics textbook as a challenge in his teaching because of how specific terms on the test changed from year to year, and how this posed a problem for English Learners:

> "Whether it's 'describe' or 'explain' which basically means the same things but from year to year in EQAO it changes in the question so a child might be prepared to answer 'describe,' get to a test and see 'explain,' and they have no idea what that means."

This focus on fine-tuning vocabulary shows the effect of the test (and of the school's underlying goal to improve students' test scores) on influencing teachers' pedagogical decisions and instructional practices.

By the final interview their focus on equity as raising achievement was probably informed by the impending standardized testing, in which individual students are assessed. In a Stan's own words:

> "I've got to get the kids prepared for Grade 3 testing on Monday and this week I've covered capacity, mass, temperature, multiplication, division, and I touched basically on coordinates. Not only did I do that, I started to go over old EQAO packages because I wanted to refresh their minds with translations, I wanted to refresh their minds with three-dimensional shapes, with nets, with all of these things that haven't been part of their common vocabulary or thinking in three or four months" (Final Interview, June, 2010).

Likewise, Leah (four days before the test was to be administered in her classroom) described her "panic attack" as she looked over sample questions from an EQAO booklet and realized that "I haven't been teaching them to answer with pictures, numbers, and words" and "to justify their answers…I haven't been on top of that."

Using the communities of practice framework, the EQAO can be seen as an object acting on behalf of humans and which influenced pedagogical practice. The test dictated what the teacher taught and what activities the students faced. Even so, Stan admitted that he didn't feel this was about the T-LCP goal of "enduring understanding" for students in an inquiry-based approach, but was a focal part of the decisions he had to make at this stage of the year. He pointed out, "so even though I'm putting that in such a small frame of time, I know that that's not endured learning." In this example, mathematics was seen as a means to the end goal of testing and as a series of skills and concepts to be covered and completed. Often this meant a focus on specific expectations from the curriculum guidelines rather than on the general expectations (which relate to big ideas in mathematics strands). For instance, in the final interview, Leah made the comment that if she were "teaching just Grade 2, I wouldn't have to make sure every single thing is covered in detail…I could do my job more equitably by figuring out the big concept that they'd [students would] need to know." In comparison, she described her typical, rushed approach to teaching mathematics because of having a split-grade class and having to ensure that the Grade 3 students were exposed to all areas of the curriculum: "O.K., let's start geometry today and this is called and this is called and how many edges does this have and what's this called?" (Final Interview). Her comment reflected the pressure she felt in relation to preparing her students for the test.

Interview analysis revealed the social effects of standardized testing that are not part of its purpose in school and in the system. When teachers conceptualized equity as raising achievement on this standardized test, both positive and negative issues arose. For instance, with a focus on the test, teachers are responsible for all students and cannot

ignore groups of students or expect that they can't learn. As well, the test results provide a landscape of how students are doing in mathematics provincially and have sparked the need to provide extra funding and support for schools underperforming in provincial standards. However, Jordan (2010) contests the idea that standardized testing increases teacher accountability and motivates effective teaching practices that will improve student achievement. He argues that "obtaining equity is not as simple as eliminating or reducing variability in test scores" (p. 148) and that the tests do not take into account factors such as motivation and aspiration, also important indicators of educational success. In fact, as Schoenfeld (2002) argues, "high-stakes testing can result both in curriculum deformation and in loss of intrinsic motivation for students" (p. 23). Suurtamm, Moisan, and Luthra (2004) in their study of the EQAO found that "an assessment that presents mathematics as isolated bits of content knowledge does not present student or teachers with a comprehensive picture of mathematics" and that "using an item mapping to curriculum expectations and Achievement Chart categories does not necessarily guarantee that the important mathematics in the curriculum is adequately assessed" (p. 6). Richardson (2003) similarly reports that "deep understanding of mathematical reasoning...is not what is being assessed on…standardized tests" (p. 3).

With the school goal to narrow the achievement gap, which Gutiérrez calls gap-gazing, there is the potential for a social deficit model in which marginalized groups of students are seen as deficient in mathematical skills. This shifts the focus away from looking at what conditions lead to these outcomes, such as barriers that exclude students from participating in mathematics (as discussed in the literature review).

The findings demonstrate the kind of pressure teachers face to increase students' performance levels in relation to the curriculum. Especially when mathematics is seen as a number of expectations from the official curriculum document, students are viewed and categorized in terms of ability, with ability as the "prime determinant of math achievement" (Stodolsky, 1988, p. 125). This focus on 'in the head' cognition and tests for individual ability lead teachers to make conclusions about intelligence as a fixed trait (often linked with children's social class background) and can lead teachers to exclude low-achieving students from higher level mathematics (discussed further in the next section). As Schoenfeld (2002) explains, "Given the stakes, many teachers feel that they deviate from skills-based instruction at their (and their students') peril" (p. 22). Procedures are either presented to students, with the teacher correcting wrong answers and students following directions or teacher guiding students toward accuracy. Students are expected to use strategies, remember tricks, and find ways to organize information. And as Wenger (1998) points out, "To assess learning we use tests with which students struggle in one-to-one combat, where knowledge must be demonstrated out of context, and where collaborating is considered cheating" (p. 3). In this approach, teachers try to find instructional strategies that engage students, but they keep the same curriculum, often giving up on trying to adjust their teaching methods to reach those students. This is contradictory to a sociocultural view of learning, which considers a child's active social participation key to learning. In my study, the emphasis early in the school year was on having students conform to the curriculum rather than on teachers rethinking their curriculum and teaching choices.

Equity does not mean equal treatment.

A conception of equity that remained constant throughout all three interviews was the idea that *equity does not mean equal treatment,* a phrase used regularly during the CRRP PD. This idea was linked to another common phrase that teachers used - "meeting the needs of students" - and was aligned with that of the provincial Ministry and the school board which defined equity as "a condition or state of fair, inclusive, and respectful treatment of all people. Equity does not mean treating people the same without regard for individual differences" (Ontario Ministry of Education, 2009).

Over the course of the study, the teachers used the same phrase, but there was a gradual change in meaning over time. In the initial interview, for instance, Stewart talked about the importance of having students learn "the difference between equity and equality, equity meaning you get what you need and the other person gets what they need. Not equality where everybody gets the same thing whether they need it or not." This comment, which was typical in the initial interview and in the final interview, was often followed by comments describing how teachers let students know why they may have been spending more time with particular students or why students may have been given different expectations. For example, Tracey, the Grade 1 teacher, tried "making the rest of the students understand, um, I have a student with autism who certainly gets more of my attention and he gets quicker rewards and isn't expected to do quite as much."

In the *stimulated recall interview*, teachers articulated ideas of *fair treatment.* For example, Sally, the Grade 4 teacher, explained that equity was about "ensuring that it's fair so that they have what they need to be successful."

Although each teacher participant drew on the phrase *"equity is not equal"* as a way to explain what was meant when they said, "every child should get what they need," in the *final interview*, the meaning was fleshed out further. The notion of differentiated support included adjusting the curriculum expectations to meet the needs of students. For Tracey, the Grade 1 teacher, achieving equity now meant "that every student is being allowed to go at their pace and being given what they need and the support that they need." Sally reiterated the idea of equity not meaning equality but used it to relate equity to *student voice*:

> "My job is to, I think for equity, is to ensure that they feel that they're equal – they have the perception of having the same voice as everybody else…So I provide the students who are shy with lots of support and coaching; the children who are going, an opportunity to share but an opportunity to listen as well."

Although this reflected ideas of fair treatment as in the earlier interviews, her conception now included changes in structuring the classroom to balance power differentials and to create equitable opportunities for student participation. Rather than using general terms related to student success, Sally was beginning to talk about democratic principles of providing space in the classroom for students to have equitable opportunities to voice their ideas. The CRRP seminar series often referred to issues of power, and the eighth session (April, 2010) in particular made power imbalances explicit.

Equity means: Providing access to high levels of mathematics.

> "Should we first help students develop efficient symbol manipulation procedures, or should we help them build relationships between symbol procedures and conceptual networks?" (Hiebert & Carpenter, 1992, p.78)

Another goal for equity that teachers talked about in the Initial Interview was related to providing students with access to 'big ideas' in the official curriculum document or in other words, important mathematics (Suurtamm, Moisan, and Luthra, 2004). The conceptualization of access, although linked to achievement carries a different meaning. In the section describing achievement, teachers' goals were to get students to do well in mathematics through raising achievement levels which is not the same as trying to make sure they are all doing deep, conceptual mathematics. Achievement can be seen as "a static outcome" (Nasir, 2007, p. 132) whereas access is related to the process of developing of students' conceptual understanding. Access, in this way, linked to the focus in the Teaching-Learning Critical Pathways (T-LCP) which looked at "big ideas" in order to develop students' "enduring understandings" of concepts. An important aspect of the mathematics reform movement is the idea that through engaging students with mathematical problem solving activities (often in connection with real world applications) and by explaining one's thinking and discussing mathematical ideas, strategies and concepts with others, students will develop mathematical reasoning and proficiency.

However, early in the school year, teachers highlighted a tension between their goal of developing students' *access to higher level mathematics* through inquiry-based teaching methods and developing students' *computational fluency* through practice and drill. Sally's comment below raised the issue of who gets access to certain mathematical opportunities:

> "I worry sometimes that we made math more complicated to students who need just to do computations. So, you know. You have to come back to a balance, I

think of – because it's sort of, it's math - very reflective, it is very inquiry-based – which is really important. But it has to be balanced out with computation skills and just practice. Because where else are they going to practice their math skills?" (Sally, Grade 4, Initial Interview)

Teachers created a lunchtime and after school math club twice a week (with snack) to support students in the development and review of basic mathematical skills which allowed "those students the time to get together and just go over the basic skills" (Tracey, Grade 1 Teacher, Stimulated Recall Interview), thus providing the computational fluency needed to participate in problem solving and work around big ideas in mathematics.

This idea was further discussed in the *stimulated recall interviews* (January and February), when teachers in the study talked about computational fluency and vocabulary skills as *prerequisites* for access to the kinds of higher-level mathematics which included discussing mathematical ideas, sharing strategies, and focusing on thinking processes. The teachers' discussion of the idea of computational fluency as a prerequisite echoes the discussions of this topic in mathematics education research which will be discussed in the next section.

Research literature on bridging computational fluency and conceptual understanding.

Conceptual knowledge is identified with understanding, or knowledge that is stored within networked relationships. Procedural knowledge is defined "as a sequence of actions" with "minimal…connections between succeeding actions in the procedure" (p. 78). Both are necessary for developing mathematical proficiency, and "if the learner

connects the procedure with some of the conceptual knowledge on which it is based, then the procedure becomes part of a larger network, closely related to conceptual knowledge" (Hiebert & Carpenter, 1992, p.78).

Although most researchers in mathematics education would agree with the claim that procedural fluency is an important part of students' conceptual understanding, it is a "very common misunderstanding that in mathematics students have to master skills before using them for applications and problem solving" (Schoenfeld, 2002, p. 23). The messages that teachers received in some of the PD were at times in contradiction to findings in the research literature. For instance, the JUMP approach argued that students needed to master computational fluency through practice as a way to access or as a prerequisite toward getting to big ideas in mathematics, to build students' automatic recall so that their "working memory would be freed up" and there would be "space for problem solving" (JUMP's founder, January, 2010). This was an idea that was readily taken up by teachers in the study. However, the idea that procedural fluency must come first has been contested in the literature. For instance, much of the literature argues for "meaning before efficiency" and "understanding before skill proficiency" (Hiebert & Carpenter,1992, p.79) because "learners who possess well-practiced, automatized rules for manipulating symbols are reluctant to connect the rules with other representations that might give them meaning" (p.78) and "when a particular approach or procedure is practiced it can become fixed, making it difficult to think of the problem situation in another way" (p.79).

Schoenfeld (2002) explains that "with well-designed curricula, it is possible to teach for understanding without sacrificing procedural skill" (p. 19) and found that

reform curriculum, when implemented well, could mitigate differences in achievement levels between marginalized and non-marginalized students. Similarly, focusing on the *relationship* between conceptual and procedural knowledge is preferable to looking at which is 'better' knowledge to have (Hiebert & Carpenter, 1992; Glaser, 1989). This reflects the need for adequate teacher preparation that helps teachers teach skills and procedures along with the development of conceptual understanding. This requires the development of both teacher content knowledge and pedagogical knowledge (Ball & Bass, 2003). JUMP at times reached both the conceptual and procedural when it allowed students the chance to think and talk about similarities and relationships between mathematical procedures, thus helping "students build a coherent mental network in which all pieces are joined to others with multiple links" (Hiebert & Carpenter, 1992, p. 68).

This tension between students needing to master basic skills through practice before getting to participate in more complex mathematics and inquiry-based activities and approaches to learning raises the issue of who gets to participate in mathematics and who is excluded. Wenger (1998) argues that "learning…changes who we are by changing our ability to participate, to belong, to negotiate meaning. And this ability is configured socially with respect to practices, communities, and economies of meaning where it shapes our identities" (p. 226). Because participation is itself learning, students need to be able to participate in all forms of mathematics. Thus, if students are excluded from activities that involve engaging with mathematical ideas and are instead left to work on computational skills as a prerequisite for joining in and accessing rich forms of mathematics, this becomes a barrier to participation in the kinds of opportunities that

allow students to see themselves as "doers of mathematics" (Nasir, 2007, p. 132) and to participate in the culture of power (Delpit, 1995).

This kind of barrier to border crossing has implications for student identity because it creates a divide between who can or cannot participate. Since students' identities are built from the social interactions and contexts in which they participate this means that for students denied access, they can begin to identify with poor performance. There is a need for the development of programs that allow students access to higher levels of mathematics in tandem with strengthening their procedural fluency. Gutiérrez (2008) argued that most gain in marginalized students' learning was from a drive for excellence. Ladson-Billings (1995) found that a common feature among effective teachers of African American students was "a classroom practice grounded in what they believed about the educability of the students" (p. 484). Mathematics instruction needs activities to build authentic practice (Nasir, 2007) and mathematical problem solving activities that strengthen students' computational skills in tandem with their engagement with rich mathematical ideas.

Access through attending to students' emotional needs.

In the *stimulated recall interview*, the idea of equity as meeting the needs of students carried over from the initial interview, but also meant supporting students both emotionally and academically as a way to provide access to higher level mathematics. Teachers discussed "reading students" (Stewart, Grade 5 teacher) and "recognizing students' emotional states" as something to consider when "planning for student success" (Stan, Grade 2/3 teacher). In my classroom observations of teachers in the study, teachers regularly demonstrated an ethic of care (Noddings, 2002) toward students through their

words and actions. For instance, teachers thanked students when they contributed in class and worked toward building a sense of community in the classroom in a variety of ways.

Noddings (2002) stated that "those who care about others in the justice sense must keep in mind that the objective is to ensure that caring actually occurs. Caring-about is empty if it does not culminate in caring relations" (p. 23-4). For example, in two separate classroom visits, I observed teachers supporting groups of students during recess in planning 'surprise' birthday celebrations for classmates that then took place during a mathematics lesson. Although this could be viewed as an interruption to students' learning, instead it created a sense of community amongst students and provided welcome for students new to the school.

Stan (Grade 2/3 teacher) tried to ensure that students who were struggling were "feeling pretty confident about what we're doing" before calling on them to contribute to group discussions or presentations of their work. For instance, in the stimulated recall interview, Stan viewed his video-taped lesson in which students played a game about attributes of three-dimensional shapes, and he explained:

> "That's why I go right down on the carpet right away to make sure that he's [one of the students who were struggling] got some really good clues [for the game]…so it's a game, it's kind of hidden even though it's still learning going on…because if you're not doing that his head would be down, he'd be looking at the carpet, he'd be upset" (Stimulated recall interview).

Stan found that games involving mathematics provided a way for students to strengthen their computational skills and their vocabulary skills while simultaneously negotiating meaning in mathematics. However, this preparation for participation didn't

necessarily build on what students knew and was more about providing students with skills to participate. In the final interview, Stan (Grade 2/3 teacher) highlighted student participation as a daily goal and included a number of strategies to ensure that students were included:

> "So if a kid goes through a year in my classroom and they're not participating every day that doesn't make me feel good so I have to address that. And so you have to find a way for them to do that successfully. So to choose those moments where it's something you know they really like and enjoy or you've supported them *in* the learning and you're not just asking for the answer, you're using their work as an example, maybe they're working with two or three other kids so they don't feel they're isolated in answering the question. And I've got a few kids like that so when you're teaching you kind of have to address that every day. I mean it's not at the forefront of my mind, but it becomes instinctual after a while."

His quote highlighted a different form of participation than what was presented in the JUMP workshops. For instance, he talked about students working together to solve problems which is different than the JUMP approach of students working individually, and he drew on students' interests in the design of his lessons and used students work as a an example. However, the focus on answering the question correctly emphasizes the importance of being correct, and implies that mistakes are a problem. Teachers felt reluctant to call on students if they were not confident that the students could provide a correct answer, which may inadvertently discourage student participation if they are only supposed to participate if they have been successful.

Equity means: Providing access to language in mathematics for English Language Learners (ELLs).

Teachers reported that one of the biggest barriers to achieving equity in their mathematics teaching was the "huge issue" of language in mathematics for English Language Learners (ELLs). Stan explained that "at least probably half the class have learned to speak English in the last three years so for children in math class that's usually the biggest challenge. They're overwhelmed by the language" (Grade 2/3, Initial Interview). Another challenge for teachers was in how to *assess* ESL students' understanding of concepts when a language barrier was present and when teachers could not speak student languages. Tracey, the Grade 1 teacher, further highlighted the challenge in assessing English Language Learners especially with the focus on having children 'Explain how you know' (a focus of the T-LCP questioning process and a component of the provincial standardized test in mathematics) and how difficult that was for "the students whose English is limited." She gave an example of a student whose "math is great but he's not going to be as capable as explaining it to me." Tracey tried "…finding ways for him to show, to explain without the language barrier being a factor" (Stimulate Recall Interview) which proved challenging for her in her daily teaching and in her design of assessment strategies.

Teachers articulated the challenge of assessing whether the child was having an issue with the language or with the mathematics. This was an important observation because mathematics is often seen as either a language-free subject or as a universal language. The comments above demonstrated the teachers' awareness that mathematics is language-laden and yet they also talked about separating language from mathematics.

The role of language is paramount in students' understanding and in their ability to participate and this becomes even more visible in urban classrooms that include a large percentage of English Language Learners. The issues that teachers faced with assessment clearly point to a need for support as teachers implement alternative forms of assessment that show learning as a process rather than as something static (Gutiérrez, 2007;,Cochran-Smith, 2004).

Teachers in this study tried to teach language in tandem with mathematics and described instructional strategies that mainly revolved around providing access to mathematics vocabulary with the goal to increase ELLs' participation in mathematical discussions and activities. In Interview 1, teachers described three strategies they relied on to help support students' language learning in mathematics and to increase their participation. Ideas included *simplifying* language for students, *extracting* language from students, and *embedding* mathematical vocabulary in daily routines or games-based lessons which are described below.

Simplifying language. Equitable mathematics teaching meant helping students "get through the language to the math" (Tracey, Grade 1 teacher, initial interview). Language support was seen as crucial for ELLs because teachers viewed students' ability to use vocabulary as a *prerequisite* for them to participate in mathematics. In this way, access meant being able to use mathematical vocabulary as a tool for participation. After his participation in the JUMP workshop in December, Stan, the Grade 2/3 teacher talked about minimizing the amount of language students were exposed to in the mathematics textbook and mathematical word problems to find ways to "reduce the excessive amount of writing" that was required of students via the work laid out in the textbooks.

For many teachers this meant simplifying the language in the curriculum by including the use of visual aids, gestures, diagrams and breaking the question down into more manageable sections. Sally, the Grade 4 teacher tried to "simplify the questions that are being asked but to still not to fill in the blank – but still talk about what's happening and pull the language out of them and decide – Do I use the word increase? Adds? Grows? Which language most makes sense?" (Initial Interview). Stewart, the Grade 5 teacher talked in terms of extracting language from the curriculum in order to have students practice it. "Really pull out the mathematics language that they should learn for this unit and reinforce that and give them a lot of practice with it" (Initial Interview). These examples highlighted dilemmas faced by teachers of how to simplify the language enough to include ELLs and yet keep the mathematical ideas alive and keep students to high standards. This led to ideas of extracting language which is described below.

Extracting language. This meant accessing something that was already 'within' the child and may have reflected an underlying theory of learning that says that students have knowledge and learning occurs when students build on this background knowledge. For example, Sally expressed a desire to develop probing questions that would "get the language out of them [the students]… Have I really covered probing questions? Have I got the language out of them yet?" Pulling language out of students meant finding a way to access student thinking and student understanding of concepts. This is an important equity piece because it is important to draw on the knowledge and linguistic resources that students bring to the classroom. The teacher's self-questioning reflected the uncertainty of her success in drawing language from her students and reflected an interest

in the linguistic knowledge that students brought to the subject rather than simplifying the language in order to meet curriculum expectations.

Embedding language. Stan embedded vocabulary needed in mathematics with the language used in their daily activities as a way for students to build their vocabulary. For instance, weather and calendar activities were part of the Grade 2/3 morning routine, and Stan drew on students' daily observations of the weather to have students "graphing how many sunny days, how many rainy days, how many cloudy days" and incorporating mathematical language and vocabulary that students found problematic in their regular mathematics lessons (e.g., "more than") as a way to strengthen their understanding of the vocabulary. As he pointed out, "any time that you can integrate your math into the other subjects it just makes your teaching easier, the kids grasp the concepts a lot sooner, and they feel more comfortable in it" (Stimulated recall interview).

During the stimulated recall interview, Stan (the Grade 2/3 teacher) described embedding geometry vocabulary into a games-based lesson so that ELL students were able to gain exposure to the language through practice and repetition in a way that he believed was engaging. He explained that "some of the children who were reticent before were actually using the words. Because before [this lesson], they weren't using terms like 'quadrilateral' or 'equilateral' or 'parallel lines'." This practice of connecting and embedding mathematical vocabulary in everyday conversation worked toward making students feel comfortable with the language, and to relate mathematics to other ways of understanding the world rather than keeping it disconnected as is often the case when taught as a stand-alone subject.

Teacher talk related to vocabulary development.

Within the broad range of possibilities teachers could have talked about language in mathematics, they focused on vocabulary development. Mosckovitch (2007) uses situated and sociocultural perspectives to highlight several different ways of thinking about the connection between language and mathematics. For her, a focus strictly on vocabulary development can lead to a deficit view of ELLs:

> "If classroom assessment only focuses on what mathematical words English learners know or don't know, they will always seem deficient because they are, in fact, learning a second language. If teachers perceive English learners as deficient and only assess and correct their vocabulary use, there is little room for addressing these students' mathematical ideas, building on them, and connecting these ideas to the discipline. English learners thus run the risk of being caught in a repeated cycle of remedial instruction that does not focus on mathematical content" (Moschkovitch, 2007, p 351)."

Instead, assessment should focus on students' mathematical ideas and take into account how students describe patterns, use mathematical representations, and alternatives to language in their communication, "…regardless of their proficiency or fluency in expressing their ideas in English" (Moschkovitch, 2007, p. 351). "Pulling language out" of students has the potential to consider more than simply vocabulary development.

New Conceptualizations of Equity to Emerge in Teacher Talk in the Stimulated Recall and Final Interviews

Two new conceptions of equity that emerged during the interviews reflected a change in the teachers' pedagogies: a) in the stimulated recall interview, teachers reported changing the content of the curriculum and infusing social justice issues into their mathematics programs to raise students' awareness; and b) in the final interview, all teachers explained equity in terms of becoming more aware of the children in their classrooms, a holistic view of the child which for some teachers included building on the cultural and linguistic knowledge that their students brought to school. The following two sections detail these changes.

Equity means: Drawing on social justice issues to promote positive social change.

By the stimulated recall and final interviews, a major change was noted in teacher talk - all teachers talked about raising students' awareness of social justice issues and making activism an explicit part of their mathematics teaching. Although teaching for equity was described as being "a juggling act," (Sally, Grade 4 teacher, final interview) by the final interview it had become a priority (and thus a pedagogical goal) for all of the teachers. For example, compared to the previous interview where he said that equity was low on his list of priorities, Stan now reported in the stimulated recall interview that "when you think about it, it's [teaching is] all about equity."

Whereas in the beginning of the school year, teachers tended to see mathematics in relation to curriculum expectations, their involvement in PD such as CRRP and PAR allowed them to view mathematics as a tool for communication and as a tool to analyze

issues of social justice to understand the world, and their involvement with the T-LCP allowed them to think about curriculum design that would empower "students as agents of change."

The Teaching-Learning Critical Pathway (T-LCP) encouraged teachers to think about what kind of "enduring understanding" they wanted their students to learn at the end of a curriculum unit of inquiry. Teachers linked the T-LCP goal for students was "for them to become agents of change and to feel empowered" (Sally, Grade 4 teacher, stimulate recall interview) when they planned the PAR data management units that had students creating surveys and graphs about recess issues. Stewart and Stan both described teaching with the goal to empower students "to become agents of change," a term used frequently in the Teaching-Learning Critical Pathway. The quote below shows how Stewart, the Grade 5 teacher linked T-LCP's focus on big ideas and overall themes of activism with PAR's social justice and inquiry approach as a way to meet curriculum expectations:

> "Our overall big idea or theme was change-maker and Grade 4's and 5's enduring understanding was basically we have a right and responsibility to make change in the world. So we did it [the T-LCP] cross-curricularly. For math [in the PAR project] we did creating survey questions doing the tallies and graphing and making some conclusions and thinking about what we needed to find out more to help us make the change we need to." (Final Interview)

In this way, the social justice agenda not only promoted social change, but brought teachers the satisfaction of seeing the possibility of meeting a number of

curriculum expectations through cross-curricular connections and integrating mathematics with other subject areas.

Through the PAR projects, teachers began to change the *content* of the curriculum which allowed them to use an inquiry-based approach to teaching and learning as a way to access more complex mathematical ideas than may be offered in the official curriculum guidelines. Concepts and procedures are deeply related to the contexts in which they are situated (Brown et al., 1989). When authentic math problems are embedded in experiences that have meaning for children, it provides a basis for connecting procedures and learning concepts. The procedures become a by-product of wanting to figure out the problem. When students worked with authentic problems in which mathematics was used to analyze issues of concern and where the results would be used to create change, the teachers were able to motivate students to create graphs and products that looked "professional" in order "for them [the principal and vice principal] to take you seriously" (Sally, stimulated recall interview). In this way, students had a clear purpose as to why they were doing the mathematical activity and the value it had as a tool for communication and social change. For instance, as students refined their surveys, generated data, and worked to represent their data to communicate their results publically, teachers introduced them to more complex mathematics and reminded students that "to think about and communicate mathematical ideas, we need to represent them in some way" (Sally, classroom observation, January, 2010). This is an example of how school mathematics is shaped by various contexts in which it is situated.

Over the course of discussing their graphs, students demonstrated a focus on the *function* of graphs which is very different than the common focus in elementary

classrooms on teaching the *conventions* of graphs (i.e., choosing the correct title for the graph and placing the correct labels for the x and y axis). Students also began to use mathematics beyond grade level curriculum expectations to organize their data (e.g., using a "quadruple bar graph" to split responses between gender and grade levels). These students divided their data into sets - grade level and gender - which provided opportunities to both raise students' awareness of gender stereotypes and use complex graphs to organize the data. Furthermore, throughout the project, the students demonstrated a sense of pride and ownership in their work (for an example of student discourse in relation to the graphs, see Appendix B).

Teachers demonstrated a tripartite goal of developing students' computational fluency, conceptual understanding, and awareness of social justice issues through changing the curriculum content. This was echoed in the Sally, the Grade 4 teacher's comments in the final interview when she described how she did a data management unit previous to PAR, and how the action piece gave the motivation for students to attend to the conventions and layout of the graph in order convey the meaning for a broader audience, in this case the school principal:

> "I think it allowed me to again create that larger scale math application that you don't get to do. You know, if we hadn't done the PAR, we would have graphed, I don't know, ice cream flavors or something that was just sort of, I don't know, more kid-friendly, let's say? But not to take it to where actually I [meaning a Grade 4 student] might use this data I've [student] got to present, like authentically present this data because that's what graphs are for. It's not just for

> getting marks. So actually I [referring to student] really have to present the data so that other people can interpret it. So I [Sally] thought that was really good."

In these activities, developing a *critical* mathematics perspective allowed students to take ownership for their learning and supported what Gutstein (2007) calls a 'pedagogy of access' (p. 208) to classical (or formal) school mathematics. Furthermore, teachers integrated mathematics with other subject areas so that mathematics was seen and used as a tool to analyze and communicate social justice issues rather than simply a sequence of skills to be acquired. This work is an example of how Gutstein's (2006) critical mathematics can be applied to elementary classrooms in which "students need to be prepared through their mathematics education to investigate and critique injustice, and to challenge, in words and actions, oppressive structures and acts – that is, to 'read and write the world' with mathematics" (p. 4).

Many of the teachers commented on the idea of students becoming more involved in the design and implementation of the curriculum. In this way, inquiry became a form of equity as was reflected in the Grade 2/3 teacher, Stan's comment, typical of many in the study:

> "Equity would be to have the children doing a large part of creating the direction of what we're going to be going in and doing the research and doing the study and have the focus come from them instead of me."

This was very different than an approach that focuses entirely on specific curriculum expectations. Teachers argued that PAR was powerful because it allowed students to express their interests and to work towards positive change at the school.

Teachers began to see their students demonstrate mathematical agency such as stating claims, defending ideas, arguing, persuading. Stan reflected on his observations of students' work in the PAR projects: "Yeah it was participatory action research, but it was watching children realize that they could make a difference, right now, and they could be the ones organizing that and it was really powerful to watch."

In asking students about how the PAR projects compared to their experiences with 'regular math' class, most students mentioned that PAR allowed opportunities to incorporate a social element and to share their work with a broader audience. The children's comments below reflect the differences that they reported:

> "In math we do plus, area, and all those. With this, you can ask kids outside, ask them 'what do you think?' Kind of math and kind of social, too"(Grade 5 student).
>
> "Because usual math class we're usually just sitting at our desks doing it, not moving around the classroom much, unless we're sharpening our pencils or doing something else" (Grade 4 student).

However, some ideas were taken up more readily than others, and there were both barriers and possibilities for participation for students typically marginalized in mathematics. For example, ELL students were encouraged to use their home language when brainstorming survey ideas and collecting data which seemed to increase their participation in mathematics. On the other hand, at times the language barriers that ELLs faced meant that their ideas weren't taken up as readily by members of their group or by their teachers. For example, one ELL student created a fairly complex graph about the frequency of bullying incidents on the playground. When interviewed, the student

displayed pride in his work and enthusiasm for sharing his results. But because he received both language and special education support, he was often withdrawn from the classroom and thus his PAR work was not taken up in a broader way in classroom discussions or in the school as other students' graphs had been.

In another study of the participation of ELLs in a Grade 4 participatory action research project, Takeuchi (2011) found that "ESL students' participation was hindered because of the group dynamics" (p. 40) and that "despite the overarching learning goal stated by the teacher (which was to empower students as agents of change), opportunities to learn …were limited for those students who did not acquire the particular mathematical discourse" (p. 41).

The idea of exploring issues of social justice through mathematics was further reinforced during the fourth Culturally Relevant and Responsive Pedagogy session (January, 2010) where teacher candidates who were placed in the teachers' classrooms shared their equity-focused mathematics lesson plans (e.g., examining inequitable distribution of world resources through simulations, using geometry with community revitalization, investigations of maps and postal codes to create graphs of poverty levels). These presentations opened the conversation in the group to discuss incorporating social justice issues into their mathematics teaching as a way to raise students' awareness of social justice issues and to provide multiple entry points into the curriculum. In the Stimulated Recall Interview, Sally, the Grade 4 teacher, commented that this experience allowed her to "[bring] the two pieces together [mathematics and social justice]." In the final interview, Sally spoke enthusiastically about that particular session in relation to her professional learning:

> "It wasn't until when they [the teacher candidates] did that social justice workshop, I was like, wow, that was *really* exciting. So some of the awesome things they are doing in the class, making sure they get implemented in their classroom in which they're teaching because then it's a learning opportunity for the associate teacher to see what's new out there."

As well, Stewart, the Grade 5 teacher (who had been part of the Radical Math project in the previous year) talked about being inspired to incorporate social justice issues into all of his teaching. Teachers talked about the desire to create a resource of lessons with a social justice focus that related to particular mathematics strands in the curriculum. Not only did the PD support particular conceptualizations of equity, it also allowed teachers to formulate new views about the purpose of mathematics. This is an important piece of the equity puzzle because it supports teachers in looking at broader themes of equity within the school system and society which can help them restructure how they teach. Skovmose and Valero (2002) found that putting mathematical problems in contexts where students could think critically about important issues in their communities "is a precondition for problematizing 'trust in numbers' and learning mathematics in meaningful ways" (p. 398). Because students generated and represented the data, they built a relationship with numbers in a way that made sense to them.

Challenges that arose through incorporating social justice issues into the curriculum included how to engage young children with social justice issues in a way that didn't "burden them," (Tracey, Grade 1, Stimulated Recall Interview) and "how to communicate with parents around the controversial issues raised in the classroom" (Stewart, Grade 5 teacher, stimulated recall interview). In the second interview, Tracey

made a distinction between equity - which she felt had to do with fairness - and teaching for social justice which she said, "goes beyond that, I think, where it's also just making them aware beyond the classroom as well that there are injustices and we can do things to help balance out the injustice." Later in the same interview she said that she had "almost been discouraged focusing on social justice because I feel that so often we're looking at the problems in society…I feel like I'm burdening six year olds with our problems instead of – I mean I can see wanting to empower them as well, but…we've gone over the top and it's problems, problems, problems."

This conflict between wanting to empower students through making activism an explicit part of teaching but maintaining a positive classroom atmosphere with her Grade 1 students weighed heavily on Tracey. In this case, there was a disconnect between her understanding of why to change the curriculum (e.g., to raise students' awareness of issues and to provide access to mathematical ideas through exploring social justice issues) understanding of how to do this in a way that was age appropriate. By the final interview, however, Tracey reported that mathematics was "a good place to bring it [social justice in…it's a good way to bring in discussions about social justice just in general…making them aware of where things might not be fair, where we could be a little more, what's the word – equitable." She described data management in Grade 1 as a place to "compare and talk about why those differences exist."

Examining issues of power and implementing democratic processes in the classroom.

Many of the CRRP sessions involved discussions of power imbalances in society and in the school. As early as the first CRRP session (September, 2009), the presenters

talked about people being a mosaic of many identities and pointed out statuses associated with these identities. For example, the CRRP PD discussions focused on the way that some groups have more power and privilege in society and are thus "advantaged" while other groups are "targeted" (PD presenter, September, 2009). Teachers participated in activities where they examined how power and privilege played out in their own lives. The focus on power allowed teachers to participate in conversations around controversial issues and to investigate social justice issues that might affect communities in and around the school (e.g., the links between post codes and poverty). This was a way to help teachers (especially those teachers who did not live in the area where the school was located and/or shared no cultural history with the students in the school) to understand the characteristics of their community better.

As well, the seventh CRRP session focused on the power that "teachers wield" (PD presenter, CRRP, April, 2010) and how teachers come with their own biases and stereotypes; for example, the presenter of the PD session stated that even stereotypes that aren't as "blatant" can affect the way they teach. These ideas were reflected in the teachers' talk in the final interviews in which some of the teachers linked their explanations of equity with examining ideas of *power* in the classroom and seemed to inspire them to incorporate democratic processes into their day-to-day teaching and running of the classroom. For instance, Sally in Grade 4, Stan in Grade 2/3 and Stewart in Grade 5 talked about creating space for discussions that encouraged multiple perspectives and focused on student voice, as well as providing equitable opportunities for students to speak. Instructional practices included "making an opportunity for the students to actually voice what they'd like to see changed in the school and then to

actually be part of the process of changing it" (Sally, Grade 4, Final Interview). This view began to surface as early as the initial PAR training as evidenced by Stewart's comment: "Isn't the bigger picture to give children *voice*?" (PAR training, October, 2009). As well, during the final interview, the same teacher reported that PAR had given him the ability to begin "…looking at how to bring more kids' voice into their learning…and actually doing things with them where we're learning alongside each other." This was a very different form of participation than merely having access to the curriculum because it began to disrupt the usual power dynamics in a classroom where the teacher holds the full authority and decision-making power.

Sally described social justice as "definitely starting to understand *my* position of power and *their* [the students] perspectives of social justice" (final interview). Furthermore, teachers reported that a student-driven curriculum such as PAR shifted the balance of power between teacher and students and brought to life "the idea of giving the children the leadership and ownership to make change…and just giving them, giving them the skills and the power and what they can do with it. Because I hadn't thought of it before." (Leah, Grade 2/3, Final Interview). This was an important revelation in terms of teaching mathematics because it reflects a theory of learning in which student ownership of learning contributes to improved attention, engagement and retention.

Equity means: Acknowledging, honouring and connecting to students' lived experiences.

In the initial interview, Sally stood out as someone who had unique views about equity compared to her peers. She talked in the interview about trying to achieve equity by creating a bridge between the way mathematics was done at school and the way it was

done at home, thus valuing students' contributions in class and recognizing students' background knowledge and honouring alternative ways of knowing. In comparison, another teacher in the study compared students from her previous (more affluent) school "where there's a lot of background knowledge from home or stimulation from home" to her current students whom she felt brought a "lack of background knowledge from home." This second teacher's description of students was based on deficit views, in which students and families are described as lacking essential qualities necessary for learning.

The final interviews were striking in that although each of the teachers continued to link equity to meeting the needs of the students and "reaching all the kids in the best way possible" (Leah, Grade 2/3), their talk reflected a change in teachers' awareness of children coming to school with a background of community, family, linguistic and cultural knowledge and experiences. For instance, Leah linked equity with thinking about students "that have different perspectives and where they're coming from." In the final interview, teachers talked about how their participation in the Culturally Relevant and Responsive Pedagogy (CRRP) Seminar Series helped them look at equity "from a completely different frame of mind," (Stan, Grade 2/3 teacher) and linking equity with "understanding where they're [the students] coming from and what their background is and making sure their needs are met" (Tracey, Grade 1 teacher). As compared to Interview One, when only Sally (Grade 4 teacher) made a link between students' cultural competencies, now each of the teachers highlighted the importance of forging connections between home and school, by being aware of the languages spoken at home

to prepare for parent-teacher interviews, and by drawing on resources available (via members of the community or people who shared students' languages) to support ELLs.

This change was evident in each of the teachers interviewed and marks a change from the talk that occurred earlier in the school year. For instance, in the initial interview, one of the ways teachers tried to achieve equity in their teaching was by "not using Eurocentric names" (Stewart, Grade 5 teacher, initial interview). Similarly, Stan examined the mathematics textbook for examples of cultural relevance and changed the names of characters to reflect the cultural backgrounds of students in their classrooms so that "you could look to see if they're culturally representative of different cultures, even in the pictures" (Stan, Grade 2/3 teacher, Interview One). He also incorporated students' names into mathematical word problems as a way to increase their engagement. This pedagogical goal for student engagement was also a beginning way to have students see themselves reflected in the curriculum. However, in this initial interview, teacher talk didn't necessarily focus on the role a student's cultural background played in relation to the curriculum or how to build on a student's cultural competence.

In contrast, during the final interview, Stan reflected on how his ideas of race had changed due to his involvement in the CRRP seminar series. The series frequently focused on issues of race and in April focused specifically on exploring issues of power, bias and stereotyping. Teachers were shown the movie *Eye of the Storm* which tells the story of Jane Elliot, a teacher in Iowa who in 1968 introduced her third and fourth grade students to the effects of racial discrimination through a social experiment - *Brown Eyes, Blue Eyes* – dividing the class by eye colour and deeming those with a specific colour to be superior to those whose eye colour was different. The idea was that by experiencing

forms of discrimination, students would build awareness and some understanding of the issues. In the final interview, Stan talked for the first time in an interview about race in relation to understanding his students as part of a broader community:

> "Before [the CRRP PD], I might say something like, 'When I look at my class it's colourblind. And I don't see children of different colours,' where now I would say I really have to try my best to understand what it would be like to live in that child and to walk through that community and to be in that classroom."

This was quite a remarkable change for this teacher who earlier in the year reported that equity was low on his list of priorities. By acknowledging race as part of a child's identity, Stan's goal became trying to understand the multiple layers of a student's identity, and the consequences of student identity for learning mathematics. As well, this acknowledgement opened the door to the possibility of that teacher exploring issues of race and racism in society and thinking deeply about how those issues affect his students and his pedagogical decision-making.

Teachers described the students they had in front of them not just in terms of curriculum but from a more holistic perspective that included students' lives outside of school. For instance, Leah (Grade 2/3) shared a revelation about her responsibility toward students and their families: "It also dawned on me that *I'm* a part of their family. For that whole school year, you're completely a part of *each* family…So kind of seeing kids with their families before seeing them as your students." Stewart, the Grade 5 teacher reported that, "I think it [CRRP] helps your teaching because it makes you more aware of the kid that you've got in front of you, makes you more aware of the issues that they're dealing with."

Teachers' perspectives of students.

Having students come to see themselves reflected in the curriculum is a step toward seeing themselves as legitimate participants in the math community. Gutiérrez (2007) argued that equity in mathematics should include the goal that marginalized students would become increasingly able to participate democratically in society and to contribute to the field of mathematics. In the interviews, teachers reported that children were coming up with questions of concern, using mathematics to represent the issues, and using their graphs as tools for change in the school community. Such pedagogical approaches and supports in math instruction (developed with and for teachers and students) had potential to support and develop students' identities as doers of mathematics.

This led teachers to think about how to connect mathematics with students' lived experiences and issues of concerns in tandem with learning goals. CRRP not only helped teachers acknowledge a variety of students' needs but also helped them recognize the need to do their own awareness-raising while planning curriculum. Tracey's (Grade 1 teacher) comment below addressed this recognition:

> "And in this classroom that's understanding there's a student who has cerebral palsy, a student with autism, and some students that possibly have developmental delays and also students from different – a student that's ESL who's just arrived from Pakistan this year and making sure that I'm considering that when I'm planning. That they may have different needs that I'm not aware or that I need to be aware of or consider."

The most poignant example of this kind of teacher change took place when Leah (Grade 2/3) reflected on the way she had treated a student in the past:

> "I was so hard on this little boy because he was so slow and I was just impatient. Like he was always the last one in line and I just was not seeing it. It was my first experience and my previous school didn't have as many situations as this school has. So I was blind to it, I was naïve, I was ignorant to the whole thing. And that poor kid, I think I tortured him all year…He was bright but I wasn't, I wasn't seeing it the other way. He was bright in *his* way…I couldn't understand why he was so bright and not organized, and you know what I mean?"

Leah drew on this vignette to make sense of a new way of seeing the whole child, which was very different from the way she identified students earlier in the school year, where she tended to categorize students as 'clientele' or as having deficits: 'needy,' 'squirrely,' 'low.' She now talked about the individuality of each child, looking at children's strengths and ways of being and recognizing students' intelligences. Leah referred specifically to the third CRRP session as a pivotal moment in her professional learning that changed the way she viewed students in her classroom. In this session, teachers learned about the history of the community of Africville, Nova Scotia and the subsequent problems it faced during the displacement of the community. The PD focused on the effect of displacement on families, a piece of Canadian history not regularly taught in the school curriculum. Within this session, participants were shown the James Banks framework of lesson design to integrate the story of Africville into the language arts and social studies curriculum. As Leah pointed out, this particular session had a great impact on the way she thought began to think about her students:

> "I think with the discussions we had, especially with the Africville, the little lesson that we had, and just seeing the families and what they would have brought to school coming from that family. So kind of seeing kids with their families before seeing them as your students."

This view was very different from a deficit model that makes negative assumptions about where students come from and emphasizes students' and families' lack of knowledge (as was seen in earlier teacher interviews). In this way, the CRRP PD opened space to think about how "those systems of classification may also be problematized" (Little, 2003, p. 928-9). The CRRP experience and the students' PAR projects helped to counter deficit thinking by reinforcing the idea of looking to the community (and the people who live there) as funds of knowledge, as valued contributors to the life of the school – to its curriculum and ways of teaching and learning. In this way, it encouraged teachers to think deeply about students and families as contributing members of the school community., The CRRP PD created possibilities of knowing students in new ways (Brown & Franke, 2010) and provided an example of "an instance that embodies the optimistic premise of teacher learning community" (Little, 2003, p. 928).

Access to student thinking.

Access to students thinking also emerged as an important goal for teachers, especially when teachers didn't share the students' cultural backgrounds. "Students' explanations are their theories of how things work." (92). Thus PAR allowed teachers a window into students' thinking. By verbalizing their thinking, teachers could interact with students about their mathematical thinking. There was a recognition that students

might have a different way of knowing than that of the teachers. This focus on student thinking was an important shift in the way that teachers began to design learning environments to suit the needs of students because it could provide the motivation to design a progressive curriculum that was based on students' thinking, prior knowledge and interests. For instance, Tracey (Grade 1 teacher) explained how she made student thinking visible by creating learning environments where students discussed strategies for solving mathematical problems: "They're looking at one [math problem] and talking about it and then they share how they got their answer" (Final Interview).

In addition, when teachers paid close attention to student thinking, they become more aware of where students needed support and guidance to continue moving them forward along a learning continuum.

Individual teachers' conceptions of equity over time

Because of the theoretical framework of situated learning that frames this study, the unit of analysis was the group of teachers rather than individuals. However, it is interesting to consider both similarities and differences in the talk across members of the group because it highlights how individual teachers' conceptions of equity contributed to the overall teacher talk within this community of practice. Above, I focused on broad themes that described general trends for all teachers. In this section, I will describe some of the differences that arose.

In terms of where equity stood as a priority for teachers, differences appeared. For example, Stan saw equity as low on the list of priorities he had to think about for teaching mathematics: "To be really honest, it's something that you think about when somebody brings it up, but off the forefront it's so far down in the list of things that you have to

think about" (Initial interview). In contrast, Stewart saw equity and social justice as something that "would be in every part of the school day, every part of the school curriculum" (Initial interview). For him, equity meant respecting differences, focusing on big ideas, and developing students' computational fluency for access to problem solving. Further differences and similarities among teachers are reported below (see Appendix C for a detailed table of teachers' responses across interviews).

Tracey.

Time 1: Tracey's main conceptualization of equity, "making sure that every student has what they need," stemmed from her background teaching experience in special education and her concern for students who struggle with mathematics, especially students with exceptionalities and students whose second language was English. When asked what equity in mathematics meant, she said she was unable to think of anything for equity in mathematics specifically, but went on to say, "I think it's that every student is being allowed to go at their pace and being given what they need and the support that they need."

Time 2: Tracey continued with the idea that equity was "ensuring that everyone has what they need to be successful." She also discussed ideas of fair treatment ("equity does not mean equal treatment") and empowering students through exploring social justice issues.

Time 3: In this interview, Tracey spoke about equity as "meeting the needs of students and also them being aware [of social justice issues]".

Leah.

Time 1: For Leah, equity in mathematics meant: "just letting children know there are issues around us outside that we need to be aware of. Social justice, I don't know how to bring it in, maybe it's looking at learning styles, or having a variety of strategies available and letting kids know they're allowed to use the tools available, or not feeling terrified about math. I really liked math but when I hear adults' aversion to it, I feel sorry for them and I don't want to perpetuate that with my students."

Time 2: Leah linked equity with trying to "make sure every student starts at the same place, to reach them all, the ones that are struggling" and providing extensions for students who finished early in mathematics tasks that she presented.

Time 3: Leah continued to link equity with "reaching all kids" but went on to describe students "who have different perspectives and where they're coming from." She tried to see beyond behaviour to the whole child and looked at children's strengths and ways of being. She also linked equity with giving students ownership for their learning and incorporating social justice issues into the curriculum to promote social change. As well, Leah tried to develop students' palate for mathematics so they would have academic choices to pursue in the future.

Stan.

Time 1: As mentioned previously, Stan initially saw equity as low on the list of priorities he had to think about in teaching mathematics. Top on this split-grade teacher's list of priorities was the number of expectations in the mathematics curriculum and how to prepare his Grade 3 students for the provincial standardized testing. His teaching goals were to have ELLs and students who struggled become more independent in

mathematics, and his teaching in this area revolved around providing "almost continuous scaffolding one-to-one." He also referred to the idea of equitable access to resources for students and to examining the textbook for cultural relevance. He referred to his responsibility as a male teacher to provide balance in girls' and boys' participation in mathematics (e.g., calling on girls and boys equally to provide answers to mathematics questions he posed).

Time 2: Stan talked about providing access to curriculum and increasing student participation by designing multiple entry points for students in his mathematics lessons, integrating mathematics with other subject areas, and connecting mathematics to issues of relevance to children. By this interview, he commented that "But when you think about it, it's all about equity."

Time 3: Stan's main conception of equity was being aware of the children in terms of their community, family and cultural background knowledge. He was the only teacher in the study to make reference to race and commented on how he moved from being "colourblind" to acknowledging race as part of a student's identity. He continued to think of ways to provide access to the curriculum and to support ELLs' understanding of the language needed in mathematics. He worked to create a community of learners and talked about student-driven inquiry as a form of equity.

Sally.

Time 1: Sally's main conceptualization of equity revolved around "recognizing all of their [the students'] needs and trying to meet them where they are at, and provide for them, which is complex." She linked equity with inviting and valuing the strategies students used to solve mathematical problems, the contributions that they brought from

home or from their background knowledge (e.g., she was "impressed with the mathematical background knowledge they have") and creating a bridge between the way mathematics is done at school and the way it was done at home. She was one of the only teachers in the initial interview to mention that the way she tried to achieve equity is to "try to get to know them [her students] as individuals and find out where they are at and meet them where they are at."

Time 2: Sally's conceptions of equity included empowering students to "become agents of change" and exploring issues of social justice through mathematics to promote social change, thus changing the content of the curriculum. She used inquiry-based teaching to develop students' conceptual understanding and computational skills as well as their awareness of social justice issues.

Time 3: In this interview, Sally spoke often about examining issues of power within her classroom and creating a space for student voice. She tried to create a community of learners and explored democratic processes in group work and in designing curriculum that was relevant to students' lives. She spoke of her changing role and wanting "to be part of the orchestra, not just the director." She talked about the larger purposes of mathematics beyond curriculum coverage.

Stewart.

Time 1: Stewart described equity and social justice as something that "would be in every part of the school day, every part of the school curriculum." For him, equity meant respecting differences, focusing on big ideas, and developing students' computational fluency for problem solving. He discussed with students the difference between equity and equality and explained that equity means "you get what you need and

the other person gets what they need. Not equality where everybody gets the same thing whether they need it or not." He hoped that students' problem-solving skills in mathematics would transfer to positive decision-making skills in life. Stewart referred to gender equity, not about systems of inequity but about creating gender balance within classroom discussions.

Time 2: Stewart described building students' foundation of computational skills as a form of equity. He used issues of social justice as a way for students to do authentic problem solving in mathematics. He talked about fostering a community of collaboration and giving students ownership for their learning. He spoke about providing students with opportunities to contribute to classroom mathematics discussions and to balance the participation of boys and girls. He developed multiple assessment strategies and accepted "different opinions without judgement." His goal was for students to become "critical literacy thinkers" in mathematics.

Time 3: Stewart spoke in this interview about developing more awareness of students and the issues they might be dealing with and examined the idea of teacher bias. He focused on the changing role of teacher in an inquiry-based model that moved from "purveyor of knowledge" to "alongside learner." He tried to create space for students to feel comfortable to have a voice in mathematics and recognized knowledge that students brought to school. Stewart also integrated mathematics strands by focusing on social justice issues and "big ideas." He continued to talk about developing students' computational skills as foundation for further learning. He continued to develop multiple assessment strategies and to provide support for students who struggled and to provide challenges for high achieving students.

CHAPTER 6: DISCUSSION, LIMITATIONS AND IMPLICATIONS

Teacher talk revealed the complexities underlying the practice of teaching mathematics. Teachers seemed to struggle to achieve competing goals that were at times incommensurable, and contradictions in the practice of teaching that were perhaps inevitable; for example, I found that rather than subscribing to one particular conception of learning, teachers' comments and practices were aligned with a variety of conceptions of learning (e.g., from behavioural, cognitive, constructivist and sociocultural theoretical frameworks) and of equity. Thus, through their interactions with multiple professional learning opportunities, teachers subscribed to multiple competing views in relation to equity, curriculum, and pedagogy. My study took into account the struggles teachers faced as they tried to incorporate ideas from the PD into their classroom teaching, and in this way it responds to Apple's (2004) vision for research that suggests, "…no analysis of education can be fully serious without placing at its very core a sensitivity to the ongoing struggles that constantly shape the terrain on which the curriculum operates" (p. 244).

Through data analysis, the following themes emerged: a) teachers wanted to pursue inquiry *and* they wanted to carefully structure lessons and sequence mathematical ideas b) they wanted to meet students' needs *and* meet curriculum expectations, c) there were conceptions of equity that remained relatively constant over time *and* there were new conceptions of equity that emerged, and d) teachers critiqued some PD *but* were enthusiastic about others. Embedded in these themes were challenges around group work, standardized testing, and assessment of students, which loomed large in teacher discourse.

In this chapter, I summarize the findings in relation to the PD and to teachers' conceptions of equity by examining the challenges, tensions and possibilities that emerged when teachers took up ideas from the various PD contexts. I use the Communities of Practice framework to discuss the findings. I also discuss the limitations of the study and consider the implications for equity-focused mathematics education and for future professional development practices and research. Finally, I provide a conclusion to summarize the study.

In the sections that follow, I discuss the possibility of inquiry as a form of equity. I then discuss two main tensions that arose in the data: a) designing inquiry-based instruction based on student interests *and* the need for careful sequencing of mathematical ideas in order to meet curriculum expectations, and b) teachers critiqued some PD but were enthusiastic about others. Within the first tension, I discuss the following challenges that teachers faced as they tried to achieve equity in their mathematics teaching: a) challenges in changing the classroom culture in an inquiry-based approach, b) challenges in the teacher's changing role in an inquiry-based classroom, c) challenges in adopting group work in an inquiry-based classroom, and d) challenges in working with "big ideas" in mathematics. I then focus on the communities of practice framework to introduce the idea of the duality between reification and participation as a way to understand how teachers navigated the patchwork of PD opportunities in which they participated over the course of the school year. This sets the foundation for a discussion of the implications for future PD in which I examine the general theme of how teachers were left to their own devices to broker or navigate the

messages and ideas from each of the PD. Finally, I examine the limitations of the study and future research possibilities, and provide a conclusion to summarize the study.

Possibilities: Inquiry as a form of equity

Throughout the various professional learning opportunities, teachers were exposed to three different approaches to inquiry. Teachers' experiences with T-LCP, PAR and ICS allowed them to develop the idea of inquiry as a form of equity. The PAR PD demonstrated the kind of learning that could occur when curriculum was built on issues of concern for students. The ICS PD demonstrated the kind of learning that could occur when curriculum was built on students' interests. And the T-LCP PD demonstrated the kind of learning that could occur when evidence of student learning was the focus of curriculum design.

One of the major ideas taken up from PAR was the importance of changing the content of the mathematics curriculum to build on students' interests, ideas and issues in order to promote social change (with the by-product that students were able to access higher level mathematics). Many of the teachers commented on the idea of students becoming more involved in the design and implementation of the curriculum. In this way, inquiry became a form of equity and was reflected in the teacher's comments about children playing a role in the direction of the curriculum. Teachers argued that PAR was powerful because it allowed students to express their interests and to work towards positive change at the school.

In contrast, the T-LCP approach began with a focus on specific curriculum expectations, and teacher inquiry involved the grade level team choice of texts in order to get at enduring understandings (compared to students' interests or ideas at the centre of

curriculum design). Although the ICS PD session was not explicitly focused on issues of equity, teachers commented on similar teaching strategies used to develop inquiry-based lessons that capitalized on student interests. In the final interview, teachers talked enthusiastically about the ICS visit (05/19/10) and its inquiry-based philosophy and its focus on discussions in classrooms as an alternate way to meet curriculum expectations. Tracey, the Grade 1 teacher, described how the Kindergarten bird and flight study "wasn't a planned activity, it was something that the students had shown an interest in and started questioning so she [the Kindergarten teacher] took that interest and built the unit around it which the students were very engaged in…it wasn't a pre-planned, pre-chosen text and activity."

This new inquiry stance affected teachers' pedagogical decisions in how to structure the classroom and how to consider issues of power when creating curriculum that was more participatory and accessible. This was an important revelation because it implied a change from focusing on students in relation to achievement and curriculum goals to moving beyond the walls of the classroom to think about how students' lived experiences affect their participation in the classroom.

In both cases (ICS and PAR), teachers commented on the value of having models of this type of instruction and involving students in projects "that make a difference to the communities that they value" (Wenger, 1998, p. 10), rather than what Sally (the Grade 4 teacher) referred to as "a small scale focus" on "covering the curriculum." Stodolsky (1988) studied patterns of student involvement and found that students were "more involved in activities that were complex, entailed collaboration with others, and conveyed novel or needed information, and less involved in activities that were simple, solitary, and

characterized by information that was already known, easily surmised, or redundant" (p.103).

Tension 1: Designing inquiry-based instruction based on student interests *and* the need for careful sequencing of mathematical ideas in order to meet curriculum expectations.

Through their participation in the multiple PD contexts, teachers took up two potentially contradictory ideas: the need for instruction to be inquiry-based and relatively student driven, and the need for careful sequencing of mathematical ideas in order to meet curriculum expectations. They moved back and forth between talking about the benefits and costs of inquiry. Embedded in the teacher talk were tensions between engaging students in big ideas (as they had learned in T-LCP) within disciplines and coverage of curriculum. They were enthused by levels of student engagement and participation that came through inquiry-based learning and acknowledged a desire to follow the path of an idea-driven curriculum - and they seemed to view it as the 'right' path to take. Embedded in this theme was the teachers' view of their responsibility to meet the academic and emotional needs of their students.

However, meeting the demands of the curriculum and the educational system (e.g., writing report cards and preparing students for standardized tests) were also an everyday reality for teachers that propelled them in the direction of more teacher-directed, procedure-based activities in their mathematics teaching. In this way, the findings suggest that teachers were caught between what Judith Warren Little (2003) referred to as "the lure of innovation and the force of tradition" (p. 939) and how the two "seem simultaneously and complexly at play in the teachers' everyday talk" (p. 940).

Furthermore, the goal of careful sequencing of mathematical ideas to meet curriculum expectations (and to prepare students for the EQAO) meant that teachers drew on programs of instruction such as JUMP that were based on a "top-down analysis" (Hiebert & Carpenter, 1992, p. 83) which didn't make contact with what students already knew and tended to fit students into the curriculum. Although teachers changed the content of the curriculum and integrated mathematics with other subject areas through their PAR projects, for the most part mathematics was taught as a stand-alone subject that entailed a carefully sequenced set of skills to be mastered. As well, teachers struggled with pedagogical decisions such as whether students needed to master computational fluency before gaining access to conceptual understanding, or how to use group work effectively in their teaching.

Challenges in changing the classroom culture in an inquiry-based approach.

Teachers tried to foster a community of learners (e.g., "to enlist the kids' help in helping each other" – Stewart, final interview), in this way revealing an expression of learning as the social construction of knowledge. This, too, brought contradiction as teachers reported mixed feelings about being in the role of co-learner with students rather than the role of knowledge authority that they had been accustomed to up to this point. Although acknowledging the positive aspect of being a co-learner, teachers also expressed doubt. Leah expressed concern about how her students might view her if she wasn't the holder of knowledge:

> "I think teaching them that I was learning as well is really helpful to them. I don't know everything, and we're always learning together and I think that's the

message that we sent there, I hope. I hope they don't think 'oh my teacher doesn't know anything.'"

The comment above demonstrates that when trying to build a community of learners and distribute power, teachers may feel powerless or judged by the students and families as not having intellectual authority.

Challenges in the teacher's changing role in an inquiry-based classroom.

One of the tensions to emerge in adopting an inquiry approach was the competing roles of teachers as typically "agents of knowledge" (Stewart, PAR PD, October, 2009) as compared to the role of teacher as participant in a knowledge building community which they referred to as "a facilitator" (Leah, Final interview), "an alongside learner" (Stewart, Final interview), and "part of the team not the coach" (Sally, Final Interview). In terms of a teacher's role in a knowledge building community, Stewart pointed out that "teachers weren't trained in this and didn't feel comfortable in that role" (PAR training, October, 2009). Stewart reiterated this tension during the final interview when he commented on his changing role in the classroom:

> "I truly think that when you do this work [PAR], what happens in the process is that the students start taking more ownership so there's times where you step back from that role of teacher as purveyor of knowledge and you participate in the acquisition of the knowledge."

However, later in the same interview he reported a contradictory view when referring to how he approached mathematics teaching in his classroom: "OK I have to teach you [the students] this. I have to actually purvey this knowledge before you get started because you need to have a base."

In Stewart's changing view of his role as an educator, phrases such as "stepping back" and "just sort of let them go" reflected some uncertainty as to what teaching in an inquiry model would look like in practice. In their attempt to relinquish some control of curriculum and to create a democratic space in the classroom, teachers seemed to see inquiry as anti-direct instruction. Richardson (2003) points out that inquiry is sometimes taken up as "laissez-faire nonteaching" (p.4) which has prompted policy makers to replace inquiry with back-to-basics approaches. This points to a need of developing models of what inquiry might look like in classrooms that are able meet the requirements of the system while at the same time honouring the ideas-centred goals of inquiry (if this is possible).

Challenges in adopting group work in an inquiry-based classroom.

The study also raised issues of who gets to participate in mathematics. Although inquiry-based approaches look inclusive, some of the factors such as group work prove difficult for ELLs and students who struggle in mathematics (Takeuchi, 2011).

Teachers spoke about creating a variety of participation structures to nurture collaborative group work and set up a community of learners "to enlist the kids' help in helping each other" with mathematical problem solving activities. Although teachers talked about the benefits of group work in an inquiry-based approach, they also talked about recurring challenges. For instance, teachers questioned what to do with students finishing at different times and how to keep all students in the group on task. During the Stimulated Recall Interview, Sally (Grade 4) viewed her introduction with students about creating surveys about recess issues and how it was "tricky to get them [the group of students] to work," or how particular groups of students "just had a hard time focusing

and coming together." She was also concerned about how many students should constitute a group for a particular assignment. The challenges with group work grew greater for her as she tried to find equitable ways for ELL students to participate in group work. In the final interview, she described group work as a complex endeavour:

> "But it's a double-edged sword because I'm worried that instead of really learning math, they're just sort of copying or going along with what the other student has. Not really understanding the math. So, I don't know. There's going to need to be some strategies. But eventually that has to become something because they need to work in groups. So, we'll keep working on it."

This quote illustrates the tension teachers reported, between teachers' efforts to create equitable group work environments and yet assess individual students' understanding.

Stan, the Grade 2/3 teacher further questioned the issues in the practice of group work, and the implications for student participation:

> "I mean you have to think about the pairings – how are you going to pair them? Is it going to be ability-wise, like you want people who are really strong helping out the other people, but I think when you pair two children together you have the child that has the firm understanding of the concept and then you've got another child who even if they have a pretty good, firm understanding, just let the other child do it" (Final Interview).

Although Stodolsky (1988) argued that "teachers do not think group work is an effective way to attain individual mastery of mathematics…" (p.109), by the final interview, teachers spoke more positively about the potential of group work to build a

community of learners in the classroom as a way to provide access to higher level mathematics. For some teachers, group work provided a structure that allowed students to build trust with one another as they worked on mathematics problems together. However, group work continued to pose challenges. Tracey (Grade 1), for instance, explained that in her mathematics teaching, "as soon as I leave that group that needs intense support, there's nothing getting done at that group." On the other hand, she reported progress - "We're getting there so that they're actually showing the other person how they're getting the answer and what they're doing and working through it with them"(final interview). As well, Sally said that at times, the complications of group work outweighed the benefits of inquiry and caused her to rely on individual seatwork for students.

Tracey found assessment more difficult with the shift to group work because she focused less on "worksheets and individual work" and more on actively engaging students through "more partnering, group work, hands-on, word problems, more discussion…" and there was less evidence of individual, paper-based mathematics. This lack of individual mathematics work affected Tracey's communication with parents, and she pointed out that "You don't have as much, I find, to show parents and when it comes time to assess it's a little more challenging." Her comment was interesting because it wasn't so much that the assessment was challenging (because she saw that students were "getting" the mathematics) but the challenge was in finding work samples to demonstrate a child's understanding to their parents. Moving toward more diversified forms of assessment could be a next step for this teacher.

Teachers raised concerns about group work, and their comments showed how teachers were able to trouble the normalcy of practices in the mathematics curriculum

that reflect and create consensus and look like common sense but are embedded with meanings and assumptions (Apple, 2004). For instance, group work is a given in reform mathematics, but teachers reported that to do group work, students need to be able to know how to work well together as well as the content knowledge needed to contribute to the group. None of the PD offered teachers ways to structure groups in ways that promoted equity. More attention needs to be given to providing teachers with concrete ways and reasons to form groups and to support effective group collaboration.

Challenges in working with "big ideas" in mathematics.

Although they were enthused with the inquiry approaches they were introduced to in the various PD, focusing on big ideas in mathematics didn't come easily for teachers. Leah (the Grade 2/3 teacher), for instance, reported the difficulty in being able to discern between big ideas in the mathematics curriculum and ideas or concepts that were less important to focus on.

> "But it's for me, as a teacher it's figuring out the main idea, the big idea of the concept and I'm still I guess I don't spend enough planning time or I don't give it enough thought until I'm in the crunch that I find that I'm always struggling, you know what I mean? To make sure I've got the big idea and not the little things. There's some things that I think aren't super important to dwell on but it's figuring out what the important part is and what you can toss away, you know what I mean?" (Final interview).

This raises the issue of how best to support teachers in learning which ideas are worthy of taking up in the mathematics curriculum. PD that develops teacher content knowledge would be an important step in learning the big ideas in mathematics. As well,

teachers were conflicted between inquiry where "the learning is so incredible, but how to keep it going and do what you need for the system."

Tension 2: Teachers critiqued some PD but were enthusiastic about others.

Although teachers critiqued the T-LCP for being too rigid and lock-step, they were enthusiastic about JUMP which was also lock-step, not designed to be student-driven, and based on teachers following a set schedule of activities. They dealt with this by modifying JUMP and deciding when, where, and how to use it, as opposed to the T-LCP where they did not seem to be able to modify the approach. There were a number of possibilities for this reaction. First of all, JUMP came to the school via a group of teachers and was therefore a ground-up PD as compared with the T-LCP which was ministry-mandated PD and therefore top-down. Farrell's (2005) work in international settings shows cases of changes that were not dictated from above, but instead through an innovation-diffusion process – teachers learning from other teachers, sharing professional practical knowledge and teaching skills, and exploring how their shared knowledge could help curriculum. Similarly, Tracey's involvement with the Wondernet PD, formed by a group of primary grade teachers in her family of schools, was based on issues that teachers themselves deemed important and provided the impetus to work on. This PD was organized by and for teachers and included special guests with expertise in primary grades' mathematics.

One of the limitations of my study was that the focus on the T-LCP for the year was on literacy. Perhaps because the focus of the T-LCP was on literacy and teachers in general have skill in teaching language arts, they may have found that the lock-step approach simplified the more complex instruction they generally used in literacy

teaching. However, if a similar process was used with a focus on specific expectations in mathematics and use of students' work to examine practice then perhaps that would have made a difference and may have contributed to developing teachers' content knowledge in relation to specific strands of mathematics.

Communities of practice

I draw on Wenger's (1998) theoretical framework of Communities of Practice, as well as related literature, to enhance my understanding of the meanings teachers made of equity and their PD experiences in relation to their teaching practice. From a sociocultural perspective, the practice of teaching abides in a complex system that is historically, politically, and socially situated. Participation in multiple contexts shapes what teachers teach, how they see themselves and how they make meaning of their work. There are many factors and demands on teachers that influence their conceptualizations of equity in mathematics and the pedagogical goals and decisions they make on a moment-to-moment, day-by-day, month-to-month and year-to-year basis. These factors include the social interactions in which teachers are involved within their professional lives with students, families, other teachers, the school and its administration, the school board, the provincial ministry, and professional development (PD) opportunities all in relation to the design and implementation of curriculum. Within each of the many contexts in which teachers find themselves participating, there exist rules, roles, routines, goals, artifacts, practices, slogans, histories, stories, and underlying theories of learning. For instance, Little and McLaughlin (1993), in their study of professional development found that: "Classroom practices and conceptions of teaching are not predetermined or invariate but emerge through a dynamic process of social definition and strategic

interaction among teachers, students, and subject matter in the context of a school…" (p. 99). In this study, PD was the vehicle or environment through which teachers changed their perception of practice through the lens of equity.

What is unique about this study is that by looking at multiple contexts of teachers' professional learning, it takes into account an area that has been identified as lacking in the literature, namely "theoretical models that fail to account for…the ways in which the multiple contexts of teaching – students, subjects, fellow teachers, school, and community – form compatible and contradictory grounds for teachers' work" (Little & McLaughlin, 1993, p. 185).

The Duality Between Reification and Participation

As teachers tried to implement a mathematics curriculum equitably, the tensions that arose formed what Wenger (1998) would call the duality[13] of *reification* and *participation. Participation* refers to the teachers' social experiences and involves building an identity through negotiating meanings of experiences as members of their teaching community, both in the school, in the educational system and in the PD. *Reification* refers to giving form to those experiences, "by producing objects that congeal this experience into 'thingness'" (Wenger, 1998, p. 58). In this way, the community of practice produces a "projected reality" (*Ibid.,* p. 59). In my study, this projected reality had to do with teaching mathematics more equitably, a concept that hadn't previously been addressed explicitly in this particular community of practice.

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[13] Duality: "…a single conceptual unit that is formed by two inseparable and mutually constitutive elements whose inherent tension and complementarity give the concept richness and dynamism" (Wenger, 1998, p. 64).

The messages taken up in the PD were transformed through the teachers' practice. For example, in my study the idea of equity is a reification that is defined and redefined through the teachers' participation in the community of practice that is trying to understand it. In order for a reification to become meaningful, such as trying to make meaning of equity in mathematics, the participation of teachers is required. Conversely, reification of concepts is necessary to make up for any limitations in participation alone. PD that takes this duality into account could be a very powerful context to support new ways of teaching mathematics more equitably because design for learning means combining the dualities productively (Wenger, 1998).

Teachers' conceptualizations of equity were often reified by a phrase, such as "reaching all students" or "equity does not mean equal treatment," both of which were directly related to the Ministry's definition[14] of equity and the one that was promoted by the school board and reiterated often through the CRRP seminar. This common phrase provided an anchor for teachers to talk about how to address student need. Similarly, "students as agents of change" was a common phrase used in the T-LCP workshops and "the brain can do almost anything if it practices" (JUMP workshops). The act of reifying the concept of equity through creating phrases or slogans can act as an anchor to help teachers to think about what equity means and can support the process of integrating the concept into their practice. Reification is powerful because it makes concepts succinct and portable (Wenger, 1998). But at the same time, slogans can become substitutes for deeper understanding and commitment. As Wenger points out, if the reification becomes

[14] The Ministry of Education defines equity "as a condition or state of fair, inclusive, and respectful treatment of all people. Equity does not mean treating people the same without regard for individual differences" (from Ontario's Equity and Inclusive Education Strategy, 2010).

disconnected from practice, it becomes "an ironic substitute for what it was intended to reflect" (p. 61). For instance, the common slogan used in JUMP, "the brain can do almost anything if it practices" could unwittingly set up inequitable opportunities for students to engage in mathematics because it takes the focus away from examining systems of inequity in society and in the classroom and puts the onus on the child to catch up through practice (which could mean being excluded from the kinds of rich mathematical problem solving activities that develop conceptual understanding). That is why it was important for me to delve deeply into what teachers meant when they used certain phrases as explanations for equity and to examine how the slogans related to providing equitable opportunities for students.

Navigating the PD through Reification and Participation

The PD provided a patchwork of practices and concepts that teachers wove into their pedagogy. Ideas that teachers took up from various PD were at times conflicting, and teachers were left to their own devices to make sense of how and when to use them. Teachers seemed to prioritize ideas that best supported their practice or alleviated the greatest demands on their use of time. Little and McLaughlin studied teacher professional development (1993) and found that "context matters and locally shared interpretations of practice, for good or ill, triumph over categorical and abstract principles" (p. 188). In their study, participation won out over reifications. In my study, teachers often combined PD efforts and made changes to the implementations to fit the community of learners in their classrooms or fit the demands of the system (e.g., meeting curriculum expectations). At times, this seemed contradictory: for example, in the classroom observations, I found examples of teachers dividing their 50 minute mathematics period into two distinct

approaches to teaching: a teacher-directed JUMP approach for the first 20 minutes of a lesson followed by an inquiry-based PAR approach for the remaining 30 minutes. Although the competing goals of the PD seemed to be incommensurable (e.g., in PAR, building curriculum up from students' ideas and JUMP, breaking mathematics down in to sequential steps), teachers seemed willing and able to live with contradictory messages they were receiving.

What is really interesting in Wenger's (1998) approach to duality is that he doesn't see them as opposites. This can help to explain how the teachers navigated through the messages they received. Depending on the goals they were trying to achieve in their teaching, they used various approaches and dropped others. For instance, Sally (the Grade 4 teacher) described how she was able to combine JUMP with an inquiry-based approach:

> "For long division I started with a question, just inquiry-based, how are they [the students] going to solve it, just to see what all of their strategies were. We talked a *lot* about the strategies, listing the strategies that they're using, what works, what's successful, what's not" (Final Interview).

This is an example of how a reification can take on a life of its own beyond the context of its original intended meaning. In this way, Sally used the reifications of PD such as JUMP and PAR or ICS and navigated the tensions between them through her participation with them in her classroom teaching, thus changing her practice *and* the reification of both approaches. Thus, the community of practice began to develop a language of critical consciousness which could be used in examining curriculum and making pedagogical decisions. In this way, the community of practice was a helpful

context for figuring things out rather than community of practice as clique, distancing people from alternate ways of doing and thinking (K. Bickmore, personal communication, March 7, 2011).

As Wenger (1998) writes, "if participation prevails, if most of what matters is left unreified – then there may not be enough material to anchor the specificities of coordination and to uncover diverging assumptions" (p. 65). That is why just giving teachers reifications (lessons with a social justice focus, or a T-LCP procedural framework, or a JUMP workbook, or a set of inquiry-based lesson plans) is not enough. Teachers need opportunities to test out the ideas in practice in the contexts in which teachers teach and to discuss and debate ideas as they relate to practice. On the other hand, if there is too strong an emphasis on reification, especially when there is "little opportunity for shared experience and iterative negotiation – then there may not be enough overlap in participation to recover a coordinated, relevant, or generative meaning" (p. 65). In this way, CRRP's lack of concrete connection to classroom practice meant that that the emphasis of the PD sessions was on reification, and teachers had difficulty making meaning without being given opportunities to test the ideas in practice.

JUMP's teacher's guides offered the 'projected reality' or reification (that JUMP's founder intended) but these were not always used by each of the teachers in the study and in some cases, the workbook was relied on as the sole instructional strategy. According to Wenger, the limitations of an artifact alone (in this case the workbook) can cause the interpretation of the idea behind it to be distorted. Although JUMP's founder stressed the importance of using the teacher's guide when implementing the program, his ideas of how to build students' conceptual understanding were at times replaced with

activities from the student workbook that focused on procedures alone. In this way, teachers weren't using the artifact in the way it was intended.

According to Wenger, in order for there to be a complementarity between participation and reification, people and artifacts should travel together. In other words, participation with the artifact or reliance on the workbooks alone is not enough. JUMP's founder projected meaning (his understandings of mathematics and how it should be taught) onto the workbooks. Without PD that creates space for teachers to move between participation and reificiation, the receiving community (the teachers) are left to make their own interpretations. The balance between participation and reification needs to be redressed in order for there to be a negotiation of meaning. This has significance for future PD related to JUMP. Rather than simply receiving training in the JUMP method, teachers need to be given time to use the program in their classrooms and use PD time to debate the contradictions that arise, collaborating on ways to make the program work with the students they have in front of them. The next step for JUMP would be to develop its use in problem solving and inquiry-based approaches. This travel between participation and reification has potential to build shared knowledge within the community of practice.

PAR provided opportunities for teachers to create projected realities through a combination of reification and participation. Evident in the teacher interviews was a tension that arose around the struggle between making PAR a student-driven, idea-focused process and taking a more teacher-directed and task-oriented approach. In practice, the PAR projects became both teacher-directed and student-driven. They were teacher-directed in that students were guided to formulate what were considered to be

"good" survey questions (i.e., questions that were 'answerable' and that were formulated in a way that would prevent bias) and to follow a list of instructions in creating surveys and collecting data. Thus, in practice, teachers by-passed PAR's focus on trusting students' ability to create questions and answer concerns to a more curriculum-focused and teacher-directed approach which involved an emphasis on the conventions of graphs and question formulation as compared to the function of graphs. Because student outcomes were difficult to predict from the outset in the PAR projects, teachers may have resisted relinquishing control of the design of the project. Teachers dealt with this by assigning students a "culminating activity" from the outset - an 'action' component involving students sharing their graphs with the principal with the idea of making positive change in the playground. Social action is an important aspect of PAR and in PAR's 'pure' form, students would decide on the action as part of having ownership over the design of the research. In this case, teachers decided what the action piece would be.

On the other hand, PAR was student-driven in the sense that students generated questions of interest (albeit guided by the teacher) and used their graphs to discuss the data they gathered and to interpret their results. Even though the above approach seemed contradictory to the 'rules' of PAR and the reification of it - where students were to have complete control of the questions to ask and how best to represent the data - many students seemed to exhibit ownership and pride in their work as they discussed their results with parents, researchers, and in the Grade 4 classroom with the principal in a 'town-hall meeting' format. In this way, the reification became changed through the participation of teachers and students in the classroom context, thus creating a changed reification.

Participatory action research as a professional learning system provided the beginnings of a paradigm shift in the way that teachers in this diverse urban school approached pedagogy in their math teaching. The PAR project captured the imagination of the teachers as they built their pedagogical knowledge in mathematics teaching in parallel with their students driving the curriculum toward the shared goal of improving recess. When teachers used the local cultural context to connect and engage students with mathematical ideas, they were developing a culturally responsive curriculum (Ladson-Billings, 1995) that builds on students' cultural competence as a way to explore students' mathematical thinking and a way to understand the communities in which teachers teach (Ladson-Billings, 1995). The schoolyard mapping activity in PAR reflected the idea of *pedagogy of place* or place-based education which has been defined as the right "to live well in the places he or she inhabits" (Gruenewald, 2005, p.8), connecting mathematics to a sense of place as well as identity and experience. The activity demonstrated how "lived experiences can become validated as a source of knowledge" (Gonzalez etc. p. 42) and helped to move teachers from an essentialist view of groups of students (special needs and ELLs) toward understanding individuals and their participation in cultural communities and activities as a pathway to learning. PAR and CRRP offered different forms of participation for students than merely having access to the curriculum *as is* because it began to disrupt the usual power dynamics in a classroom where the teacher holds the full authority and decision-making power. This is an important piece of the equity puzzle because it supports teachers in looking at broader themes of equity within the school system and society which can help them restructure how they teach.

However, as was reported in Chapter 5, even an approach that is supposed to be transformative and redress power issues such as the PAR PD raised issues of whose ideas get taken up in the classroom (Takeuchi, 2011). As George Dei (2006) points out, just because you have included everyone at the table it doesn't mean that they will all have equitable opportunities to participate: "Inclusion is not bringing people into what already exists; it is making a new space, a better space for everyone" (p.2).

Implications for future PD

A major finding was that although single forms of PD may have been of high quality, the effect for teachers was contradictory. Teachers were left to their own devices to navigate through the various PD without a guide to help them make sense of the different messages they were being given and that existed simultaneously in their practice and to allow them space to work with the ideas. This raises questions about the importance of coherence across PD. None of the teachers complained about lack of coherence in their interviews, but instead took up some of the ideas and left others behind or created a new version of the PD message. For instance, teachers struggled to understand inquiry in contrast to more traditional forms of teaching.

The provincial government and local school board are putting a lot of money into developing PD for teachers to narrow the achievement gap. Findings from my study suggest that there needs to be a kind of brokering between the multiple contexts of professional learning, otherwise not every teacher develops a shared understanding of what the PD is trying to achieve. According to Wenger (1998), brokering involves the idea of "multimembership" (p. 109) and allows elements of one practice to be transferred to another. For Wenger, it is the boundary encounters, or weaving of boundaries and

peripheries that creates the tension where new learning can emerge. "Brokers are able to make new connections across communities of practice" thus enabling coordination, translation and "open new possibilities for meaning" (Wenger, 1998, p. 109). By asking teachers to reflect on ideas of equity in their practice and between PD, I took up the role of a broker on a certain level.

The role of a PD broker could help draw attention to certain ideas that compete with the goals of education that need to be contested. For instance, the idea of having to reach computational fluency before participating in 'real' mathematics means a focusing on the mechanics of learning at the cost of meaning (Wenger, 1998). Similarly, Schoenfeld (2002) argues that it is necessary to "counteract the very common misunderstanding that in mathematics students have to master skills before using them for applications and problem solving" and that "with well-designed curricula, it is possible to teach for understanding without sacrificing procedural skill" (p. 23).

Wenger (1998) argues that the kinds of meanings that students find worthy of investing themselves in are "those meanings that are the source of the energy required for learning" (Wenger, 1998, p. 266). The PAR project provided an example of the kind of mathematics toward which students generated energy. As well, they developed numeracy skills as a by-product of their work to improve the conditions of the playground which relates to Wenger's (1998) claim that "when the meanings of learning are properly attended to, the mechanics take care of themselves" (p. 266). In this way, teachers saw how computational fluency and conceptual understanding could work in tandem rather than as separate entities.

This study has implications for future PD. Whether PD was mandated, or teachers volunteered to participate or were "voluntold" (Stan, Initial Interview), they seemed to take up ideas from each session offered. The idea of a PD broker for schools is one that may be difficult to implement but seems necessary considering the number of PD activities in which the teachers participated over the course of this school year. A broker could capitalize on the PD contradictions. Principals or vice principals could act as brokers and use structures that are already in place at schools (e.g., monthly staff meetings) to provide a space to debate and discuss the contradictions. In this way, a broker could support teachers in lessening the distance between what they learn in the PD and what they practice in their classroom mathematics teaching. It is important that in the future PD be coordinated to achieve the greatest effect for supporting teachers as they support and understand how students learn.

The findings suggest that teachers need PD that provides concrete examples of how to implement inquiry-based programs that build on students' lived experiences while at the same time structuring lessons and sequencing mathematical ideas to meet curriculum expectations and to develop students' conceptual understanding and procedural fluency. If PD just provides examples to teachers, that is only passing on a reification (one side of the participation-reification duality). In order for learning to take place or for teacher change to occur, participation and reification need to be combined.

Crucial to any successful PD program is the development of teachers' understanding of the mathematics and their pedagogical content knowledge (Ball & Bass, 2003). As well, teachers need to be given the time and space to test out ideas or reifications in their practice and to contribute to the research about how to teach for

equity in mathematics. They need to have sustained PD in which they build knowledge based on their practice and that are "grounded in teachers' investigations of children's mathematical learning" (Little, 2003, p. 919). The CRRP provided sustained investigation into issues of equity facing students, families, and communities because teachers spent the most hours in that PD. The CRRP PD also influenced their conceptualizations of equity as shown by changes in their talk during the stimulated recall interview and final interview. If the T-LCP focused on mathematics and equity, it could provide the potential for sustained investigations into student thinking and teacher inquiry into research-based equitable mathematics practices. Conversely, if CRRP focused more specifically on mathematics curriculum and equitable mathematics practices in conjunction with its strong foundation in equity issues, it could be a very powerful PD for teachers.

Although there were conflicting messages, teachers managed to live between PD worlds, using what they found useful and dropping what wasn't, or creating hybrid instructional practices to aid in their pedagogical decision-making. This phenomenon can be explained through Wenger's (1998) words:

> "In practice, understanding is always straddling the known and the unknown in a subtle dance of the self. It is a delicate balance. Whoever we are, understanding in practice is the art of choosing what to know and what to ignore in order to proceed with our lives" (p. 41).

The nature of the PD influenced the ideas that teacher took up, and this has implications for the development of future PD. For instance, there was teacher buy-in with PD that offered concrete ideas to use in the classroom and provided what teachers saw as new ways for students to access the curriculum (e.g., PAR, JUMP, ICS) because it

supported what they were already doing in the classrooms. In contrast, T-LCP offered a framework for how to take an inquiry approach to teaching, but it didn't offer concrete ideas of how to get there. Teachers also responded positively when they could see pedagogy in action and observe students' responses to a mathematics lesson (JUMP, ICS). Teachers were conflicted in their reporting of the T-LCP. They reported favourably about how it allowed them to form a professional learning community within the school (T-LCP) and draw out big ideas in the curriculum and examine student work as evidence for learning. PD that made students' thinking visible and showed students to be more capable than expected seemed to inspire teachers (PAR and ICS). Finally, PD that revealed inequities in society seemed to change the way that teachers talked about students and thought about curriculum (CRRP/PAR).

Effective PD would build on current research literature around creating equitable teaching practices for marginalized students and reform ideas in mathematics in which effective approaches have been developed. Again this raises the importance of having a person or system in place to help navigate these approaches into something that teachers can use in the contexts in which they teach. Future PD that combines teacher content and pedagogical knowledge, that develops teachers' awareness of the political nature of teaching, and "that allows examinations of assumptions about practice, focuses collective expertise on solutions based on classroom realities, and supports efforts to change and grow professionally" (McLaughlin, 1993, p.98) could be very powerful PD. Further, because children need "access to rich opportunities to learn mathematics with the cultural resources that they bring to school" (Confrey, 2010, p. 25), teachers need concrete examples of what this might look like in their classroom practices. These communities

are essential "to changing norms of practice and pedagogy in ways that benefit both students and teachers" (McLaughlin, 1993, p.98). In this way, a community of practice with an inquiry and equity stance could leverage policy. Policy that supports inquiry must take a knowledge building stance itself. However, this is easier said than done because policy initiatives are usually done on a large scale and an inquiry approach would be difficult to disseminate and assess.

Implicit messages are often communicated by and to teachers about which mathematical strategies are valued in school (Werner, 1991). Sally (the Grade 4 teacher) demonstrated to her students that she valued the mathematical strategies that they brought from home which is different than how the valorization of school practices are often not questioned because they are seen as superior to any other method (De Abreau & Cline, 2007). Therefore, it is important to develop professional development for teachers that emphasize a variety of ways of thinking about mathematical concepts and the many cultural contributions that have been made in the discipline of mathematics (e.g., ethnomathmatics[15]). Ideally, professional development would allow teachers to share ideas as well as provide new ideas that support teachers in building an understanding of how to develop a more equitable mathematics program for their students in their unique setting.

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[15] *Ethnomathematics* is a term developed in the 1970's by Brazilian professor Ubiratan D'Ambrosio and highlights the intersection of mathematics and cultural anthropology. Gelsa Knijnik (1997) uses an *ethnomathematical approach* to support marginalized groups in interpreting and decoding knowledge produced by academic mathematicians, "…thus being able to analyze the power relations involved in the use of both these kinds of knowledge" (p. 405).

Effective PD would involve reform mathematics *plus* equity, following Gutstein's recommendation for what is needed to become an effective mathematics teacher: content knowledge (Hill and Ball, 2004), pedagogical content knowledge and curricular knowledge (Shulman, 1986), knowledge of one's students and the community in which one teaches (Ladson-Billings, 1995) and knowledge of the sociopolitical, economic, and cultural-historical workings of society. The results of my study suggest that as important as this endpoint of knowledge for teachers is, the process of teacher learning is equally important. By following teachers' experiences in multiple professional development contexts and examining how they integrated these experiences with their classroom practices, this study showed how professional development can be seen more broadly. Teachers are always developing, and formal PD contexts are just a slice of their ongoing professional learning.

Limitations

There were a variety of limitations to my study. For instance, there was a vast amount of data to sift through which meant that the study had more breadth than depth.

Because the unit of analysis was the group of teachers, I didn't study in-depth differences between teachers. In this way, I didn't delve into subtle differences in the way the PD was taken up and implemented in each classroom. As well, I didn't examine participation levels of individual teachers in the PD which may have given a clearer picture of what types of PD experiences are beneficial for teachers. I also didn't study one intervention deeply to document teacher change. Another limitation of the study was that the T-LCP PD for the year was in literacy, not numeracy. This made it difficult to effectively study its implications. A minor limitation of my study is that I never asked

teachers why they only did inquiry through PAR for data management unit but not for any other mathematics units. On that topic, I also wish that I had have asked more probing questions during the interviews to delve even more deeply into their conceptions of equity. Finally, I didn't study the effects of the PD interventions on student learning. This would have been useful in mathematics education research to examine how various forms of teaching have the potential to improve marginalized students' mathematical proficiency.

Future research

The study opened up a variety of possibilities for further research. For instance, it would be interesting to code the data through Cochran-Smith's (2004) six principles of teaching for social justice. In this way, I could have contributed to her framework by highlighting areas that teachers found lacking and to think about PD to support their development. As well, the teachers' conceptualizations of equity found in this study could be used as a foundation for further research to develop an "Indicators of Change" framework related to equitable teaching practices in mathematics that schools could use to document the process of teacher change in schools.

It would also be interesting to study what a T-LCP would look like with a mathematics focus. Would there be more buy-in? What would the effects for student learning be? A more detailed study could examine the drawbacks and strengths of PD structures to improve teacher practice and student achievement. As well, a closer examination of classroom practice and student learning in relation to the PD could contribute to research that generates meaning making in support of student learning and

an understanding of how both teachers and students learn mathematics with an equity focus.

In the future, with the existing data I could create case studies of individual teachers as a way to offer insight into how equity is conceptualized, achieved and taken up in day-to-day teaching and to examine how their identities (e.g., class, racial, ethnic, and gender) interact within communities of practice to form those conceptualizations. It would also be interesting to do a similar study but with teachers of different racial backgrounds (because four of the five teachers in my study were White). Finally, because so many of the teachers commented on the difficulty with group work and assessment, a study of interventions related to these issues would be beneficial. As well, a detailed study of PD to support teaching ELLs would also be helpful for mathematics education research.

Conclusion

The goal of the study was to better understand what it means to teach toward equity in mathematics in an urban Canadian elementary school context. Six key conceptualizations of equity emerged which included: a) raising achievement levels of marginalized students, b) providing access to higher level mathematics, c) providing access to language in mathematics for English Language Learners, d) raising students' awareness of social justice issues, e) inquiry as a form of equity, and f) connecting mathematics to students' lived experience. I have highlighted the complexity of teacher professional learning in an inner-city setting and have considered the role that multiple PD contexts might play in a teacher's professional life. Key ideas that were taken up by teachers through the PD sessions included benefits and costs of inquiry-based teaching

and learning approaches, strategies to develop mathematical proficiency, integrating mathematics with other subject areas, the importance of becoming aware of students and their communities and of raising students' awareness of social justice issues.

Analysis revealed tensions in relation to teachers' notions of teaching and learning and included the tension between inquiry and more traditional forms of teaching, the role of teacher in inquiry (participant in knowledge building community) and the role of teacher in more traditional forms of teaching (knowledge purveyor), and tensions to emerge within the PD experiences. In Little and McLaughlin's (1993) study of teachers' professional development, they discuss "emergent tensions between choice and constraint, between individual initiative, and institutional imperative" (p. 1). Likewise, my study showed possibilities and tensions between opportunities and barriers for equity in mathematics teaching and learning, teacher autonomy and the demands of the system. Challenges to achieving equity in teaching included issues around group work and assessment, and access to language in mathematics for ELL students. These contradictions demonstrate that there are no easy answers for a teacher who is faced with the job of developing students' mathematical proficiency.

Teaching for equity in mathematics is rife with complexity. Teachers strive to find a balance in their mathematics teaching between covering curriculum, exploring issues of social justice, integrating themes, creating student-driven curriculum and inquiry-based learning, strengthening students' procedural understanding, developing their computational fluency and conceptual understanding of mathematics, and teaching socialization skills. Count into the mix the demands from above via the principal, the school community, the parent community, the school board and its new initiatives, the

provincial ministry, not to mention the teachers having a personal life, and the actual classroom community made up of a range of students with diverse abilities and background experiences and cultural competence, and this goal of balance seems lofty and unreachable. Yet teachers continue on a daily basis to live within this world, bringing their strengths to bear, recognizing their limitations and demonstrating a deep commitment in their quest to create and provide inclusive, accessible, and equitable mathematics learning environments for the students in their care.

REFERENCES

Apple, M. (2004). *Ideology and curriculum* (3rd ed.). New York: Routledge.

Assembly of Alaska Native Educators. (1998). *Alaska standards for culturally responsive schools*. Fairbanks, AK: Alaska Native Knowledge Network, University of Alaska, Fairbanks.

Atweh, B. (2004). Understanding for changing and changing for understanding: Praxis between practice and theory through action research in mathematics education. In P. Valero & R. Zevenbergen (Eds.), *Researching the socio-political dimensions of mathematics education: Issues of power in theory and methodology* (pp. 187-206). Norwell, MA: Kluwer.

Ball, D. L., & Bass, H. (2003). Interweaving content and pedagogy in teaching and learning to teach: Knowing and using mathematics. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and learning.* Westport, CT: Ablex Publishing.

Ball, D. L., & Bass, H. (2003). Toward a practice-based theory of mathematical knowledge for teaching. In B. Davis & E. Simmt (Eds.), *Proceedings of the 2002 Annual Meeting of the Canadian Mathematics Education Study Group,* 3-14. Edmonton, AB: CMESG/GCEDM.

Banks, J. (1995). Multicultural Education and Curriculum Transformation, *The Journal of Negro Education, 64* (4), 390-400.

Banks, J. (2004). Series Forward. In Cochran-Smith, M. (2004).*Walking the road: Race, diversity, and social justice in teacher education.* New York: Teachers College, Columbia University.

Bates, D.G. & Plog, F. (1990). *Cultural Anthropology*, *3rd ed*. New York: McGraw-Hill.

Battiste, M. (2002). Indigenous knowledge and pedagogy in First Nations education: A literature review with recommendations. Prepared for the National Working Group on Education and the Minister of Indian Affairs, Indian and Northern Affairs, Ottawa Ontario, Canada.

Boaler, J. (1999). Participation, knowledge, and beliefs: A community perspective on mathematics learning. *Educational Studies in Mathematics, 40*(3), 259-281.

Boaler, J. (2000). Exploring situated insights into research and learning. *Journal for Research in Mathematics Education, 31*(1), 113-119.

Brown, R. (2006).The TDSB Grade 9 Cohort Study: A Five-Year Analysis, 2000-2005. *Organizational Development, Research & Information Services*, *2* (1).

Burowoy, M. (1998). *Sociological theory.* Berkeley: UC Press.

Buysse, V., Sparkman, K., & Wesley, P. (2003). Communities of practice: Connecting what we know with what we do. *Council for Exceptional Children, 69* (3), 263-277.

Caswell, B., Esmonde, I., & Takeuchi, M. (2010). Towards culturally relevant and responsive teaching of mathematics. In C. Rolheiser, M. Evans, & M. Gambhir, M. (Eds.), *Inquiry into practice: Reaching every student through inclusive curriculum practices*. Toronto: Ontario Institute for Studies in Education.

Caswell, B., Stewart Rose, L., Douara, D. (2010). Teaching mathematics with a social justice focus. In C. Rolheiser, M. Evans, & M. Gambhir, M. (Eds.), *Inquiry into practice: Reaching every student through inclusive curriculum practices*. Toronto: Ontario Institute for Studies in Education.

Charmaz, K. (2003). Grounded theory. In S. Nagy Hesse-Biber, S., & P. Leavy. *Approaches to Qualitative Research: A reader on theory and practice* (pp.496-521). Oxford: Oxford University Press.

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis.* Thousand Oaks, CA: Sage.

Civil, M. (2007). Building on community knowledge: an avenue to equity in mathematics education. In Nasir, N.S. & Cobb, P. (2007). *Improving access to mathematics: Diversity and equity in the classroom* (pp.105-117). New York: Teachers College Press.

Cochran-Smith, M. (2004).*Walking the road: Race, diversity, and social justice in teacher education.* New York: Teachers College, Columbia University.

Cohen, E.G., & Lotan, R.A. (1997). *Working for equity in heterogeneous classrooms: Sociological theory in practice.* New York: Teachers College Press.

Cohen, S. (2004). *Teachers' professional development and the elementary mathematics classroom: Bringing understandings to light.* Mahway, NJ: Lawrence Erlbaum.

Confrey, J. (2010). Response Commentary: "Both and" – Equity and mathematics: A response to Martin, Gholson, and Leonard. *Journal of Urban Mathematics Education, (3)*(2), 25-33.

Connelly, M., He, M.F., & Phillion, J. (Eds.) (2008). *The SAGE handbook of curriculum instruction.* Los Angeles: SAGE Publications.

Connelly, F. M., & Xu, S. (2008). The landscape of curriculum and instruction: Diversity and continuity. In Connelly, M., He, M.F., & Phillion, J. (Eds.) (2008). *The SAGE handbook of curriculum instruction* (pp. 514-533). Los Angeles: SAGE Publications.

Cotterill, P. (1992). Interviewing women: Issues of friendship, vulnerability, and power. *Women's Studies International Forum, 15*(5/6), 593-606.

Creswell, J.W. (2007). *Qualitative inquiry & research design: Choosing among the five approaches* (2nd ed.). Thousand Oaks, CA: Sage.

D'Ambrosio. (1999). Literacy, matheracy, and technocracy: A trivium for today. *Mathematical Thinking and Learning, 1,* 131-153.

Darder, A., & Torres, R.D. (2002). Shattering the "race" lens: Toward a critical theory of racism. In A. Darder, M. Baltodana, & R. D. Torres (Eds.), *The critical pedagogy reader* (pp.245-261). New York: Routledge Falmer.

Darling-Hammond, L., & Bransford, J. (Eds.). (2005). *Preparing teachers for a changing world: What teachers should learn and be able to do.* San Francisco: Jossey-Bass.

De Abreau, G., & Cline. T. (2007). Social valorization of mathematical practices: the implications for learners in multicultural schools. In Nasir, N.S. & Cobb, P. (2007). *Improving access to mathematics: diversity and equity in the classroom* (pp.118-131). New York: Teachers College Press.

Dei, G.S.N. (2006, September). Meeting equity fair and square. Keynote address to the Leadership Conference of the Elementary Teachers' Federation of Ontario, Mississauga, Ontario. In Ontario Ministry of Education (2009), *Realizing the promise of diversity: Ontario's equity and diversity strategy.* Retrieved from http://www.edu.gov.on.ca/eng/policyfunding/equity.pdf

Delpit, Lisa (1988). The silenced dialogue: Power and pedagogy in educating other people's children. *Harvard Educational Review, 58*(3), 280-298.

Demmert, Jr., W.G. & Towner, J.C. (2003). A review of the research literature on the influences of culturally based education on the academic performance of Native American students. Retrieved on July 6, 2006 from: http://wwww.nwrel.org/nwreport/2003-03/index.html. In J. Leonard. (2008). *Culturally Specific Pedagogy in the Mathematics Classroom: Strategies for Teachers and Students*. New York: Routledge/Taylor & Francis.

Deng, Z. & Luke, A. (2008). Subject matter: Defining and theorizing school subjects. In

F. M. Connelly, M.F. He, & J. Phillion, (eds.), *The Handbook of curriculum and instruction* (pp. 66-87). Thousand Oaks, CA: Sage Publishers.

Denzin, N.K., & Lincoln, Y.S. (Eds.). (2000). *Handbook of qualitative research (2nd ed.).* Thousand Oaks, CA: Sage.

Dixson, A.D. & Rousseau, C.K. (2005). And we are still not saved: Critical race theory in education ten years later. *Race Ethnicity and Education, 8,* (1), 7-27.

Donovan, S., & Bransford, J. D. (2005). *How students learn: History, mathematics, and science in the classroom.* National Academies Press.

Duncan, G., Dowsett, C., Claessens, A., Magnuson, K., Huston, A., Klebanov, P., Pagani, L., Feinstein, L., Engel, M., Brooks-Gunn, J., Sexton, H., Duckworth, K., Japel, C. (2008). School readiness and later achievement. *Developmental Psychology,44(*1) p. 232.

Education Quality and Accountability Office. (2011). *About the EQAO.* Retrieved from http://www.eqao.com/IP/ImprovementPlanning.aspx?Lang=E

Emerson, R.M., Fretz, R.I., & Shaw, L. (1995). *Writing ethnographic fieldnotes.* Chicago: University of Chicago Press.

Farrell, Joseph (2008). Community education in developing countries: The quiet revolution in schooling. In F.M. Connelly, M.F. He, & J. Phillion (Eds.). *The SAGE Handbook of curriculum and instruction* (pp. 369-389). Thousand Oaks, CA: Sage Publishers.

Fine, M. & Torre, M. (2006). Intimate details: Participatory Action Research in Prison. *Action Research*, Vol. *4*(3), 253-269.

Freire, Paulo (1970). *Pedagogy of the Oppressed*. New York: Continuum.

Gay, G. (2000). *Culturally responsive teaching: Theory, practice and research.* New York: Teachers College Press.

Geertz, C. (1973). Thick description: Toward an interpretive theory of culture. In *The Interpretation of Culture* (pp. 3 – 30). New York: Basic Books.

Giroux, H., & Purpel, D.(Eds.). (1983). *The Hidden Curriculum and Moral Education,* Berkeley, California: McCutchan Publishing Corporation.

Glaser, B.G. & Strauss, A. L. (1967). *The discovery of grounded theory.* Chicago: Aldine.

Gonzalez, N., Andrade, R., Civil, M., & Moll, L. (2001). Bridging Funds of Distributed Knowledge: Creating Zones of Practices in Mathematics. *Journal of Education for Students Placed at Risk (JESPAR), 6*(1-2), 115-132.

Goodwin, J., & Horowitz, R. (2002). Symposium on methodology in qualitative sociology. Introduction: The methodological strengths and dilemmas of qualitative sociology. *Qualitative Sociology, 25*, 33-47.

Gruenewald, D.A. (2003). The best of both worlds: A critical pedagogy of place. *Educational Researcher, 32*(4), 3-12.

Guskey, .T. (1995). Professional development in education: In search of the optimal mix. In T. Guskey & M. Huberman (Eds.). *Professional development in education: New paradigms and practices.* New York: Teachers College Press, 114-132.

Guskey, T. (2000). *Evaluating professional development.* Thousand Oaks, Sage.

Gutiérrez, R., & Rogoff, B. (2003). Cultural ways of learning: Individual traits or repertoires of practice. *Educational Researcher, 32*(5), 19-25.

Gutiérrez, R. (2007). (Re)defining equity: the importance of a civil perspective. In N.S. Nasir, & P. Cobb, (2007). *Improving access to mathematics: diversity and equity in the classroom.* New York: Teachers College Press.

Gutiérrez, R. (2008). A 'gap-gazing' fetish in mathematics education? Problematizing research on the achievement gap. *Journal for Research in Mathematics Education, 39*(4)*,* 357 – 364.

Gutstein, E., Lipman, P., Hernandez, P., & de los Reyes, R. (1997). Culturally relevant mathematics teaching in a Mexican American context. *Journal for Research in Mathematics Education, 28*(6), 709-737.

Gutstein, E. (2006). *Reading and writing the world with mathematics. Toward a pedagogy of social justice*. New York: Routledge.

Gutstein, E. (2007) "So one question leads to another": using mathematics to develop a pedagogy of questioning. In N.S. Nasir, & P. Cobb. (2007). *Improving access to mathematics: diversity and equity in the classroom.* New York: Teachers College Press.

Hiebert, J., & Carpenter, T.P. (1992). Learning and teaching with understanding. In D. Grouws (Ed.), *The handbook of research on mathematics teaching and learning* (pp. 65-97). New York: Macmillan.

Howard, T.C. (2003). Culturally relevant pedagogy: Ingredients for critical teacher reflection. *Theory into Practice, 42*(3), 195-202.

Irvine, J.J. (2002). African American teachers' culturally specific pedagogy. In J.J. Irvine (ed.), *In search of wholeness: African American teachers and their specific classroom practices* (pp. 139-146). New York: Palgrave.

Jordan. W. (2010). Defining equity: Multiple perspectives to analyzing the performance of diverse learners. *Review of Research in Education, 34*(1), 142-178.

Kitchen, R., DePree, J., Celedon-Pattichis, S., & Brinkerhoff, J. (2007). *Mathematics education at highly effective schools that serve the poor: Strategies for change.* Mahwah, NJ: Erlbaum.

Kliebard, H. (1975). The rise of scientific curriculum making and its aftermath. *Curriculum Theory Network 5*(1), 27-38.

Knijnik, G. (1997). An Ethnomathematical approach in mathematical education: A matter of political power. In A. B. Powell & M. Frankenstein (Eds.), *Ethnomathematics: challenging eurocentrism in mathematics education*. Albany, NY: SUNY Press.

Kobayashi, A. (2001). Negotiating the personal and the political in critical qualitative research. In M. Limb & C Dwyer, (Eds). *Qualitative Methodologies for Geographers: Issues and Debates* (pp.55-72). London and New York: Arnold and Oxford University Press.

Kumashiro, K. (2000). Toward a theory of anti-oppressive education. *Review of Educational Research, 70*(1), 25-53.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32*(3),465–491.

Ladson-Billings, G. (2006). From the achievement gap to the education debt: Understanding achievement in U.S. schools. *Educational Researcher, 35*(7), 3-12.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* New York: Cambridge University Press.

Leonard, J. (2008). *Culturally Specific Pedagogy in the Mathematics Classroom: Strategies for Teachers and Students*. New York: Routledge/Taylor & Francis.

Levine, D. (2001). Radical equations. *Rethinking schools online, 15*(4), 1-7.

Lipka, J. & Adams, B. (2002). *Improving Alaska Native rural and urban students' mathematical understanding of perimeter and area.* Unpublished manuscript. Alaska School Research Fund.

Little, J.W. (2003). Inside teacher community: Representations of classroom practice. *Teachers College Record, 105*(6), 913-945.

Little, J.W. & McLaughlin, M.W., (Eds.). (1993). *Teachers' work: Individuals, colleagues, and contexts.* New York and London: Teachers College Press.

Lubienski, S.T. (2000). Problem solving as a means toward mathematics for all: An

exploratory look through a class lens. *Journal for Research in Mathematics Education, 31*(4), 454-482.

Lubienski, S. & Gutierrez, R. (2008). Bridging the gaps in perspectives on equity in mathematics education. *Journal for Research in Mathematics Education, 39*(4)*,* 365 – 371.

Lustick, D. & Sykes, G. (2006). National Board Certification as professional development: What are teachers learning? *Education & Policy Analysis, 15*, 129 – 151.

Martin, D.B. (2003). Hidden assumptions and unaddressed questions in *Mathematics for All* rhetoric. *The Mathematics Educator, 13*(2), 7-21.

Mason, R. T. (2006). A kinder mathematics for Nunavut. In Y. Kanu (Ed.), *Curriculum as Cultural Practice: Postcolonial Imaginations* (pp. 131-148). Toronto: University of Toronto Press.

McCarthy, C. (1995). The problems with origins: Race and the contrapuntal nature of the educational experience. In C.E. Sleeter & P.L. McLaren (Eds.), *Multicultural education, critical pedagogy, and the politics of difference* (pp. 245-268). Albany, NY: SUNY Press.

McLaughlin, M.W. (1993). What matters most in teachers' workplace context? In J.W. Little & M.W. McLaughlin, (Eds.), *Teachers' work: Individuals, colleagues, and contexts* (79-103). New York and London: Teachers College Press.

Millory, W. (1992). An ethnographic study of the mathematical ideas of a group of carpenters [Monograph}. *Journal for Research in Mathematics Education, 5.*

Moses, R., & Cobb, P. (2001). *Radical Equations: math literacy and civil rights.* Boston, MA: Beacon Press.

Nasir, N.S. (2002). Identity, goals and learning: Mathematics in cultural practice. *Mathematical Thinking and Learning, 4*(2&3), 211-145.

Nasir, N.S. (2007). Identity, goals, and learning: the case of basketball mathematics. In N.S. Nasir, & P. Cobb, P. (2007). *Improving access to mathematics: diversity and equity in the classroom (*132-145). New York: Teachers College Press.

Nasir, N.S. & Cobb, P. (2007). *Improving access to mathematics: diversity and equity in the classroom.* New York: Teachers College Press.

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and Standards for School Mathematics*. Reston, VA: NCTM.

Neuman, W.L., & Kreuger, L. (2003). *Social work research methods: Qualitative and*

quantitative approaches. Boston: Allyn & Bacon.

Nicol, C. & Brown, L. (2008) Creating emotionally healthy mathematics classrooms: Educating mind and heart through culturally responsive teaching. *Proceedings of the Canadian Aboriginal Science and Engineering Society*.

Nicol, C., Archibald, J., Kelleher, H., Brown, L., Hutchingson, V., Nielsen, W., & Owuor, J. (2007).

Culturally responsive approaches to mathematics teaching and learning in aboriginal communities. Paper presented at the American Educational Research Association Annual Meeting, 2007 in Chicago, USA.

Nieto, S. (2002). *Language, culture and teaching: Critical perspectives for a new century*. Mahwah, NJ: Lawrence Erlbaum.

Ontario Ministry of Education. (2005). *Education for all*, Queen's Printer of Ontario.

Ontario Ministry of Education. (2005). *The Ontario curriculum grades 1-8: Mathematics*. Queen's Printer for Ontario.

Ontario Ministry of Education. (2009). *Realizing the promise of diversity: Ontario's equity and inclusive education strategy*. Queen's Printer for Ontario.

Palincsar, A.S. (1998). Social constructivist perspectives on teaching and learning. In J.T. Spence, J.M. Darley, & D. J. Foss (Eds.), *Annual review of psychology* (pp. 345-375). Palo Alto, CA: Annual Reviews.

Piaget, J. (1965). *The child's conception of number.* New York: Norton.

Pollock, M. (2004). *Colormute: Race talk dilemmas in an American school.* Princeton, New Jersey: Princeton University Press.

Rolheiser, C., Evans, M., & Gambhir, M. (2010). *Inquiry into practice: Reaching every student through inclusive curriculum.* Toronto: Ontario Institute for Studies in Education.

Rutman, D., Hubberstey, C., Barlow, A., & Brown, E. (2005). Supporting young people's transitions from care: Reflections on doing participatory action research with youth from care. In L. Brown & S. Strega (Eds.). *Research as resistance: Critical, indigenous, and anti-oppressive approaches.* Toronto: Canadian Scholar's Press.

Schoenfeld, A. (2002). Making mathematics work for all children: Issues of standards, testing, and equity. *Educational Researcher, 31*(1), 13 – 25.

Schwartz, M. & Fischer, K. (2003). Building vs. borrowing: The challenge of actively constructing ideas. *Liberal Education*, *89*.

Sheets, R.H. (2005). *Diversity pedagogy: Examining the role of culture in the teaching-learning process.* Boston: Allyn and Bacon.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15* (2), 4-14.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57* (1), 1-22.

Skovsmose, O., & Borba, M. (2004). Research methodology and critical mathematics education. In P. Valero & R. Zevenbergen (Eds.), *Researching the socio-political dimensions of mathematics education: Issues of power in theory and methodology* (pp. 207-226).

Sleeter, C.E.(1997). Mathematics, multicultural education, and professional development. *Journal for Research in Mathematics Education, 28*(6), 680-969.

Stein, M.K. & Brown, C. (1997). Teacher learning in a social context: Integrating collaborative and institutional processes with the study of teacher change. In E. Fennema and B.S. Scott (Eds.),*Mathematics teachers in transition.* Mahwah, NJ: Lawrence Erlbaum.

Strauss, A., & Corbin, J. (1994). Grounded theory methodology. In N. Denzin & Y Lincoln, (Eds.). *Handbook of qualitative research.* Thousand Oaks, CA: Sage.

Steele, C.M. (1997). A threat in the air: how stereotypes shape the intellectual identities and performance of women and African Americans. *American Psychologist, **52,** 613-629.*

Stodolsky, S. (1988). *The subject matters: Classroom activity in math and social studies.* Chicago: University of Chicago Press.

Strega, S. (2005). The view from the poststructural margins: Epistemology and methodology reconsidered. In L. Brown, & S. Strega (Eds.), *Research as resistance* (pp. 199-235). Toronto: Canadian Scholars' Press.

Suurtamm, C., Moisan, P., & Luthra, V. (2004). *Does the mathematics being measured by the Grade 9 assessment of mathematics represent the "important" mathematics to be learned in the Grade 9 curriculum?* Paper commissioned by the EQAO Assessment Review Project.

Takeuchi, M. (2011). Pedagogical contexts of mathematics classrooms and opportunities to learn for English language learners: An ethnographic study on classroom interaction. Paper presented at the annual conference of the American Educational Research Association, New Orleans, Louisiana.

Thomas, J. (1993). *Doing critical ethnography.* Newbury Park, CA: Sage.

Tyler, R.W. (1949). *Basic principles of curriculum and instruction*. Chicago: The University of Chicago Press.

Vithal, R. (2008). Complementarity, mathematics and context. *Journal of education, **45,*** 43-64.

Vygotsky, L. (1978/1932). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Wallace, J., & Louden, W. (1994). Collaboration and the growth of teacher's knowledge. *Qualitative studies in education, 7* (4), 323-334.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity.* Cambridge: Cambridge University Press.

Wenger, E., McDermott, R., & Snyder, W.M. (2002). *Cultivating communities of practice.* Cambridge, MA: Harvard Business School Press.

Werner, Walter (1991). Curriculum and uncertainty. In R. Ghosh, & D. Ray, (Eds.). *Social Change and Education in Canada, 2nd edition* (pp. 105-115). Toronto: Harcourt Brace.

Appendix A: Interview Questions

Interview questions:

1. [*Only for beginning-of-year interview]* Introductions
   a. Can you tell me about how long you've been teaching, how long you've been at this school, and what you've taught in the past?
   b. What brought you to teaching?

2. Teaching mathematics:
   a. Can you describe the class that you are teaching right now? What mathematical topics do you focus on this year?
   b. What are the major challenges that you face in teaching mathematics in this class?

3. Equity and social justice:
   a. In the school context, what do equity and social justice mean to you?
      i. Prompt: Is there anything specific for mathematics?
   b. How do you try to achieve equity and social justice in/through your teaching?
   c. What challenges do you face as you try to teach more equitably?
      i. Prompt: Is there anything specific for mathematics?

4. [*Only for end-of-year interview]* Professional development:
   a. Of the issues that have come up in the PD sessions, which are most important to you and your teaching?
   b. Have you made any changes to your teaching because of discussions or activities in the PD sessions?
   c. Anything you would suggest to change the PD sessions? How could they be more relevant and effective?

5. Wrap up:
   a. Is there anything else you'd like to tell me?

Appendix B: Initial Codes in Analysis of Interview Data: teachers' conceptions of equity

- Providing access to concepts
- Developing students' computational fluency through practice
- Trying to support students who struggle in mathematics
- Scaffolding students' conceptual understanding

Changing the names in the textbook to reflect students in the class
Providing emotional support
Providing access to resources

- Fair treatment: Differing expectations for different students

Extending student thinking. Going beyond curriculum expectations.
Building on student background knowledge
Developing students' critical literacy skills in mathematics

- Fostering community of collaboration
- Raising students' awareness of social justice issues

Examining teacher bias

- Using math to make connections to issues
- Connecting math to issues of relevance to students

Building a respectful environment
Acknowledging one's social identity
Seeing students as contributors to mathematics
Teacher as co-learner/ Teacher as participant in knowledge building community

- Integrating subject areas, connecting math to other areas, mathematics not taught separately

Awareness of students' background, cultural knowledge, community, issues
Seeing children as individuals

- Changing content of curriculum – changing structure of instructional practice Inquiry as a way to learn math, make math relevant, as a form of equity

Moving beyond colourblind
Looking for multiple ways of assessing/differentiated instruction

- Creating equitable participation structures – validating students' contributions, recognizing students' knowledge and expertise, giving students ownership for learning/ Giving students choice
- Changing the curriculum so that it is student-driven: going beyond curriculum expectations
- Valuing differences
- Bridging home and school mathematics
- Examining systems of power: Changing the power dynamic in the class
- Developing students' critical literacy skills
- Developing a critical stance

Appendix C: Individual Teachers' Conceptions of Equity

Individual Teachers' Conceptions of Equity Answering the question: *In the school context, what does social justice and equity mean to you?*			
Teacher	Initial Interview	Stimulated Recall Interview	Final Interview
Tracey Gr. 1	**October 6, 2009:** •"Making sure everyone has what they need." • Addressing language barriers in mathematics • Having students understand why there are differentiated expectations	**February 4, 2010:** • "Ensuring that everyone has what they need to be successful" •Fair treatment •Empower students through exploring social justice issues • Equity doesn't mean equal treatment.	**May 20, 2010:** • "Meeting the needs of students and also them being aware [of social justice issues]." • "Understanding where they [students] are coming from and what their background is and making sure their needs are met."
Leah Gr. 2/3	**October 5, 2009:** • Desire to raise students' awareness of social justice issues but not knowing how to bring that into mathematics curriculum • Providing students with access by showing them a variety of strategies for computation	**February 2, 2010:** • "Reaching all kids" • Providing access to the curriculum by building on students' prior knowledge • "Giving everybody the background knowledge that they need." • "Make sure every student starts at the same place, to reach them all, the ones that are struggling." • Explaining instructions well • Providing extensions for students who finish task early • Creating a community of learners in the classroom	**June 1, 2010:** • "Reaching all kids" • Thinking about students who "have different perspectives and where they're coming from." • Seeing beyond behaviour to whole child. • Looking at children's strengths and ways of being. • "Seeing kids with their families before seeing them as your students" (feeling responsible to families). • Developing students' palate for mathematics so they have choices to pursue in future • Giving students ownership and leadership for their learning and to promote social change. • "Giving them [the students] the skills and power."
Stan Gr. 2/3	**September 30. 2009:** • "Equity as low priority" • Providing ELLs with access to language in mathematics • Examining textbook "to see if they're culturally representative of different cultures" • Balancing participation between girls and boys. • Providing equitable access to resources	**February 24, 2010:** • "But when you think about it, it's all about equity." • Providing access: designing multiple entry points to lessons for students, integrating mathematics with other subject areas • Thinking about ways to increase student participation in higher level mathematics • Creating activities that assess students' understanding' • Connecting mathematics to issues of relevance to children	**June 3, 2010:** • Being aware of child coming from community, families, diverse backgrounds • Recognizing students' race – moving away from being 'colourblind' • Creating multiple forms of assessment • Creating access to the curriculum: create lessons "at the level where my kids get it" • Supporting ELLs to understand the language in mathematics • Creating a community of learners – learning collectively • Student-driven inquiry as form of equity
Sally	**October 8, 2009:**	**February 4, 2010:**	**June 10, 2010:**

Gr. 4	"Recognizing all of their needs and trying to meet them where they are at, and provide for them, which is complex." • Recognizing students' background knowledge • Providing access to the language of mathematics • "Social justice…is the way we treat each other…we have to treat each other the way that we want to be treated…I don't treat everybody the same." • Teaching students to recognize and value differences and similarities and to find common ground • Recognizing and valuing multiple strategies and solutions • "…try to get to know students as individuals." • Bridging between the way mathematics is done at home and school • Inviting and honouring contributions from home • Developing a community of learners • Trying to "get through the language to the math" for ELLs • "Making sure I hear everyone for math." • Balancing inquiry-based learning with computation practice.	• Empowering students to become "agents of change." • Exploring issues of social justice through mathematics – changing content of curriculum • Providing access to higher level thinking in mathematics: developing students' conceptual understanding and skills in tandem with awareness of social justice issues and activism skills. • Changing content of curriculum • Giving students time to process • Extending students' thinking • Using inquiry-based teaching in mathematics	• Examining systems of power within classroom: Creating space where students are comfortable to have a voice in mathematics. • Changing content of curriculum • Validating students' strategies • Creating a community of learners • Changing the role of teacher - "I want to be part of the orchestra" • "I give them what they need." • Student-driven inquiry • Building on students' lived experiences • Thinking about larger purpose of mathematics education • Making curriculum relevant to students'' lives
Stewart Gr. 5	**October 8, 2009:** • "Getting what you [the students] need. • Equity in every part of the curriculum. • Differentiated instruction • Going beyond curriculum expectations • Raising students'' awareness of social justice issues in mathematics • Respecting differences • Development of students' problem solving skills in mathematics to transfer to decision-making skills in life. • Focusing on Big Ideas • Developing computational fluency for problem solving	**January 29, 2010:** • Reaching all students • "Looking at where kids are" and building instruction from there. • Building a foundation of computational skills • Exploring issues of social justice through mathematics – authentic problem solving. • Fostering a community of collaboration • Giving students ownership of and leadership in their learning. • Providing opportunities for students to contribute to classroom mathematics discussions. • Balancing participation between girls and boys. • Using multiple assessment strategies • Accepting different opinions without judgment. • Getting students to be "critical literacy thinkers" in mathematics.	**May 19, 2010:** • Developing more awareness of students, issues they're dealing with and teacher bias. • Changing the role of teacher from "purveyor of knowledge" to "alongside learner." • Giving students time to do inquiry and to develop "deep" questions • Creating space where students are comfortable to have a voice in mathematics. • Recognizing students' knowledge and expertise. • Integrating mathematics strands by focusing on social justice issues and big ideas. • Giving students choice • Moving away from teaching mathematics as a separate entity • Taking a critical stance with resources • Building students'' computational skills as foundation for further learning

			• Providing support for students who struggle and challenges for high-achieving students. • Using multiple assessment strategies • Combining conceptual and procedural.

Appendix D : Grade 4 students use PAR to create inclusive activities for recess

In the example below, a pair of fourth grade students were concerned that a number of children seemed to have no one to play with or nothing to do during recess (often children new to the school or ELLs), so they conducted a survey on what games children would like to have on the yard. The student who spoke with me studied the graph intently and referred to it to describe the process of how she and her partner thought about and conducted the survey and how they used the numbers to make sense of the data:

> "First we kind of planned out what we wanted to do and we wanted to organize games at recess so people who didn't have anything to do would have something to do and enjoy their recess more. And then we kind of started off planning so we organized it into a tally chart."

They talked about the categories they chose and expressed surprise at the number of students who chose the category entitled "Other." "We were kind of surprised with some of our data… so one of the things that was surprising was 'Others'." What the quote below shows is how the drive to improve the conditions of the playground for children led these students to refine their data collection and data management skills :

> "So our second step would be going to those juniors and ask them, "What games would be under 'Others'? What games would you like to have organized under

> 'Others'?" Yeah, so we can do *another* tally chart and organize that into *another* graph so we know what kinds of games to organize under 'others'. And um, our next step is to go to the principal and vice principal and say, "You think we could organize these games at recess to help, to help, to try and give kids um something to do at recess who have nothing to do. So we're going to try and *convince* them to actually to get us to organize these games and maybe we'll be able to sometime. If this succeeds, K and I will be the leaders then we'd get volunteers also because like it would be a help to us 'cause we're only in Grade 4."

In this way, the idea of fairness was top on their minds but the by-product was mathematics that exceeded curriculum expectations. Their engagement with the data provided the impetus to think about the function of a graph and demonstrated how the results were used to direct an action, in this case to actually organize games to meet the needs of the students. The students were able to see the results of her graph benefiting many students in the school. The excitement in the students' voice as she reflected on the PAR graphing experience illustrates the potential of PAR to create identities as "doers of mathematics":

> "We followed up with Ms X [school principal] and now our games are going on. We have Right to Play, my partner and I are both leaders and we have so many students, we have parent volunteers and we have um– it's only for Grade 4s and we have different Grade 4s from different classes volunteering to go out there and actually help these kids so it was a big success. We worked hard, the process was

really long, but our hard work paid off, we got kids going out there and having fun."

In this way, students could begin to see themselves as contributors to the school, doers of mathematics.